Associations Among Different Types of Quantitative Pain Measures in TMD Patients

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The aims of this study were to investigate the relationships among several types of thermal pain thresholds, and pressure pain thresholds. This study was designed to examine whether there were associations among different types of pain thresholds, and among different recording sites for each pain threshold measurement. Pain sensitivity thresholds including cold pain threshold (CPT), heat pain threshold (HPT), heat pain tolerance threshold (PTT), and pressure pain threshold (PPT) of 56 subjects with symptoms of temporomandibular disorders were measured on temporal muscle, masseter muscle, TMJ, and tibial areas. Thermal pain thresholds including CPT, HPT, and PTT did not show any gender differences. However, women showed significantly lower PPTs than men on all recording sites. Three thermal pain thresholds including CPT, HPT, and PTT showed weak to high correlations on all the recording sites ($r= 0.324$ to 0.754, $p<0.05$). PPTs did not show any significant correlations between each thermal pain threshold. The pain threshold of each recording site showed weak to high correlations in all pain threshold measures ($r= 0.284$ to 0.878, $p<0.05$). Our study demonstrated that thermal pain thresholds, and pain tolerance thresholds were significantly correlated, but did not show any correlation between thermal pain thresholds and pressure pain thresholds. There were relatively high correlations among the pain thresholds of different recording sites.

Key words: Quantitative sensory testing, Thermal pain, Pressure pain thresholds, Gender difference

I. INTRODUCTION

The measurements of pain perceptions are necessary in the clinical neuroscience and the study of pain mechanism. The pain perception is not easily measured by single perceptual or physiological modalities because complex and highly integrative mechanisms mediate the perception of pain sensation. Many types of quantitative psychophysical measurements have been developed to measure pain sensitivity in patients showing orofacial pain symptoms. However, there is little consensus on whether findings from quantitative sensory testing (QST), or psychophysical studies of pain are relevant to the clinical experience of pain.[1)] Truly, pain induced by laboratory-administered noxious stimuli can differ substantially from naturally occurring pain. However, studies demonstrating alterations in pain perception among many clinical populations have highlighted the potential value of experimental pain assessment, or QST in understanding chronic pain.[2-5)]

QST depends on the co-operation of the patient

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since it is a psychophysical test and has certain limitations especially in malingering subjects. Nevertheless, this test has been found reliable and useful within orofacial area. It enables the verification and quantification of sensory dysfunction even when the results of nerve conduction studies are normal.[6] Among several sensory measurement modalities, thermal QSTs assess the function of small myelinated A and unmyelinated C fibers. Thermal sensory measurements have been proposed useful clinical method that is able to measure the positive sensory symptoms often encountered in chronic pain patients.

QST can be used to assess group differences within healthy populations and also evaluate differences in pain perception between certain clinical populations and healthy controls. Such research has important implications regarding the pathophysiology of pain disorders and may ultimately be used to generate a system of mechanism based diagnosis, which would affect treatment decisions. Potentially more important findings than cross sectional associations are that QST can predict future risk for developing and maintaining pain.[1]

In the orofacial area, measuring the pressure pain threshold (PPT) has been proposed as an objective method used to quantify changes in muscular pain threshold in TMD patients. As a tool of measurement, the pressure algometer has been reported to be sensitive and reliable in many studies for evaluation of masticatory muscle tenderness and for measuring the PPT in the orofacial region.[7]

The aims of this study were to investigate the relationships among several types of thermal pain thresholds, and pressure pain thresholds commonly used in orofacial pain research. This study was designed to examine whether there were associations among different types of pain thresholds, and among different recording sites for a pain threshold measure.

Ⅱ. MATERIALS AND METHODS

1. Subjects

Fifty-six subjects were recruited among the patients who visited at the Department of Oral Medicine, Seoul National University Dental Hospital complaining of symptoms of temporomandibular disorders. The subjects consist of age-matched 41 women (31.3±12.8 years) and 15 men (30.7±15.3 years). The study was approved by an Institutional Review Board and informed consent was obtained from each subject.

2. Thermal pain thresholds

The Thermosensory Analyzer II (Medoc, Israel) was used for all thermal threshold measurements. To help the patient adjust to the test procedures we had a practice session by attaching the thermode to the forearm of the patient and running the test 1-2 times. The tip of the thermal stimulator consists of a 16x16 cm^2 contact surface which can be heated or cooled to temperatures between 0℃ and 50℃ at a rate of 1℃/sec. Low rates of temperature change (0.5℃/sec-1℃/sec) minimize reaction time artifact and has been proposed to stimulate cutaneous C-fibers.[8,9]

To determine the cold pain threshold (CPT) of the patient, the thermal stimulator was placed on the temporal muscle, masseter muscle, TMJ, and tibial areas of the pain side. Temperature was lowered from a baseline of 32℃ to 0℃ at a rate of 1℃/sec, until the patient perceived the temperature as painful and pressed a button on a computer mouse. This was repeated four times and the average value was determined as the cold pain threshold of the patient.

To determine C-fiber mediated heat pain threshold (HPT), the thermal stimulator was once again placed on the same sites as for the cold pain threshold. Once the temperature increase was started from a baseline of 32℃, the temperature was increased to 50℃ at a rate of 1℃/sec. Subjects were instructed to press the button when the heat started to feel painful. This was repeated four times and the average value was determined as the heat pain threshold of the patient. Next, the heat pain tolerance threshold (PTT) was determined by the same method. But this time the patient was instructed to press the button when the temperature was no longer tolerable. For safety reasons the upper limit of temperature change was set at 50℃ and lower limit was 0℃.[10)]

3. Pressure pain threshold

A pressure algometer (Somedic, Sweden) was used to test the sensitivity to pressure of the sites that were subjected to the thermal threshold test. The patient was instructed to push a button when the pressure pain threshold (PPT) was reached. The PPT was determined in triplicate with a constant application rate of 30 kPa/sec and a probe diameter of 1 cm. The mean value was used as the pressure pain threshold.[11)]

4. Statistical analyses

Student t-test was used to investigate the gender differences in each pain sensitivity threshold. Pearson's correlation analyses were performed to investigate relationships among different types of pain thresholds, and among different recording sites for a pain threshold measure.

Ⅲ. RESULTS

1. Gender differences in pain thresholds

The means and standard deviations of each pain threshold on the different recording sites are shown in Table 1.

Thermal pain thresholds including cold pain

Table 1. Descriptive values of pain thresholds in each recording site and comparison between women and men

Threshold	Location	Total	Women	Men	*p-value*
CPT	Temporal	15.2 ± 10.4	16.0 ± 10.6	12.9 ± 10.0	0.330
	Masseter	17.4 ± 9.3	17.6 ± 9.6	16.9 ± 8.7	0.815
	TMJ	17.7 ± 9.5	18.5 ± 9.3	15.6 ± 10.0	0.316
	Tibial	12.0 ± 9.9	13.5 ± 9.8	8.0 ± 9.2	0.066
HPT	Temporal	44.9 ± 4.0	44.6 ± 4.0	45.9 ± 4.0	0.286
	Masseter	43.9 ± 3.7	43.6 ± 3.8	44.7 ± 3.5	0.317
	TMJ	43.9 ± 4.3	43.5 ± 4.2	44.9 ± 4.5	0.269
	Tibial	45.8 ± 3.9	45.4 ± 4.2	46.9 ± 3.0	0.221
PTT	Temporal	48.1 ± 2.7	47.9 ± 2.8	48.5 ± 2.5	0.473
	Masseter	47.7 ± 2.2	47.5 ± 2.4	48.2 ± 1.6	0.341
	TMJ	47.3 ± 2.9	47.0 ± 3.1	48.2 ± 1.6	0.195
	Tibial	48.2 ± 2.4	47.8 ± 2.6	49.1 ± 1.3	0.015
PPT	Temporal	322.9 ± 162.0	291.8 ± 133.8	408.0 ± 203.5	0.054
	Masseter	231.0 ± 121.8	211.7 ± 107.5	283.5 ± 145.6	0.050
	TMJ	284.7 ± 137.7	260.8 ± 117.0	350.2 ± 170.8	0.030
	Tibial	544.5 ± 294.3	473.3 ± 258.3	739.1 ± 307.1	0.002

* p-values were obtained by t-test

Table 2. Correlations among different types of pain thresholds by each recording site.

Location	Threshold	CPT	HPT	PTT
Temporal	HPT	-0.528^{**}		
	PTT	-0.519^{**}	0.754^{**}	
	PPT	−0.149	−0.012	−0.061
Masseter	HPT	-0.505^{**}		
	PTT	-0.370^{**}	0.719^{**}	
	PPT	−0.028	0.170	0.139
TMJ	HPT	-0.704^{**}		
	PTT	-0.549^{**}	0.725^{**}	
	PPT	−0.058	0.089	−0.070
Tibial	HPT	−0.226		
	PTT	-0.324^{*}	0.506^{**}	
	PPT	−0.170	−0.075	0.216

*: significant at 0.05 level, **: significant at 0.01 level

threshold (CPT), heat pain threshold (HPT), and heat pain tolerance threshold (PTT) did not show any gender differences. However, women subjects showed significant lower pressure pain thresholds (PPTs) than men subjects on the all recording sites. (Table 1)

5. Correlations among different types of pain thresholds

Correlations among the various thermal pain thresholds and pressure pain thresholds by each recording site are shown in Table 2. Three thermal pain thresholds including CPT, HPT, and PTT showed weak to high correlations on temporal muscle, masseter muscle, and TMJ area (r= 0.370 to 0.754, p<0.05). These thermal pain thresholds showed weak to moderate correlations on tibial area (r= 0.324 to 0.506, p<0.05). PPTs did not show any significant correlations between each thermal pain threshold. (Table 2)

6. Correlations among different recording sites for each pain threshold measure

Correlations among four recording sites by each pain threshold are shown in Table 3. The pain thresholds of three recording sites in the orofacial region including temporal muscle, master muscle, and TMJ area showed significant moderate to high correlations in all pain threshold measures (r= 0.530 to 0.878, p<0.05). The pain thresholds of tibial area showed weak to high correlations with the pain thresholds of three orofacial recording sites in all pain threshold measures (r= 0.284 to 0.780, p<0.05). (Table 3)

Ⅳ. DISCUSSION

Our study showed relatively strong correlations among thermal pain thresholds and pain tolerance threshold, but did not show any significant correlations between pressure pain threshold and each thermal pain threshold. We expected the cold pain threshold and heat pain threshold to be

Table 3. Correlations among different recording sites for each pain threshold measure.

Threshold	Location	Temporal	Masseter	TMJ
CPT	Masseter	0.710**		
	TMJ	0.680**	0.852**	
	Tibial	0.702**	0.584**	0.631**
HPT	Masseter	0.516**		
	TMJ	0.530**	0.738**	
	Tibial	0.284*	0.277*	0.287*
PTT	Masseter	0.718**		
	TMJ	0.652**	0.878**	
	Tibial	0.482**	0.748**	0.706**
PPT	Masseter	0.873**		
	TMJ	0.838**	0.856**	
	Tibial	0.780**	0.656**	0.652**

*: significant at 0.05 level, **: significant at 0.01 level

strongly related because they could be activated by the same receptors and utilize same pathways for pain transmission. Furthermore, we found high correlations (r= 0.719 to 0.754) between heat pain thresholds and pain tolerance values especially in three recording sites of the orofacial region. Our results are consistent to the study of Bhalang et al.[12] but in contrast to the other previous studies.[13,14] Pain tolerance thresholds has been considered to be more influenced by physiologic, and psychological factors and showed individual differences.[15] Therefore, these two pain measurement should not be considered as extremes of a identical pain scale. However, our findings suggest that pain thresholds and tolerance for heat pain are transmitted and modulated in part.

In contrast to the previous study of Bhalang et al.,[12] we did not find any relationships between heat pain thresholds and pressure pain thresholds. Heat pain and pressure pain could be transmitted by same receptor, however pressure pain is a diffuse, deep, and dull aching originating from both superficial and deep muscles, but heat pain is a well-localized and more superficial sensation. The pressure pain of muscle structure could be related with more convergence effects and mixed modulation with cutaneous and deep muscle neural transmission than heat pain. Our study showed significant lower PPTs in women than men but did show any gender differences in heat pain thresholds. We interpreted that the gender effect on pain modulation could affect more on the deep and mixed pain input such as muscular pressure pain.

Our study also showed relative high correlations between each recording site in all pain measures. These results suggest that pain perception could be involved by both peripheral and central pathways. Interesting results were that the correlations between each recording site were relatively higher in pain tolerance thresholds than the others. The pain perception could be influenced by central neurons rather than peripheral receptors during persistent noxious thermal stimulation.[16] The neural mechanisms of persistent pain states have been reported to be similar pathways of C-fiber temporal summation.[17] As heat stimuli progresses, temporal summation of C-fiber could be activated and the increase in pain perception could be mediated by central mechanism rather than peripheral factors.[18)]

For effective and reliable use of quantitative sensory measures in the orofacial pain research, a standardized comprehensive QST battery should be developed considering different natures of various orofacial pain diseases and individual responsiveness to the pain perception. After this development, we can use the QST measures more effectively for diagnosis of orofacial pain diseases in the clinic.

In sum, our study demonstrated that thermal pain thresholds and pain tolerance thresholds were significantly correlated, but did not show any correlations between thermal pain thresholds and pressure pain thresholds. There were relatively high correlations among the pain thresholds of different recording sites. However, weak to moderate correlations in some pain measures implies the need of careful and various measurements for the study of pain. The researcher should consider the difference in an individual's sensitivity to pain by using various modalities of sensory measurements.

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국문요약

측두하악장애환자에서 다양한 종류의 정량적 통각검사들의 연관성에 관한 연구

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다양한 종류의 정량적 통각검사들의 연관성을 알아보기 위하여 56 명의 측두하악장애 환자를 대상으로 측두근, 교근, 측두하악관절 부위, 그리고 경골근의 냉통각역치 (Cold Pain Threshold, CPT), 열통각역치 (Heat Pain Threshold, HPT), 열통증인내역치 (Heat Pain Tolerance Threshold, PTT), 압력통각역치 (Pressure Pain Threshold, PPT)를 측정하였으며, 각기 다른 통각 역치 간의 상관관계와 측정 부위 별 통각 역치 간의 상관 관계를 분석하였다. CPT, HPT, PTT를 포함한 온도통각역치의 성별간 차이는 나타나지 않았다. 그러나 PPT는 여성이 남성에 비하여 모든 부위에서 유의하게 낮은 역치를 나타내었다. CPT, HPT, PTT를 포함한 세 가지의 온도통각역치들은 모든 측정 부위에서 약정도에서 강정도 (mild to high)의 상관관계를 나타내었다 ($r= 0.324-0.754$, $p<0.05$). PPT 값은 각각의 온도통각역치와 통계적으로 유의한 상관관계를 나타내지 않았다. 모든 측정 부위의 통각역치값들은 서로간에 약정도에서 강정도 (mild to high)의 상관관계를 나타내었다 ($r= 0.284-0.878$, $p<0.05$). 측두하악장애 환자의 온도통각역치와 열통각인내역치 사이에는 유의한 상관관계가 존재하나 온도통각역치와 압력통각역치 간에는 상관관계가 나타나지 않는 것이 관찰되었으며, 각기 다른 부위에서 측정된 통각역치 간에는 비교적 높은 상관관계가 나타났다.

주제어: 정량적감각측정검사, 온도통각역치, 압력통각역치, 성별 차이