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RESEARCH ARTICLE

INVESTIGATION OF THE CORRELATION BETWEEN PAIN, PROPRIOCEPTION AND RANGE OF MOTION IN PATIENTS WITH TEMPOROMANDIBULAR JOINT DYSFUNCTION

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ABSTRACT

Purpose: The aim of study was to investigate the relationship between pain, proprioception and range of motion in patients with temporomandibular joint dysfunction (TMD).
Material and Methods: The study was completed with 45 participants diagnosed with TMD and 45 healthy controls. Visual analog scale and graded chronic pain scale were used to assess pain intensity, dolorimeter was used for pain pressure threshold (PPT) assessment. Evaluation of cervical proprioception by cervical joint position error test (JPET), cervical joint range of motion assessment by digital goniometer, mouth opening measurements were made with a ruler.
Results: In the study, pain intensity was high and PPT was low in the TMD group. In the JPET, the right-left rotation and left lateral flexion values in the TMD group had higher mean values than the control group (p=0.028, p=0.003, p=0.004, respectively). There was a significant difference between the groups in digital goniometer measurement in right-left rotation, right-left lateral flexion movements(p=0.008, p=0.001, p=0.041, p=0.005, respectively). The TMD group had a lower mean than the control group in painless, maximum assisted and unassisted mouth opening measurements(p=0.001, p=0.001, p=0.001, respectively).
Conclusion: TMD patients presented a lower PPT, less accurate head repositioning, and some impairment in cervical range of motion.

Keywords: temporomandibular joint, pain, proprioception, range of motion

INTRODUCTION

Temporomandibular joint dysfunction (TMD) is a musculoskeletal disorder involving the temporomandibular joint (TMJ), masticatory muscles, ligaments, and surrounding tissues (1). Conditions characterized by tenderness, pain, clicking sound during movement, or functional limitations in the TMJ or surrounding tissues are included under TMD (2). Although few patients seek treatment, the prevalence of TMD is between 3% and 15% in developed societies (2). TMD increases in the population mostly between the ages of 20–40 years and is more common in women than in men (3).

Pain is the most common sign of degenerative changes in TMD. A clicking sound felt in the joint and associated with uncomfortable jaw movement, neck pain, or headache is indicative of muscle issues in TMJ disorders. When people with TMD have discomfort, joint issues, and restricted jaw movements, it affects their ability to eat, chew, swallow, and talk, which lowers their quality of life as the disease progresses (4,5).

TMD is associated with problems in the cervical region, and dysfunctions in the cervical region affect the masticatory region (5,6,7). According to Silveira et al., high degrees of muscle tenderness in the upper trapezius and temporalis muscles were associated with high levels of jaw and neck dysfunction. Furthermore, severe neck disability was associated with severe jaw dysfunction (5). Another study by von Piekartz et al. investigated whether subjects with acute/subacute temporomandibular disorders exhibit associated cervical impairments and indicated that the greater the dysfunction and pain in the temporomandibular region, the greater the dysfunction on a number of cervical musculoskeletal function assessments (6). Additionally, Cuenca-Martnez et al. performed a systematic review and meta-analysis of observational studies to examine craniocervical and cervical spine features in TMD patients and discovered statistically significant variations in the relationship between neck impairment and jaw disability (7). Because of the close relationship between these two regions, cervical region functionality and proprioception can be expected to be affected in individuals with TMD. It has been demonstrated that movement limitation or functional impairment in the cervical region may affect the TMJ as well as the cervical fascia and masticatory muscles, and it is recommended that programs prepared for the evaluation and treatment of patients with TMD should include the cervical region.

The purpose of the current study was to compare measurements between patients with TMD and healthy controls by examining the pain intensity, pain pressure threshold (PPT), cervical proprioception, cervical range of motion (ROM), and mouth opening.

MATERIAL AND METHODS

Participants

Ethical approval was obtained from the Health Sciences Research Ethics Committee of Istanbul Okan University (Decision Date: 24.11.2021, Number: 8) and the study was conducted in accordance with the Declaration of Helsinki. Healthy individuals (control group (CG)) and participants with TMD (TMD group) who matched the inclusion criteria were included in the study. After the participants were given thorough information regarding the assessments to be conducted, informed consent for the study was acquired. The inclusion criteria were patients have the appropriate diagnostic criteria for TMD (DC-TMD) a result of evaluation by a dentist, be in arthrogenic, myogenic, mixed type according to the DC/TMD classification, TMJ pain for at least 3 months, and age more than 18 years, while the exclusion criteria were the presence of an orthopedic or neurological problem that would prevent the evaluations from being performed; the presence of any psychiatric disease; and a history of surgical operations involving the face, jaw, and cervical region, rheumatoid arthritis, fracture, and malignant conditions.

Sample Size

The sample size for this study was calculated using the G*POWER program. Yıldırım et al. obtained a moderate effect size (Eta squared (η2) = 0.49) using the mean and standard deviation values of the pain intensity in patients with TMD. For this effect size, it was determined that there should be at least 45 observations for each group in the sample with a statistical power level of 81.7% and a significance level of 5%. In line with these results, the study was planned to include a minimum of 90 participants (8).

Evaluation Methods

The demographic information of the study participants was obtained using the sociodemographic form (age, gender, body weight, height, educational status, occupation, complaints, pain duration, and pain type). Within the scope of the present study, pain intensity, pain pressure threshold, cervical region proprioception sensation, cervical region range of motion, and mouth opening were measured. All assessments were done face-to-face by two physiotherapists who are blinded to groups.

Assessment of Pain İntensity

The pain intensity was assessed using the Visual Analog Scale (VAS) and Graded Chronic Pain Scale (GCPS). For the VAS, two points on a 100 mm line, with markings from “0”, indicating no pain, to “10”, indicating excruciating pain, were determined.

Between 0 and 10, patients were asked to mark the severity of their pain during three different actions (rest, activity, night (9). The GCPS Version 2.0 is a scale that assesses pain intensity, overall chronic pain severity, and pain-related disability in two dimensions over the previous 1 month. The GCPS consists of eight items in total, six of which are scored from 0 (no pain) to 10 (highest pain), and the results are calculated by adding the number of days for the remaining two items (10).

Assessment of Pain Pressure Threshold

The PPT was evaluated using a dolorimeter. Before using the dolorimeter for measurement, it was tested by pushing it on the pulp of the thumb. The algometer was then pressed vertically on the masseter, temporalis, trapezius, sternocleidomastoid, and lateral to the TMJ muscles while the patient sat until pain was felt. The pressure was applied in 1kg/cm2 increments. The patient was asked to raise his/her hand when he/she first felt pain. This technique was carried out three times and mean values was calculated (11).

Evaluation of Proprioception Sensation in the Cervical Region

A participant sits in a chair, 90 cm distant from a target on a wall. A laser pointer is put on top of the participant's head, and the subject is blindfolded. The participant is told to move their head away from the target while starting with the laser pointer exactly in the middle of the target. After returning to the center, the difference between the initial and final positions is calculated. The final laser location is measured in centimeters in relation to the initial position. The test was repeated ten times and the arithmetic mean of the results was used. The active neck movements (flexion, extension, right and left rotation, right and left lateral flexion, and right and left lateral flexion) were assessed (12,13).

Evaluation of Range of Motion in the Cervical Region

Flexion, extension, lateral flexion, and rotation angles of motion were measured using a digital goniometer for the ROM assessment of the cervical region. Cervical flexion and extension measurements were

Table 1. Evaluation and comparison of demographic characteristics of the participants

		Groups		Test Statistics	P
		TMD (n = 45)	Control (n = 45)		
		Mean ± SD Median (IQR)	Mean ± SD Median (IQR)		
Age (years)		29.11 ± 7.90 29 (11)	28.93 ± 6.07 29 (9)	-0.120	0.905 [1]
Height (cm)		169.51 ± 9.06 169 (12)	172.02 ± 11.44 171 (13)	1.153	0.252 [1]
Body Weight (kg)		69 ± 11.05 67 (15)	73.36 ± 10.16 73 (15)	1.945	0.055 [1]
BMI (kg/m^2)		24.05 ± 3.56 23 (5)	25.14 ± 5.15 24 (6)	1.170	0.245 [1]
		n (%)	n (%)		
Gender	Male	4 (%9)	4 (%9)	0.001	0.999 [2]
	Female	41 (%91)	41 (%91)		

SD: Standard deviation, TMD: Temporomandibular Joint Dysfunction, BMI: Body Mass Index,[1]: Independent t test (t); [2]: Chi-Square test-Fisher's Exact test (χ^2); summary statistics are given as mean ± standard deviation for continuous data; Median (IQR) and Number (percentage) for categorical data.

Table 2. Comparison of pain pressure threshold, proprioception and range of motion of cervical region, measurements of mouth opening

			TMD Mean ± SD Median (IQR)	Control Mean ± SD Median (IQR)	Test Ist.	p
Pain pressure threshold	Masseter muscle		1.56 ± 0.59 1.3 (0.9)	2.5 ± 0.74 2.3 (1.45)	-5.425	0.001 **
	Temporalis muscle		2.27 ± 0.90 2.1 (1.8)	3.03 ± 0.53 3.2 (1)	-4.183	0.001 **
	Sternocleidomastoid muscle		1.5 ± 0.74 1.3 (1.03)	2.52 ± 0.85 2.8 (1.5)	-5.146	0.001 **
	Trapezius muscle		2.18 ± 0.79 2.1 (1.4)	3 ± 0.59 3.1 (0.7)	-4.702	0.001 **
	TMJ lateral		2.47 ± 0.81 2.3 (1.6)	3.35 ± 0.38 3.5 (0.35)	-5.271	0.001 **
Proprioception of the cervical region	Flexion		12.47 ± 6.80 12 (7.35)	11.63 ± 2.48 12 (2.4)	-0.008	0.993
	Extension		13.57 ± 6.77 14 (6.5)	12.06 ± 2.35 12 (2.75)	-1.331	0.183
	Rotation	R	14.28 ± 8.88 13 (7.25)	10.99 ± 2.76 10 (4.5)	-2.200	0.028 *
		L	14.24 ± 8.60 13 (7.25)	10.18 ± 3.39 9 (4)	-2.994	0.003 **
	Lateral Flexion	R	12.61 ± 6.73 12 (6.75)	9.32 ± 3.59 8 (5.5)	-2.898	0.004 **
		L	12.36 ± 6.53 10.33 (5.5)	10.55 ± 3.83 9.5 (4.75)	-1.423	0.155
Cervical region joint movements (°)	Flexion		43.54 ± 5.91 43.2 (3)	43.58 ± 1.84 43.5 (2.65)	-0.146	0.884
	Extension		44.09 ± 4.53 44.1 (3.35)	44.16 ± 1.73 44.3 (2.3)	-0.747	0.455
	Rotation	R	55.66 ± 5.69 56.9 (7.15)	58.22 ± 3.96 59.4 (4.5)	-2.632	0.008 **
		L	55.74 ± 5.45 57.1 (5.75)	58.75 ± 3.28 59.4 (3.35)	-3.217	0.001 **
	Lateral Flexion	R	41.46 ± 3.68 42.3 (3.95)	42.9 ± 1.98 42.9 (2.9)	-2.043	0.041 *
		L	41.21 ± 4.10 41.8 (4.65)	43.39 ± 2.47 43.8 (3.5)	-2.793	0.005 **
Mouth Opening (mm)	PMO		16.87 ± 3.71 17 (5)	19.69 ± 1.90 20 (2)	-4.647	0.001 **
	MMO		40.96 ± 6.04 42 (8.5)	46.44 ± 4.33 48 (6)	-4.679	0.001 **
	MAMO		49.49 ± 5.59 51 (7.5)	53.47 ± 3.81 54 (4)	-3.625	0.001 **
	Lateral	R	12.67 ± 2.02 13 (2)	12.73 ± 1.28 13 (1.5)	-0.650	0.516
		L	12.2 ± 2.10 12 (3)	12.84 ± 1.41 13 (2)	-1.660	0.097

*****$p < 0.05$; **$p < 0.01$ [1]: Mann–Whitney U Test (z); mean ± standard deviation for summary statistics ; Median (IQR) is given as value. SD: Standard deviation, TMD: Temporomandibular Joint Dysfunction, R; Right, L; Left, PMO: Painless mouth opening, MMO: Maximum Mouth Opening, MAMO: Maximum Assisted Mouth Opening* performed in the sitting position. The pivot point of the goniometer was set as the acromion. The fixed arm was parallel to the floor and the moving arm followed the midline of the ear.14 During the rotation movement measurement, the participants were seated and the physiotherapist stood behind the patient. The pivot point of the goniometer was placed at the center of the head, the fixed arm was kept parallel to the ground, and the moving arm followed the head movement. During lateral flexion movement, the patient was seated, the pivot point of the goniometer was placed at the spinal process of C7 and the fixed arm was parallel to the floor. The moving arm followed the spinal processes of the cervical vertebrae and it was ensured that there was no head rotation during the measurement (14).

Assessment of Mouth Opening

In the assessment of painless mouth opening (PMO), the patient was seated with the head in the neutral position and asked to open his/her mouth without straining until they felt pain and the distance between the upper and lower incisors was measured using a ruler. Care was taken to avoid any slippage in the jaw. In the maximum mouth opening (MMO), the patient was asked to open the mouth as wide as possible in the same position and the distance between the upper and lower incisors was measured. In the maximum assisted mouth opening (MAMO), the patient was asked to open the mouth as wide as possible in the same position and the lower jaw was supported to increase mouth opening (15). For the lateral mouth opening, the patient was seated and the mouth was slightly open and the upper and lower teeth were not in contact. The distance between the midpoint of the anterior incisors during right lateral and left lateral movements was measured (16).

Statistical Analysis

The SPPS 25 (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) statistical package program was used in the analysis of the data. Descriptive statistics were used as categorical and continuous variables. The normality assumption was checked using the Shapiro–Wilk test; the Student t test was used to examine differences between two groups when the conditions for parametric testing were met, and the Mann-Whitney U test was used when they were not. When the conditions for a parametric test were not met, the correlation between two continuous variables was assessed using the

Table 3. The relationship between pain intensity and pain pressure threshold in TMD group

			VAS			GCPS
			Rest	Activity	Night	
Pain pressure threshold	Masseter muscle	r	-0.235	-0.409	-0.296	-0.452
		p	0.121	0.005 **	0.048 *	0.002 **
	Temporalis muscle	r	-0.325	-0.289	-0.358	-0.508
		p	0.029 *	0.054	0.016 *	0.000 **
	Sternocleidomastoid muscle	r	-0.232	-0.482	-0.244	-0.313
		p	0.130	0.001 **	0.110	0.039 *
	Trapezius muscle	r	-0.433	-0.317	-0.273	-0.304
		p	0.003 **	0.034 *	0.069	0.042 *
	TMJ lateral	r	-0.191	-0.408	-0.366	-0.139
		p	0.208	0.005 **	0.013 *	0.363

*p < 0.05; **p < 0.01 [1]: Spearman Correlation Coefficient (r); TMD: Temporomandibular Joint Dysfunction, VAS: Visual Analog Scale, GCPS: Graded Chronic Pain Scale

Pearson and Spearman correlation coefficients. Statistical significance was set at $p < 0.05$.

RESULTS

The mean age were 29.11±7.90 and 28.93±6.07 years in the TMD and CG, respectively. There were no significant differences in the demographic characteristics between the groups (p>0.05) (Table 1)
In the TMD group, all PPT assessments and proprioception in right and left cervical rotation, and right lateral cervical flexion had higher mean compared to the CG (p<0.05). Proprioception in the cervical region flexion, extension, and left lateral flexion did not differ between the groups (p>0.05) (Table 2). In the TMD group, right-left rotation, and right-left lateral flexion ROM of the cervical region had lower compared to the CG (p<0.05). Flexion and extension ROM in the cervical region also did not differ between the groups (p>0.05). In PMO, MMO, MAMO measurements, the TMD group had lower mean values than the CG (p<0.05). Right-left lateral mouth opening did not differ between the groups (p>0.05) (Table 2).
VAS-rest was negatively correlated with PPT in the temporalis and trapezius muscles, while VAS-activity was negatively correlated with PPT in all regions except the temporalis muscle, and VAS-night was negatively correlated with PPT in all regions except the sternocleidomastoid and trapezius muscles (p<0.05) (Table 3).
In the TMD group, there was a positive correlation between only the cervical left rotation proprioception measurement and VAS-activity and night (p<0.05). In addition, a negative correlation was present between VAS-activity and MAMO and unassisted mouth opening (p<0.05) (Table 4).

DISCUSSION

In the present study, the TMD group had higher pain intensity and lower PPT values, had decreased proprioception during right-left rotation and right lateral flexion compared to CG. Cervical ROM (excluding flexion and extension ROM) and mouth opening (excluding right-left lateral) of the TMD group were limited compared to the CG. Mostly, the source of pain in temporal and the angle of the mandible is effected cervical and occipital region. Tenderness on trapezius, cervical, occipital (specially deep small muscles) and masseter muscles, neck pain and spasm in cervical region may limit the proprioceptive inputs during especially rotation movements and also limit the range of motion with increasing pain intensity.
In studies, TMD is more common in women than in men (17,18). Kuttila et al. suggested that higher levels of stress perception in women cause visible TMD symptoms, and therefore, the prevalence is higher in women (18). Eraslan et al. found that TMD is more common in women (19). In the present study, in agreement with the literature, 91% of the participants in the TMD group were female. Arıkan et al. reported that joint involvement was unilateral in patients with TMD, while Sahin et al. reported that bilateral joint involvement was more common (20,21). In the present study, 71% of the participants in the TMD group had bilateral joint involvement. We believe that can be attributed to the overloading of the painless side during speaking, chewing, and swallowing activities after the onset of unilateral pain, leading to bilateral dysfunction.
Pain intensity, multidimensional assessment of pain, and measurement of pain pressure threshold play an important role in comprehensive patient assessment. In study on the effect of trigger point therapy on pain and functionality in TMD, VAS score was found to be 5.48 ± 2.76 before treatment (21). Pihut et al. examined masseter muscle pain in TMD and found that the VAS was 4.86 ± 1.84 (22). In the present study, the scores of pain intensity were 6.11 ± 2.55, 6.20 ± 2.91, 5.91 ± 2.86, and 4.80 ± 1.841 (VAS-rest, VAS-activity, VAS-night, GCPS, respectively). In line with published literature, the participants also reported more intense pain during exercise. We believe that this is because activity puts more stress on the TMJ, which is subjected to strong forces when opening and closing.
Wanman et al. reported that the PPT was lower in both masticatory muscles and neck and shoulder muscles in individuals with TMD compared to healthy individuals (23). De Laat et al. found that the PPT was lower in the sternocleidomastoid and trapezius muscles in patients with TMD (24). Benli et al. found that TMD-induced pain and PPT were lower in the neck and masticatory muscles of patients with TMD compared to controls (25). In present study, we found that the PPT was lower and sensitivity to pain was higher in individuals with TMD than CG. This can be attributed to psychological factors, such as deterioration in the quality of daily life of individuals with TMD, increased stress factors, decreased belief that the pain will subside, and decreased pain tolerance of tissues and surrounding structures, due

Table 4. The relationship between pain intensity and cervical region proprioception sensation, cervical region range of motion and mouth opening in TMD group

				VAS			GCPS
				Rest	Activity	Night	
Cervical Proprioception Measurement	Flexion		r	0.244	0.024	0.031	0.151
			p	0.107	0.877	0.839	0.323
	Extension		r	0.245	0.169	0.132	0.214
			p	0.105	0.268	0.389	0.158
	Rotation	R	r	0.116	0.102	0.139	0.086
			p	0.446	0.507	0.363	0.574
		L	r	0.176	0.303	0.296	0.165
			p	0.246	0.043 *	0.049 *	0.279
	Lateral Flexion	R	r	0.076	0.056	0.063	-0.092
			p	0.618	0.714	0.682	0.549
		L	r	0.113	0.246	0.092	0.119
			p	0.460	0.104	0.550	0.435
Cervical region joint movements (°)	Flexion		r	-0.192	-0.143	-0.081	0.065
			p	0.207	0.350	0.595	0.673
	Extension		r	-0.009	0.077	0.030	-0.078
			p	0.955	0.615	0.847	0.611
	Rotation	R	r	0.132	0.094	-0.034	-0.083
			p	0.389	0.539	0.826	0.589
		L	r	0.000	-0.175	-0.218	-0.216
			p	0.998	0.251	0.150	0.153
	Lateral Flexion	R	r	0.095	0.096	0.099	0.136
			p	0.534	0.530	0.518	0.371
		L	r	0.125	0.055	-0.076	0.005
			p	0.413	0.720	0.622	0.975
Mouth opening (mm)	PMO		r	-0.147	-0.063	-0.089	-0.131
			p	0.336	0.683	0.561	0.391
	MMO		r	-0.014	-0.466	-0.212	-0.103
			p	0.926	0.001 **	0.161	0.501
	MAMO		r	0.008	-0.400	-0.246	-0.079
			p	0.958	0.007 **	0.103	0.606
	Right-Lateral		r	-0.126	-0.180	-0.128	-0.025
			p	0.408	0.236	0.402	0.871
	Left-Lateral		r	0.079	-0.289	0.099	0.128
			p	0.608	0.055	0.517	0.401

*p < 0.05; **p < 0.01 [1]: Spearman Correlation Coefficient (r); TMD: Temporomandibular Joint Dysfunction, R; Right, L; Left, VAS: Visual Analog Scale, GCPS: Graded Chronic Pain Scale PMO: Painless mouth opening, MMO: Maximum Mouth Opening, MAMO: Maximum Assisted Mouth Opening

to physiological factors, such as the chronicization of the pain-spasm-pain cycle, overuse, and faulty chewing patterns.

Cervical proprioception is defined as the awareness of the head or neck's location in space, explaining the interaction between efferent and afferent receptors to track position with movement. Bevilaqua-Grossi et al. found that cervical joint problems accompanied TMJ symptoms (26). Matheus et al. reported that patients with TMD had symptoms of cervical region problems, and stated that the cervical vertebrae are directly connected to the structures related to the head and mastication through muscles, fascia, joints, and neurovascular structures, therefore, changes seen in either region may affect the other region (27). Cervical spine problems may affect the cervical region as well as the cranium, TMJ, and shoulder (28). We hypothesized that cervical region dysfunction can directly affect proprioception due to the aforementioned structural relationships, and TMD can indirectly affect proprioception in the long term through the relationships between the TMJ and cervical structures. Receptors in the cervical spine are connected to various regions of the central nervous system and vestibular and visual inputs. Cervical dysfunction differentiates afferent input and may subsequently alter sensorimotor control. Measurable changes in cervical joint proprioception, postural stability, and reports of imbalance in patients with neck conditions can be associated with changes in sensorimotor control. Abnormal cervical somatosensory input and sensorimotor control should be evaluated in patients with cervical pain. Trauma, functional impairment of receptors, changes in muscle spindle sensitivity, and the broad impacts of pain at many levels of the nervous system can all modify afferent information from cervical receptors. Based on the evidence to date, recommendations for the clinical assessment and management of such sensorimotor control deficits in difficulties involving the cervical region are offered (29). Some studies that have evaluated the proprioception in the cervical area in patients with neck pain have been published, but there are none that do so for patients with TMD (30,31). Ozgoren et al. evaluated proprioception in patients with chronic neck pain and found significant results in favor of the healthy group in all directions except left lateral flexion (32). Treleaven et al. found that participants with chronic neck pain had higher joint position error values than healthy individuals (33). In a study with 64 female participants with chronic neck pain, Jull et al. reported that cervical joint proprioception was low in patients with neck pain (34). De Vries et al. examined cervical proprioception in people with neck pain using the SEPT test and reported that proprioception in those with neck pain was worse than in healthy individuals (35). Civelek et al. stated that cervical proprioception and head-eye coordination disorder due to receptor dysfunction in patients with cervical region problems should be evaluated after the patients exercise and that increasing sensorimotor input is beneficial for these patients; other recent studies also support these results (36). If we consider TMD problems to be a part of cervical problems, the results of the present study are similar to those of previous studies. Lendraitiene et al. and De Laat et al. found that cervical joint ROM was lower in patients with TMD compared to healthy individuals (29, 24). In the present study, except for the flexion and extension ROM measurements in the cervical region, the TMD group had less ROM than healthy controls. Because of unilateral mastication and occlusion problems in individuals with TMD, the masticatory and as well cervical muscles and joint structures are overloaded, and joint movement limitation may develop accordingly. In addition, muscular connection between the head, neck and jaw, forward head posture, and changes in the activity of masticatory muscles also influence the vertical and horizontal position of the mandible and vice versa. However, the present study found no limitation of sagittal plane movement (flexion-extension), despite other cervical movement loss. This may be due to individual disease related differences such as duration of dysfunction, unilateral or bilateral involvement, painful areas.There is a need for studies that will evaluate jaw, head, neck posture and joint range of motion in detail by increasing the number of samples.

Studies have shown that TMD-related pain, psychological problems, and limitation of jaw movements may negatively affect the patients' QoL. Patients have difficulty in performing basic tasks, such as speaking and chewing, especially due to the limitation of mandibular movements (37). Armijo-Olivo et al. reported that cervical joint restriction affects the limitation of jaw joint movement in patients with TMD (38). Shiozaki et al. reported that the ROM in the cervical region and mouth was lower in individuals with TMD compared to healthy individuals (39). La Touche et al. examined the effect of cervical posture on mouth opening and pain pressure threshold in TMD (40). It concluded that worsen cervical posture reduces the mouth opening of the TMJ and surrounding muscles. In the present study as well, mouth opening measurements were evaluated in the study groups and similar results were obtained.

To the best of our knowledge, this study is the first to evaluate proprioception during cervical movements in individuals with TMD. One of the limitations was we did not the subclassifications (arthrogenic, myogenic, mixed) according to the DC/TMD classification because of clinical conditions did not allow it. In addition, postural evaluations of the head, neck, and spine could have increased the quality of the present study, especially considering that it may affect the participants' perception of body schema. And also, disease related or jaw-specific questionnaires for assessment of pain or functionality could be beneficial.

CONCLUSION

In summary, this case-control study compared functional and sensory variables of the cervical region between healthy participants and patients with TMD. TMD patients presented a lower PPT, less accurate head repositioning, and some impairment in cervical range of motion. These findings emphasize the importance of considering functional and sensory variables of the neck when evaluating and treating patients with TMD.

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