

Orofacial Thermal Quantitative Sensory Testing (QST): A Study of Healthy Korean Women and Sex Difference

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Purpose: Thermal sensory test as an essential part of quantitative sensory testing (QST) has been recognized as a useful tool in the evaluation of the trigeminal nerve function. Normative data in the orofacial region have been reported but the data on differences in the test site, sex and ethnicity are still insufficient. Thus, this study aimed to investigate the normal range of orofacial thermal QST data in the healthy Korean women, and assess sex difference of thermal perception in the orofacial regions.

Methods: Thermal QST was conducted on 20 healthy women participants (mean age, 26.4 years; range, 21 to 34 years). The thermal thresholds (cold detection threshold, CDT; warm detection threshold, WDT; cold pain threshold, CPT; and heat pain threshold, HPT) were measured bilaterally at the 5 trigeminal sites (the forehead, cheek, mentum, lower lip and tongue tip). The normative thermal thresholds of women in the orofacial region were evaluated using one-way ANOVA and compared with the previously reported data from age- and site-matched 30 healthy men (mean age, 26.1 years; range, 23 to 32 years) using two-way ANOVA. One experienced operator performed the tests of both sexes and all tests were done in the same condition except the time variability.

Results: Women showed significant site differences for the CDT ($p < 0.001$), WDT ($p < 0.001$), and HPT ($p = 0.047$) in the orofacial region. The CDT ($p < 0.001$) and the CPT ($p = 0.007$) presented significant sex difference unlike the WDT and the HPT.

Conclusions: The thermal sensory evaluation in the orofacial region should be considered in the context of site and sex and the normative data in this study could be useful for assessment of the sensory abnormalities in the clinical setting.

Key Words: Orofacial; Quantitative sensory testing; Sex; Site; Thermal threshold

INTRODUCTION

The trigeminal nerve damage may cause the sensory abnormality including unpleasantness and pain as well as sensory deficit in the orofacial region.¹⁾ Therefore, the issue how to assess these sensory changes has been of importance for patients and dentists. However, evaluating sensory nerve damage is a challenging and difficult process, because there are few validated methods that provide clinically relevant information with neurologic functional status

or neuropathic pain.²⁾

At the present time, quantitative sensory testing (QST) as a psychophysical method³⁾ has cut an appearance as a valuable diagnostic tool for sensory nerve function. The German Research Network on Neuropathic Pain (DFNS) implemented a standardized QST protocol which measures 13 parameters⁴⁾ and a comprehensive protocol for clinical usages were suggested.⁵⁾ In particular, thermal sensory testing as an essential part of QST presented acceptable inter- and intra-examiner reliabilities in the orofacial region.^{6,7)}

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There are several factors which may influence thermal perception, including site, sex, stimulation area size, time variability and baseline temperature.⁸⁻¹²⁾ For more accurate and valid evaluation of sensory abnormality in the orofacial region, thermal sensory profile of the trigeminal region using QST should be established in the healthy populations and furthermore influential factors such as site and sex should be considered.

Recent studies established QST profiles in the trigeminal region and reported site and sex differences in the healthy humans.^{8,13)} However, thermal sensory profiles in the orofacial area are still insufficient and more QST procedures according to various test sites and sex deserve to be performed in diverse ethnic background.

In the previous study for healthy Korean men which was examined from September to December 2011,¹²⁾ normal values were established and substantial site differences in the 5 trigeminal sites were observed. Thus, this study aimed to collect the normative site-specific data for thermal thresholds of healthy Korean women and compare the orofacial thermal sensitivity between women and men using the previously published men's data.

MATERIALS AND METHODS

1. Participants

This study included the 20 healthy women volunteers (mean age, 26.4 years; range, 21 to 34 years) who were recruited from students of the Dankook University Dental Hospital (Cheonan, Korea) and measurements of orofacial thermal thresholds were performed from April to May 2013. All volunteers were healthy subjects without any pain and somatosensory dysfunction in the orofacial region including head and neck. The normative thermal thresholds of women were compared with the previously reported data¹²⁾ from age- and site-matched 30 healthy Korean men (mean age, 26.1 years; range, 23 to 32 years). A written informed consent was obtained from all subjects. This study was approved by the Institutional Review Board at Dankook University Dental Hospital (IRB No. H-1303/004/003).

2. Test Site

Five trigeminal test sites consisted of 4 extraoral and 1

intraoral sites were selected for the experiments for women just the same as men. These were the mentum (above the mental foramen); the vermilion of the lower lip; the tip of the tongue; the midpoint of the cheek and the forehead (2 cm above the midpoint of the brow).

3. Equipment

Thermal stimuli were delivered by a TSA II neurosensory analyzer (Medoc, Ramat Yishai, Israel) using a method of limit. The contact thermode has a 5×5 mm area. The range of temperature for thermal stimulation is between 0°C and 50°C with ramped stimuli at a rate of 1.0°C/s for detection thresholds and 1.5°C/s for pain thresholds. The intertrial interval was randomized at 4 to 6 seconds for detection thresholds and at 10 seconds for pain thresholds. Baseline temperature was set at 32°C for the extraoral sites and 36°C was set for the tongue considering the different surface temperature between extraoral and intraoral tissues.¹²⁾

4. Quantitative Sensory Testing Procedure

QST procedure in this study was performed in the same experimental condition with the Kim et al.'s study for men.¹²⁾ Testing was done to determine the cold detection threshold (CDT), warm detection threshold (WDT), cold pain threshold (CPT), and heat pain threshold (HPT) in the order of the mentum, lower lip, tongue tip, cheek and forehead last. Thermal thresholds were measured on the selected test sites bilaterally, selecting alternatively from the right and left sides. Mean value for each variable was used after 3 consecutive trials. All subjects experienced pilot test on the left mentum a day before the main experiment. Trials ended when subjects pressed the button as soon as she detects the cool sensation (i.e., CDT); warm sensation (i.e., WDT); the sensation of cold pain (i.e., CPT); the sensation of heat pain (i.e., HPT). If the thresholds reached the cut off temperature on any trial, the trial was stopped and the cut off temperature was recorded as the threshold. Thermal thresholds were determined in the order of the CDT, WDT, CPT, and HPT. Testing was carried out in a quiet room in the room temperature with subjects seated in a comfortable chair with their eyes closed. One experimenter guided all participants including both sexes and made all measurements.

5. Data Evaluation

Descriptive statistics were conducted for the CDT, WDT, CPT, and HPT. Mean absolute threshold and standard deviation were calculated for all measurement. Differences between sides and sites in the 20 women respectively were analyzed by one-way ANOVA. Two-way ANOVA was conducted to calculate the influences of sex and site on these four thermal variables in the orofacial region. Tukey post hoc tests were used when differences were significant. Statistical tests were done at the 5% significance level. All statistical calculations were made using the PASW Statistics version 18.0 (IBM Co., Armonk, NY, USA).

RESULTS

For detection thresholds, the decrement or increment in the reversal temperature from baseline temperature (delta value) was used as the threshold value, and absolute values were used for pain thresholds. As the analyses presented no significant difference between sides for all four variables, the average value of the right and left side was used for the thermal thresholds at each test site.

Results of one-way ANOVA exhibited significant site differences on the thermal thresholds in the orofacial region of 20 women. The additional analysis to investigate the sex differences on the thermal perception between 20 women and 30 men showed statistically significant differences.

CDT: Mean cold detection thresholds of 20 women differed from sites ($p < 0.001$; Table 1). The tongue tip showed

the highest delta value and the forehead is next. The lower lip, mentum and cheek showed the least thermal differences from the baseline (Tukey post hoc analysis, $p < 0.05$). Women reported significantly lesser CDT differences than men ($p < 0.001$; Fig. 1A).

WDT: All test sites were differed one another significantly for the warm sensitivity in the women ($p < 0.001$; Table 1). The lower lip showed the highest sensitivity for warmth and the least warm sensitivity was seen in the forehead. Contrary to CDTs, WDTs had no significant sex difference with an interaction between sex and site ($p < 0.001$, $p = 0.226$; Fig. 1B).

CPT: Site differences for noxious cold stimuli were not seen in women ($p = 0.900$; Table 1). Women consistently exhibited lesser sensitivity for cold pain in all test sites than men ($p = 0.007$; Fig. 1C).

HPT: For noxious heat stimuli, women presented significant site differences with the most sensitive cheek and the least sensitive tongue tip (Tukey post hoc analysis, $p < 0.05$). Women exhibited lower threshold for heat stimuli than men but the findings were not statistically significant ($p = 0.061$; Fig. 1D).

DISCUSSION

The current study investigated the normative value of orofacial thermal thresholds for young Korean women and the trigeminal sensory profiles of age- and site-matched healthy men which had been previously reported were

Table 1. Thresholds of thermal quantitative sensory testing of young healthy Korean women in the orofacial region (n=20)

	CDT ($\Delta^\circ\text{C}$)	WDT ($\Delta^\circ\text{C}$)	CPT ($^\circ\text{C}$)	HPT ($^\circ\text{C}$)
Sensory modality				
Mentum	0.8±0.3	1.8±0.7	12.5±17.9	43.6±3.6
Lower lip	0.8±0.3	1.0±0.5	10.5±10.9	43.6±3.1
Tongue tip	2.5±0.9	3.2±1.1	13.3±9.4	44.9±2.6
Cheek	0.9±0.4	2.1±0.8	13.8±12.0	41.5±4.3
Forehead	1.8±0.8	5.1±2.0	14.4±12.6	43.8±3.4
One-way ANOVA				
F	32.3	37.9	0.265	2.514
P	<0.001	<0.001	0.900	0.047

CDT, cold detection threshold; WDT, warm detection threshold; CPT, cold pain threshold; HPT, heat pain threshold.

Values are presented as mean±standard deviation.

CDT ($\Delta^\circ\text{C}$) and WDT ($\Delta^\circ\text{C}$) indicate difference from the baseline temperature in the CDT and WDT, respectively.

CPT ($^\circ\text{C}$) and HPT ($^\circ\text{C}$) indicate the absolute threshold value in the CPT and HPT, respectively.

The baseline temperature was set at 32°C for test sites except the tongue tip (36°C).

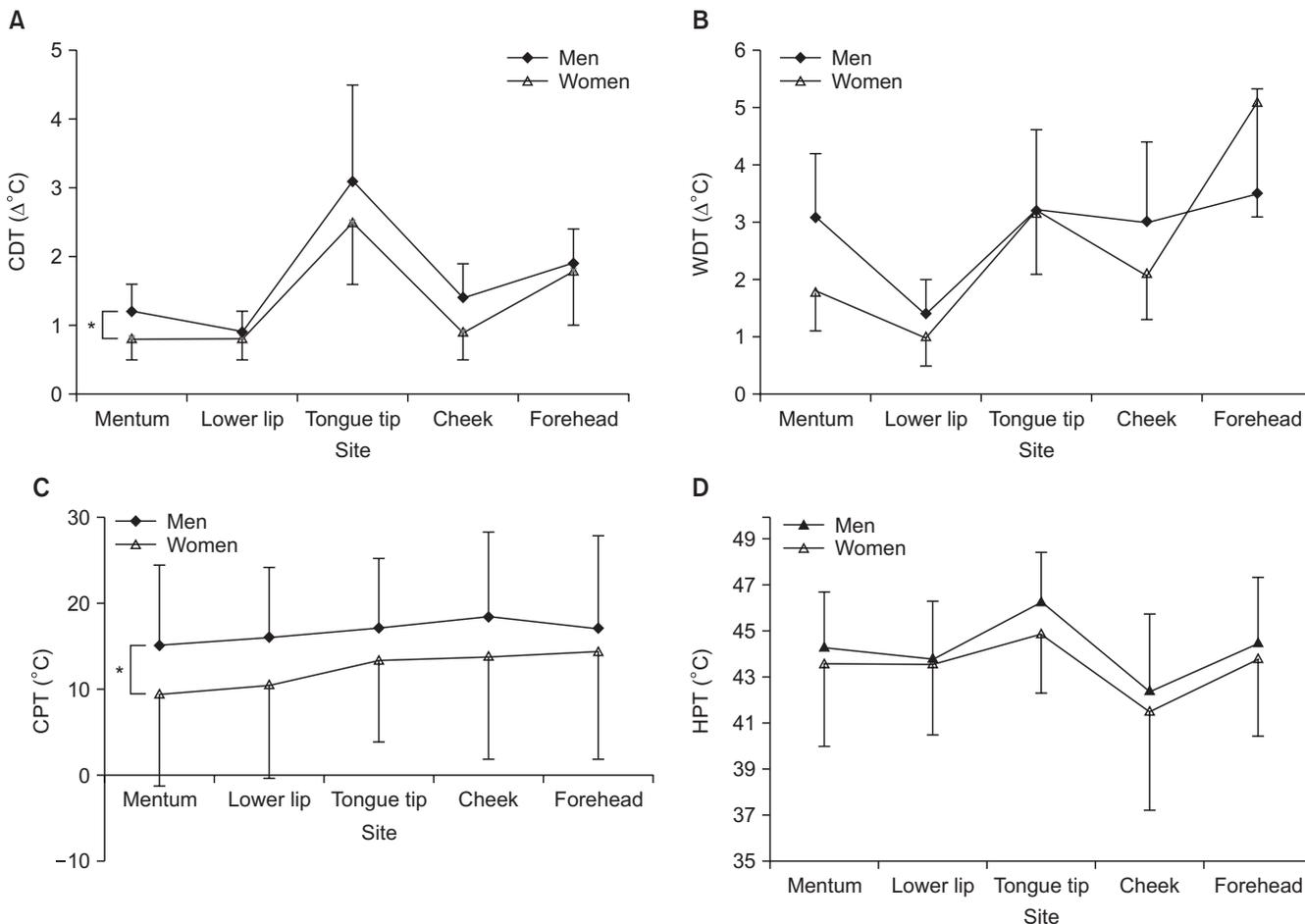


Fig. 1. (A) Cold detection threshold (CDT) investigated in the 5 trigeminal sites for women (n=20) and men (n=30). Differences from the baseline temperature (mean±standard deviation [SD]) are depicted for the CDT. *Difference in the thermal thresholds between women and men after two-way ANOVA ($p<0.05$). (B) Warm detection threshold (WDT) investigated in the 5 trigeminal sites for women (n=20) and men (n=30). Differences from the baseline temperature (mean±SD) are depicted for the WDT. (C) Cold detection threshold (CPT) investigated in the 5 trigeminal sites for women (n=20) and men (n=30). Absolute thresholds (mean±SD) are illustrated for the CPT. *Difference in the thermal thresholds between women and men after two-way ANOVA ($p<0.05$). (D) Heat pain threshold (HPT) investigated in the 5 trigeminal sites for women (n=20) and men (n=30). Absolute thresholds (mean±SD) are illustrated for the HPT. The baseline temperature was set at 32°C for test sites except the tongue tip (36°C). All men's data is modified and reprinted from the article of Kim et al.¹²⁾ (J Orofac Pain 2013;27:263-270) with original copyright holder's permission.

compared with the women's data.

The main findings in this study are as follows:

1. Site differences for thermal perception in the orofacial region which had been established in the previous data for healthy Korean men were reproduced in the age- and site-matched women.

2. Women exhibited more sensitivity for cool perception and on the other hand, lesser sensitivity for cold pain than men. There was no sex difference for heat perception statistically.

1. Normative Data for Thermal QST and the Influence of Site

Through this investigation, we have established the orofacial thermal sensory profile of healthy Korean women and demonstrated the clear effect of site on thermal perception in women, which has been shown previously in Kim et al.'s study.¹²⁾ Our study once again ensured that test site is one of the main factors that could influence on thermal perception in accordance with many previous reports.^{4,5,8-13)}

The site differences in the CDT of women corresponded exactly with age- and site-matched men's data¹²⁾ and this

result indicates that the mentum, lower lip and cheek are more sensitive to cold detection than the tongue tip and forehead. WDT of women also presented site differences like men's data. The tongue tip and forehead are less sensitive to warm stimuli than the other sites in common with CDT. Unlike the CDT, the WDT of women needed larger thermal changes for thermal perception, which was also observed in Kim et al.'s result.¹²⁾ Such a fact could be explained by prior researches suggesting that the thermal sensitivity for warm stimuli in the orofacial region are more heterogeneous than cold sensitivity^{9-11,13-15)} and the skin has a relatively small number of warm spots.¹⁶⁾

In general, the pain thermal thresholds of women varied more for all test sites than the detection thresholds. In particular, the CPT of women were the most imprecise without site difference in accordance with its notoriety for its high variability.^{6,12,16-18)}

Unlike CPT, our study exhibited site differences with the least sensitive tongue tip and the most sensitive cheek for noxious heat stimuli. The pattern of site differences of women for heat pain perception was similar to men's data.

From the above results, it is suggested that biophysical properties of anatomical site are significantly influential on the thermal perception in the orofacial region regardless of sex.

2. Comparison of Sex Differences for Thermal Sensitivity in the Orofacial Region

We compared thermal perceptions between women in this experiment and the men in the Kim et al.'s study¹²⁾ and found that there is, in part, difference between the sexes. Previous studies reported inconsistent results on the sex differences for the non-nociceptive stimuli.^{4,19-23)} Our study showed sex differences in the CDT but not in the WDT in accordance with Matos et al.'s study,¹³⁾ i.e., women presented higher sensitivity for cold detection than men in the orofacial region. In contrast to our result, Lautenbacher and Strian²⁴⁾ concluded that sex differences are in the WDT but not in the CDT. As a reason for these inconsistent results, the heterogeneity of the test sites as well as the experimental conditions in many relevant researches might be considered. In addition, sex-associated differences in peripheral mechanisms (i.e., differences in sensory receptor density,

tissue compliance and thickness) could lead to the sex difference for the thermal perception.²⁵⁾

Unlike the innocuous stimulation, greater pain sensitivity for noxious stimuli among women has been reported and sex differences in pain have been well-documented especially in clinical pain conditions.²⁶⁻²⁸⁾ Extensive experimental pain studies have been conducted to examine possible sex difference using various methods to induce noxious stimulation such as pressure, electric, thermal, mechanical, ischemic and cold pressor.^{19,27,29)} One of the most commonly used laboratory pain inducers is thermal stimulation due to its characteristics of an ideal pain stimulus.³⁰⁾ However, the response to thermal pain stimulation have yielded inconsistent results.^{13,19,21,24,30-32)} In our study, women showed lesser sensitivity for cold pain while, for heat pain detection, men and women were in the same range statistically. Several factors have been proposed to explain these conflicting sex differences for noxious stimuli, i.e., the experimenter gender, different body size and menstrual cycle. Although these situational and biological factors may not be adequate to explain sex differences, they should be controlled in further research to reduce the variability of pain response.²⁵⁻²⁷⁾

The limitation of our study is that the time variability exists between the experiment sessions for women in this study and men in Kim et al.'s data.¹²⁾ Although Pigg et al.⁶⁾ reported that measurement of the thermal thresholds in the orofacial region is acceptably reliable, there have not yet been longitudinal studies over several weeks on the reliability in thermal thresholds between two measurement sessions. Therefore, the time variability in the current study could be a challenge in the validity of our results on comparison between the sexes and we should interpret the data in this study with caution. Nevertheless, the thermal thresholds between both sexes deserve to be compared each other given that the same operator examined both sexes in the same experimental conditions except the time variability. Conclusively, our study made a significant contribution to the establishment of the thermal sensory profiles of healthy Korean adults in the orofacial region and the normative data at each trigeminal site would help clinicians to evaluate the sensory abnormalities at the affected orofacial sites. The current results underline the point that normative data should be applied using site- and sex-matched values.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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