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Change of Balance Ability in Subjects with Pain-Related Temporomandibular Disorders

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Purpose: Temporomandibular disorder (TMD) is a condition defined as pain and dysfunction of temporomandibular joints and masticatory muscles. Abnormal interconnections between temporomandibular muscles and cervical spine structures can cause the changes of postural alignment and balance ability. The aim of this study was to investigate changes in static balance ability in subjects with pain-related TMD.

Methods: This study conducted on 25 subjects with TMD and 25 control subjects with no TMD. Pressure pain thresholds (PPTs) of the masseter and temporalis muscles were measured using a pressure algometer. Static balance ability was assessed during one leg standing using an Inertial Measurement Unit (IMU) sensor. During balance task, the IMU sensors measured motion and transfer movement data for center of mass (COM) motion, ankle sway and hip sway.

Results: PPTs of masseter and temporalis muscles were significantly lower in the TMD group than in the control group ($p < 0.05$). One leg standing, hip sway, and COM sway results were significantly greater in the TMD group ($p < 0.05$), but ankle sways were not different between group.

Conclusion: We suggest pain-related TMD is positively related to reduced PPTs of masticatory muscles and to static balance ability. These results should be considered together with global body posture when evaluating or treating pain-related TMD.

Keywords: Temporomandibular disorder, Pressure pain threshold, Balance, Range of motion, Pelvic

INTRODUCTION

Temporomandibular disorder (TMD) is a generic term that includes a number of clinical problems such as pain or dysfunction of masticatory muscles, temporo-mandibular joint (TMJ), and related structures.[1,2] The prevalence of TMD has been extensively investigated in adult population and 5 to 12% have pain-related TMD; a common musculoskeletal state that causes pain and disability.[3] Musculoskeletal pain is often associated with trigger points, and this musculoskeletal inconvenience is considered to indicate muscle and fascia tension and painful disturbance, which can be referred to as local or referred pain with sensitivity and pressure upon palpation.[4,5] The cause of TMD is multifactorial[6] and its symptoms include TMJ and masticatory muscle pain. Furthermore, various etiological factors include functional, structural, and postural aspects.[7]

Abnormal interconnections between masticatory muscles and cervical spine structures can cause pain in the head and orofacial region,[8-10] and it has been well established that increased pain sensitivity of the cervical spine in patients with TMD may be related to reduced pain thresholds in masticatory muscles.[11,12] In addition, cervical spine movements might influence masticatory muscle pain sensitivity.[13,14] The correlation between masticatory system and the cervical system has been recorded, and these biomechanical interactions are closely associated with functional dependence.[15-17] Moreover, cervical spine ROM appears to be limited in TMD and changes in neck position might influence masticatory muscle sensitivities,[18-22] and changes in global body posture can cause severe pain in TMJ or in the spinal area and dysfunctions associated with the cervical spine, TMJ, and masticatory system.

Changes in postural alignment are commonly found in individuals with TMD and may cause pain due to lengthening or shortening of adjacent muscles.[23-25] TMD restricts masticatory and cervical movements and causes

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pain in the neighboring musculature leading to referred pain and postural changes associated with neck and cervical muscles.[26,27] Several previous studies have shown that neck pain is not limited to cervical areas but also affects postural control and stability.[28,29] As the effects of neck pain diminish ability to recruit the muscular proprioceptive system, it has been reported to be associated with slow postural balance and postural responses.[30,31]

The posture control system must be constantly activated to compensate for an unstable upright posture.[31] Posture control systems are generally assessed by quantifying posture (or body) sway during static balance. Center of mass (COM) trajectory, as determined using force plate data, is commonly used to measure postural sway in static balance.[32,33] One leg standing balance is a high-level balance function that requires complex actions of the musculoskeletal system and the sensory system related to balance control. Therefore, the balance evaluation in standing on one leg is a static balance evaluation method that can evaluate the motor system and the nervous system in a complex way. Consequently, the purpose of this study was to compare pressure pain thresholds (PPTs) of masticatory muscles and standing balance of subjects with or without TMD.

METHODS

1. Subjects

Twenty-five subjects with TMD (13 males and 12 females, mean 22.84 years) and 25 age-and sex-matched, healthy control subjects (10 males and 15 females, mean 21.72 years) with no history of TMD were recruited for this study. The 25 subjects with TMD were recruited from among 130 subjects that participated in TMD-Pain Screener questionnaire according to the following qualification criteria: 1) age between 20 and 30 years, 2) diagnosis of TMD based on TMD-pain Screener results of >3 points for the full six-item version and of >2 points for the three-item version. The 25 control subjects were recruited according to the following qualification criteria: 1) age between 20 and 30 years, 2) pain screener results of 0 point for the full six-item version (Figure 1).

Exclusion criteria for all subjects were: 1) a balance or vestibular function abnormality, 2) the receipt of orthopedic surgery within the previous 6 months, 3) a history of congenital orthopedic transformation, 4) a pregnant status, 5) the presence of an autoimmune disease (e.g., fibromyalgia, rheumatism, or a neurological problem), 6) treatment for TMJ during the previously 6 months (e.g., occlusal stabilization splint, medication or injection therapy).

The clinical and demographic characteristics of the subjects are detailed in Table 1. All subjects provided written informed consent agreement, and the study was approved by the Institutional Review Board of the Dankook University (DKU-2019-10-015).

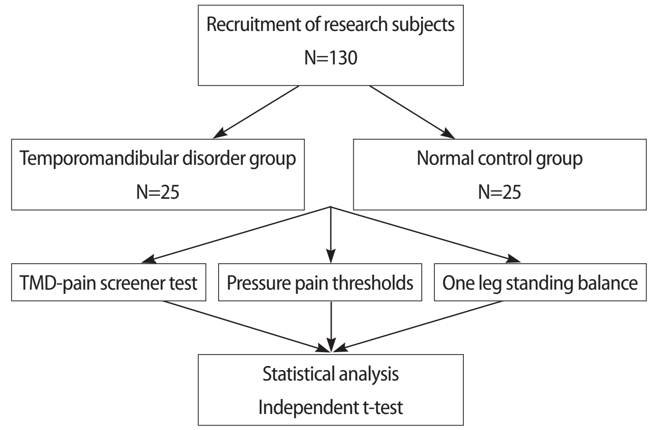

Figure 1. Diagram of research.

Table 1. Demographic data of the TMD group and control group

	TMD group (n=25)	Control group (n=25)
Age (yr)	22.8±2.0	21.7±1.4
Gender (M/F)	13/12	10/15
Height (cm)	169.0±7.5	166.3±8.8
Weight (kg)	63.7±12.3	61.6±13.5

Values represent mean±standard deviation. TMD: Temporomandibular disorder.

2. Measurements

1) TMD–pain Screener

The TMD-Pain Screener is used to diagnose pain-related TMD with a sensitivity and a specificity of ≥0.95.[34] The questionnaire addresses the existence of pain in the jaw or temple regions, jaw pain or stiffness at time of awakening, and changes in pain in the jaw or temple regions during jaw activities. The TMD-Pain Screener is available as six- and three-item versions; the former is suitable for evaluating individuals in clinical circumstances, whereas the latter is appropriate for evaluations in research settings. Each of 0 to 2 points is awarded to each item response.[35]

2) PPT Measurements

PPTs were measured using a pressure pain algometer (Hand-held dynamometer, Lafayette Instrument Company, Indiana, USA) at both sides of the masseter (body) and temporalis (anterior belly), which were taken to be representative of masticatory muscles.[8,17] In order to determine PPT values, a researcher consecutively tested masseter and temporalis anterior muscles. Subjects were informed to press a handheld button when they

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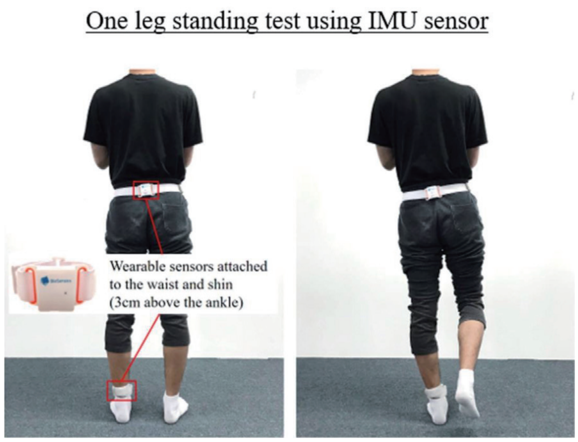

Figure 2. Marker models for the Inertia Measurement Unit sensor (IMU) for the one leg standing test.

experienced pain; a researcher then immediately removed the pressure. PPTs were defined to be the amount of pressure that a subject found painful,[36] and for each test, the PPT values continued to be displayed after removing the pressure. PPT values were acquired every 5-10s for each muscle and values were randomly evaluated twice, with a 5-minute rest time between two tests. Final PPT values were defined as the mean of two trials on left and right sides of both masseter and anterior temporal muscles.[37]

3) Balance ability

Balance ability during one leg standing was measured using the BalanSens system (BioSensics, Cambridge, Massachusetts, USA). Two wearable sensors were attached to the waist and shin (3 cm above the ankle) with elastic Velcro straps (Figure 2). When a subject performs a balance task, sensors measure motion and transfer movement data in real time (sample frequency 100 Hz) to provide; center of mass (COM) motion (unit: cm^2), ankle sway and hip sway (unit: deg^2). Functional changes in balance associated with upper body rotation around hips and lower body rotation around ankles to calculate COM is accomplished by entering the subject's data of weight and height (unit: cm^2/height). Each subject was initially asked to look at a point on a wall with arms folded across on chest during double-stance standing before the one leg standing test. The one leg standing test was performed for 15s with eyes open without talking. During the test, the subject stood with feet close together, but not touching. Testing was performed three times on right and left legs with a 5-minute rest time between two tests.

3. Statistical analysis

Statistical analysis was performed using SPSS version 21.0 (SPSS Inc., Chicago, Illinois, USA). Descriptive data are presented as means and standard deviations (SDs), and Shapiro-Wilk test is used for testing normality of results. Results of PPT and balance ability showed that both group had normally distributed data. Independent t-test was used to compare the difference of PPT, ankle way, hip sway and COM sway between TMD group and control group. Statistical significance was accepted for p values < 0.05.

Table 2. Comparison of PPTs, cervical ROM, balance ability, and pelvic mobility in gait between the TMD group and the control group

	TMD group	Control group	p-value
PPT			
Masseter (kg)	10.81±2.52	13.53±2.57	<0.001*
Temporalis anterior (kg)	15.45±2.93	18.63±3.48	0.001*
One leg standing			
Ankle Sway (deg^2)	8.66±3.65	6.88±3.75	0.095
Hip Sway (deg^2)	16.88±13.77	9.02±5.70	0.013*
COM Sway (cm^2)	1.67±0.98	0.87±0.42	0.001*

Values represent mean±standard deviation. TMD: Temporomandibular disorder, PPT: Pressure pain threshold, COM: Center of Mass. *$p<0.05$.

RESULTS

Table 2 summarizes the result of statistical analysis between TMD group and control group. Mean PPTs in the TMD group was 10.81±2.52 kg for masseter muscles and 15.45±2.93 kg for temporalis anterior muscles. In contrast, the control group had mean PPTs of 13.53±2.57 kg for masseter muscles and 18.63±3.48 kg for temporalis anterior muscles. Mean PPT values of masseter and temporalis anterior muscles were significantly lower in the TMD group ($p<0.05$).

In the results of one leg standing, mean ankle, hip, and COM sway in the TMD group were 8.66±3.65 deg^2, 16.88±13.77 deg^2, 1.67±0.98 cm^2, respectively, and in the control group respective values were 6.88±3.75 deg^2, 9.02±5.70 deg^2, 0.87±0.42 cm^2. Sway of hips and COM were significantly greater in the TMD group ($p<0.05$), but ankle sway was similar in the TMD group ($p<0.05$).

DISCUSSION

The purpose of the present study was to investigate differences between subjects with or without TMD in terms of PPTs of masticatory muscles and levels of static balance. We found that significant intergroup differences for PPTs and balance ability; 1) the TMD group had a significantly lower PPTs for masseter and temporalis anterior muscles; 2) significantly greater hip sway and COM sway during one leg standing. In contrast, ankle sway during one leg standing did not showed significant difference between group. In terms of body posture, previous studies have described structural imbalances in spinal alignment in TMD patients.[23,24,38] Previous study reported on the relationship between global body posture and TMJ internal derangement,[38] and suggested that 66.7% of subjects with TMJ internal derangement showed forward shoulder and forward head posture, whereas only 25% of controls did so.[38] Consequently, TMD is thought to induce a change in the posture of the neck due to severe TMJ pain and an altered postural position.[39] In addition, it is known that changes in the alignment of the trunk and spine affect the static or dynamic balance function of the body.[40,41]

Static balance is defined as the ability to maintain the COG (center of gravity) within the support base.[42] Of the various balance tests, the one leg standing test provide a means for screening higher postural stability when static and is commonly used to assess fall risk in older adults or in those with a neurologic pathology.[43] In the present study, the TMD group showed significantly greater COM and hip sway during the one leg standing test. This result suggests that in the temporomandibular region would present an attendant postural disequilibrium because of the alterations of the entire body muscular chain. Several previous studies have reported the effects of TMD on balance ability.[35,44,45] In 2012, Arruda et al.[46] investigated the immediate effects of mandibular mobilization on balance ability in people with TMD. After mandibular mobilization, anteroposterior sway velocity of center of pressures (COPs) was significantly reduced in the static standing position with both eyes open and closed.[46] In 2017 Nota et al.[47] investigated difference in postural stability according to the presence of TMD and mandibular conditions. Subjects with TMD had significantly greater COP velocity (mm/s) and sway area (mmq) during quiet stance with eyes open than controls.[47] In another study, the presence and severity of TMD in older adults was found not to alter balance-related variables, including velocity and frequency of anteroposterior COP sway and mediolateral COP sway during one leg standing.[44] These differences may be due to subject ages or the inclusion criteria or balance measurement methods used. However, in this study, ankle sway during one leg standing did not differ between TMD group and control group. These results are thought to be due to balance maintenance using the ankle strategy mainly when controlling balance in young adults. Consequently, we suggest more detailed assessments of balance ability should be conducted in homogeneous TMD groups.

In conclusion, we found that pain-related TMD was associated with lower pressure pain threshold of masticatory muscles and greater hip and COM sway. These results support the hypothesis that there are close anatomical and functional relationships between TMD and balance. We believe that the main factor of this functional relationship is the pathogenic effect of TMD on the balance, which suggests that more comprehensive body posture assessments, especially of painful areas, should be undertaken when studying TMD patients. However, the present study has a number of limitations that warrant consideration. First, because of the small number of subjects, we are not able to generalize our experimental results. wereSecond, no consensus has been reached regarding the clinical diagnosis of TMD. The questionnaire used only describes the presence of TMD which not be seen as a segmentalized TMD diagnosis, and as a result, subjects were not diagnosed with TMD. In order to further explain the association to body muscular chain of TMD patients, large-scale, randomized controlled trials are required that includes an investigation of the effectiveness of interventions in TMD patients.

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