# Ethnic differences in oro-facial somatosensory profiles— quantitative sensory testing in Chinese and Danes

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SUMMARY Ethnic differences in pain experiences have been widely assessed in various pathological and experimental conditions. However, limited sensory modalities have been described in previous research, and the affective-motivational factors have so far been estimated to be the main mediator for the ethnic differences. This study aimed to detect the ethnic differences of oro-facial somatosensory profiles related to the sensory-discriminative dimension in healthy volunteers. The standardised quantitative sensory testing battery developed by the German Research Network on Neuropathic Pain was performed bilaterally in the infraorbital and mental regions on age- and gender-matched healthy Chinese and Danes, 29 participants each group. The influences of ethnicity, gender and test site on the somatosensory profile were evaluated by three-way ANOVA. The ethnic disparities were also presented by Z-scores. Compared to Danes, Chinese were more sensitive to thermal detection, thermal pain, mechanical deep pain and mechanical pain rating parameters ($P < 0.002$) related to small fibre functions. However, the inverse results were observed for mechanical tactile modality related to large fibre function ($P < 0.001$) and wind-up ratio ($P = 0.006$). Women presented higher sensitivity compared to men. The mean Z-scores of all the parameters from Chinese group were in the normal zone created by Danish Caucasians' means and SDs. The ethnic disparities in somatosensory profile illustrated the necessity of establishing the reference data for different ethnic groups and possibly individual pain management strategies for the different ethnic groups.

KEYWORDS: ethnic groups, Asia Continental Ancestry Group, European Continental Ancestry Group, trigeminal nerve, quantitative sensory testing

## Introduction

Increasing evidence indicates ethnic disparities in the prevalence and courses of many medical conditions (1). The pioneering work in the 1950s laid the groundwork for more recent investigations of the relationship between ethnicity and the experience of pain (2). Pain severity of patients varied according to the different ethnicity (3). African-Americans reported higher pain intensity in diverse clinical conditions and had less improvement after therapies compared to White people (4). In addition

to the clinical findings, ethnic pain perception disparities were presented for different kinds of experimental pain modalities, including thermal pain (5) and cold pressure pain (6). There are evidences for ethnic differences in pain perception and tolerance for both African and Hispanic American in comparison with non-Hispanic White people (7). Also a few studies reported that South Asians and Japanese demonstrated higher somatosensory sensitivity than Caucasians (8, 9). Additionally, large ethnically diverse sample studies provide empirical evidence that psychological distress, lower educational level (3), pain coping strategies, beliefs to pain severity, socioeconomics, behavioural impairment (10), ethnic identity (6) were significant predictors for explaining ethnic differences in pain severities. It has been suggested that more attention should be directed to make the healthcare policies depend on ethnic variation (11).

Although, most of the studies actually assessed the pathological pain differences between ethnic minorities and non-minorities who were born and raised in one country, few of them involved the physical somatosensory disparities amongst different non-minority ethnicities in different countries (8). Additionally, ethnic differences in clinical pain responses can be influenced by factors such as disease severity and disparities in pain treatment. It is important to explore ethnic differences in pain perception amongst healthy individuals (12).

The previous studies included limited sensory modalities, and a comprehensive evaluation of the somatosensory disparities in different ethnic groups has so far not been systematically performed. The German Research Network on Neuropathic Pain (DFNS) has developed a standardised and comprehensive quantitative sensory testing (QST) battery, which consists of seven tests measuring 13 parameters for nearly all aspects of thermal and mechanical somatosensation, the good test–retest and interobserver reliability were demonstrated (13, 14). The pain diagnosis and treatment for individuals from different ethnic background could possibly be improved by a better understanding of putative ethic differences in somatosensory sensitivity.

Therefore, the aim of this study was to elucidate the possible ethnic differences between Chinese and Danish Caucasians in oro-facial somatosensory functions by the use of a standardised QST battery.

## Methods

### Participants

The participants in this study were university students and staff recruited through fliers distributed around local college campuses of Aalborg University and Peking University separately. Inclusion criteria were as follows: no experience with similar tests; born and raised in their home country without migration; at least 3 years of university education. Exclusion criteria were as follows: ongoing pain or reports of chronic pain during the last 6 months; serious systemic diseases (e.g. metabolic diseases, neurogenic diseases, cardiovascular disorders) or previous radiotherapy or chemotherapy; intake of medicine affecting the central nervous system; fibromyalgia syndrome (FMS), self-reported bruxism or psychogenic illnesses. Thirty-five Danish Caucasians and thirty-six Chinese responded to the flyers. Finally, 29 Danish Caucasians (14 men and 15 women, age 22–39 years) and 29 age- and gender-matched Chinese participants, who met the criteria, were recruited (Danes, mean ± s.d., 27·0 ± 5·0 years; Chinese, 28·2 ± 4·0 years). The body weight and height of each participant were recorded, and body mass index (BMI) was calculated.

All subjects obtained the declaration and informed consent. The study followed the Helsinki Declaration and was approved by the local ethics committee in Denmark (N-20080057) and China (PKUSSIRB-2013012).

### Quantitative Sensory Testing protocols

The standardised QST battery developed by DFNS (13) and modified for the trigeminal region (15, 16) was used in this study. All QST measures were performed in a quiet room with approximate temperature between 21 °C and 23 °C in two separate laboratories in Beijing and Aalborg. The QST battery in the present study consisted of six tests measuring a total of 12 different thermal and mechanical parameters: cold detection threshold (CDT), warmth detection threshold (WDT), thermal sensory limen (TSL), paradoxical heat sensation (PHS), cold pain threshold (CPT), heat pain threshold (HPT), mechanical detection threshold (MDT), mechanical pain threshold (MPT), mechanical pain sensitivity (MPS), dynamic

mechanical allodynia (DMA), wind-up ratio (WUR) and pressure pain threshold (PPT)(13, 15). The vibration detection threshold (VDT) was not included in this comparison, as the two test centres do not have the same equipment for vibration testing. The two investigators (one in Aalborg and one in Beijing) in this study were both Chinese, who were carefully instructed and trained together under supervision according to the latest guidelines (16) to minimise interexaminer variability. Interexaminer reliability has been examined for these techniques and found acceptable (17). Written instruction boards in Danish for Danish participants and in Chinese for the Chinese participants were presented to the participants before every test. The instructions were translated into Danish and Chinese from the verbal instructions used by the German Research Network for Neuropathic Pain (13).

In the present study, all participants were investigated bilaterally on two skin regions: the infraorbital region and the mental region except for PPT, which was performed in the most bulky points of masseter muscles bilaterally determined during contraction, in the midline and approximately 2 cm superior to the lower border of the mandible. Test sites were identified based on anatomical landmarks to ensure that the same site could be accurately chosen for different participants (Fig. 1).

*Thermal thresholds and thermal sensory limen.* Thermal testing was performed using the Medoc Pathway* with ATS thermode (*:30 × 30 mm, square surface). Cold detection threshold, WDT, CPT and HPT were measured in triplicates, and the means were used for further analysis. For the TSL, the temperature first went up, and the participants pressed a button when they perceived a change in temperature, then the temperature ramp changed direction and the thermode cooled down and was again reversed when the participants perceived a change in temperature and pressed the button. The number of PHS during this procedure was recorded. Baseline temperature was set at 32 °C, for all thermal testing, ramped stimuli of 1 °C s$^{-1}$ was used, and the procedure ended when the participants pressed a button. Temperatures cut-offs were set at 0–50 °C (13).



**Fig. 1.** The test was applied to the skin overlying the infraorbital and mental foramen bilaterally. The infraorbital foramen is located bilaterally in the maxilla on the frontal side and the inferomedial direction is located under the infraorbital ridge by about 1 cm. The mental foramen is generally located bilaterally between the first and second premolar teeth in the mandibular bone.

*Mechanical detection threshold.* Mechanical detection threshold (MDT) was measured with a standard set of Semmes–Weinstein monofilaments (Touch Test TM Sensory Evaluator[†]) with 20 different diameters. The number of each filament (1·65–6·65) corresponds to a logarithmic function of the equivalent forces of 0·08–3000 mN (15). The monofilament was applied perpendicularly to the examination site. Contact time was 1–2 s. Five repeated threshold measurements were made, each through applying a series of ascending and descending stimuli intensities (13). The final threshold was the geometric mean of the five series of ascending and descending stimulus intensities.

*Mechanical pain threshold, mechanical pain sensitivity for pinprick stimuli, dynamic mechanical allodynia and wind-up ratio for repetitive pinprick stimuli.* Weighted pinprick stimuli were delivered with seven custom-made punctate mechanical stimulators with fixed stimulus intensities (flat contact area of 0·2 mm diameter) that

exerted forces of 8–512 mN to determine the MPT (13). Contact time was 1–2 s. All pinprick tests were made with the stimulator perpendicular to the examination site. The 'method of limits', which was used to determine the MDT, was also used to determine the MPT. The final threshold was the geometric mean of the five series of ascending and descending stimulus intensities.

Mechanical pain sensitivity (MPS) and DMA were evaluated using two sets of instruments in a stimulus–response assessment (13). To determine MPS, seven weighted pinprick stimulators (as for MPT) were used. Three tactile stimulators were used to determine DMA: a cotton wisp (~3 mN), a cotton wool tip (Q-tip, ~100 mN) attached to a flexible handle and a disposable toothbrush (~200–400 mN, Top Dent®‡). The tactile stimulator was applied in a single stroke over about 1–2 cm in length of skin. A series of 10 measurements were made three times, each with the 10 stimulators (seven pinpricks and three tactile stimulators) applied in a different order, as specified in the DFNS protocol (13). For each of the resulting 30 stimuli, the participants chose a pain rating on a 0–100 numerical rating scale with the endpoints '0' indicating 'no pain' and '100' indicating 'most intense pain imaginable'. Mechanical pain sensitivity was calculated as the geometric mean of all numerical rating for pinprick stimuli. Dynamic mechanical allodynia was calculated as the geometric mean of all numerical rating across all three different types of light touch stimulators.

To measure the WUR for repetitive pinprick stimuli, the perceived magnitude of a train of 10 pinpricks stimuli repeated at a rate of 1 Hz was divided by that of a single pinprick stimulus with the same force (13). The custom-made pinprick stimulators used in the MPT determinations were used for WUR assessment. The instrument delivered a force which the subject perceived as 'slightly painful' was chosen, and the 128 mN stimulator was tried first. If the response was '0' (not painful), the test was repeated with a stronger force. If the subject perceived the stimulus as intolerable, a weaker force was used. If a subject did not perceive the 512 mN stimulator to be painful, the test was abandoned. The WUR test was repeated three times. Wind-up ratio was calculated as the ratio:

mean rating of the five series divided by the mean rating of five single stimuli.

*Pressure pain threshold.* The pressure pain threshold (PPT) was measured with the use of computerised pressure Algometer§ with a probe covered with rubber with surface area of 1 cm². Pressure pain threshold was measured on the masseter muscle bilaterally with a constant application rate of 30 kPa s⁻¹. At the first painful sensation, the participants pressed a button to interrupt stimulation (13). The test was repeated three times, and the means were used for further analysis.

All participants received careful instructions and a training test to ensure compliance. The whole trial of four tests took about 2 h per participant. The participants kept their eyes closed throughout the QST procedure (13).

## Data processing

All statistical calculations were performed using SPSS 17.0 software for windows¶. The original threshold data of each parameter were first transformed using $\log_{10} X$ to get logarithmic data. The normality of all original and logarithmic data was investigated by the Kolmogorov–Smirnov method. Differences amongst ethnicities, genders and sites were analysed using a three-way ANOVA with BMI as co-variate. The interactions and effect sizes of the factor ethnicity, gender and site were also calculated. *Post-hoc* comparisons were estimated using Tukey *post-hoc* test with correction for multiple comparisons. All data were presented as means ± SDs by original data in the text and tables. The comparisons between women versus men, Chinese versus Danes were investigated by unpaired *t*-tests. $P < 0.05$ was taken as an indication of a statistically significant difference.

To provide a direct visual image of the group differences, the ethnic disparities in QST profile between Chinese and Danes were also presented by Z-transformation and diagram (13): the logarithmic values of Danish participants were considered as population reference data. The QST means and SDs of the Danish group were calculated. The Chinese participants' individual logarithmic data were Z-trans-

formed for each parameter by the following formula to get the individual $Z$-score:

$$Z\text{-score} = (X_{\text{single Chinese}} - \text{mean}_{\text{Dane}})/\text{SD}_{\text{Dane}} \text{ for} \\ \text{CDT, CPT, MPS, WUR;}$$

$$Z\text{-score} = -(X_{\text{single Chinese}} - \text{mean}_{\text{Dane}})/\text{SD}_{\text{Dane}} \text{ for} \\ \text{WDT, TSL, HPT, MDT, MPT, PPT.}$$

$Z$-scores above '0' indicated a gain of function when the Chinese participants were more sensitive to the tested stimuli compared with Danes, while the $Z$-scores below '0' indicated a loss of function referring a lower sensitivity of the Chinese participants. If the parameter $Z$-scores of Chinese participants were outside the 95% confidence interval of the Danish group (i.e. $Z$-values $> 1.96$ or $< -1.96$), the values were considered as significantly different.

## Results

### Participants

There were no significant age differences between the two ethnic groups (unpaired $t$-test age: $P = 0.329$) or the two genders of Danes (unpaired $t$-test, $P = 0.539$) or Chinese ($P = 0.778$).

### The ethnicity, gender and site differences

None of the participants in two ethnic groups reported PHS or DMA in this study. Most of the threshold values of different QST parameters were normally distributed only after logarithmic transformation (Kolmogorov–Smirnov, $P > 0.05$) (13). The results of the three-way ANOVA on the QST logarithmic data with the factors ethnicity, gender, site and covariate BMI are displayed in Table 1. Significant ethnic differences were found for most of the QST parameters except for MPT. The Chinese participants showed higher sensitivity than Danes with regard to CDT ($P < 0.001$), WDT ($P = 0.002$), TSL ($P = 0.001$), HPT ($P < 0.001$), CPT ($P < 0.001$), MPS ($P < 0.001$) and PPT ($P < 0.001$), while the inverse results were obtained for MDT ($P < 0.001$) and WUR ($P = 0.006$) (Table 1). Women had higher sensitivity for MDT, MPT, PPT and higher WUR than men. There were also significant site differences for HPT and MDT, with higher sensitivity to heat pain in the infraorbital region compared with the mental region, while higher sensitivity for MDT in the mental region than infraorbital area (Table 1).

### Interactions

There was a significant ethnicity × gender interaction with Danish men having higher sensitivity for MDT than Chinese men ($P < 0.001$) (Table 2). The significant ethnicity × site interactions were also presented, with Chinese group showing higher sensitivity with regard to CDT and HPT, but lower sensitivity to mechanical detection (MDT) in both test regions than Danes (Table 2). The women in this study showed higher sensitivity for CDT ($P = 0.004$) in the mental region than the men (Table 2).

### Z-scores

The mean $Z$-scores of Chinese group were above '0' for all the QST parameters except for MDT and WUR. Even though some individual $Z$-scores were outside the normal zone, all the Chinese group mean $Z$-scores were inside the 95% confidence intervals of the Danish reference database ($-1.96 < Z$-scores $< 1.96$) (Fig. 2).

## Discussion

This study suggested ethnic somatosensory differences in the oro-facial region between healthy Chinese and Danish Caucasians using the identical QST protocol and equipment. Over all, Chinese participants were more sensitive to most of the QST parameters than Danes, including thermal detection, thermal pain, mechanical pain rating and mechanical deep pain. On the other hand, Danish participants were more sensitive to mechanical tactile stimulus (especially for men) and presented higher temporal summation for repeated painful pinprick stimulus. Women were more sensitive compared to men for most stimulus modalities, which is in agreement with a number of studies on gender differences in somatosensory sensitivity (13, 15).

The term 'ethnicity' describes a group of people with shared culture, heritage and beliefs (18). The ethnic differences in pain perception in various pathological and experiment pain conditions have been reported in many studies (3, 4, 7, 10). The ethnic differences in pain experiences were considered to consist of sensory-discriminative and affective-motivational dimensions. Furthermore, the affective dimension, that is 'psychological factors', was thought

**Table 1.** The ethnic somatosensory differences between Danes and Chinese in trigeminal region (infraorbital and mental) for 12 quantitative sensory testing (QST) parameters were assessed by a three-way ANOVA

| QST parameters | Danes (mean ± s.d.) | Chinese (mean ± s.d.) | Ethnicity 1 P (effect size) | Gender 2 P (effect size) | Site 3 P (effect size) | Interaction P | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 1 × 2 | 1 × 3 | 2 × 3 |
| CDT (△T °C) | −1·37 ± 1·02 | −0·85 ± 0·53 | **<0·001 (0·135)** | n.s (0·011) | n.s (0·009) | n.s | **0·018** | **0·013** |
| WDT (△T °C) | 1·35 ± 0·72 | 1·08 ± 0·45 | **0·002 (0·042)** | n.s (0·004) | n.s (0·004) | n.s | n.s | n.s |
| TSL (°C) | 2·85 ± 1·50 | 2·31 ± 0·87 | **0·001 (0·057)** | n.s (0·007) | n.s (0·004) | n.s | n.s | n.s |
| PHS (−/3) | n.o | n.o | − | − | − | − | − | − |
| HPT (°C) | 41·4 ± 3·9 | 36·6 ± 1·7 | **<0·001 (0·429)** | n.s (0·009) | **<0·001 (0·108)** | n.s | **0·037** | n.s |
| CPT (°C) | 17·4 ± 8·7 | 27·4 ± 2·1 | **<0·001 (0·197)** | n.s (0·002) | n.s (0·009) | n.s | n.s | n.s |
| MDT (mN) | 0·083 ± 0·017 | 0·101 ± 0·033 | **<0·001 (0·113)** | **0·003 (0·040)** | **0·010 (0·031)** | **0·007** | **0·038** | n.s |
| MPT (mN) | 123 ± 109 | 82 ± 56 | n.s (0·004) | **0·003 (0·040)** | n.s (0·017) | n.s | n.s | n.s |
| MPS (−/100) | 1·30 ± 1·41 | 7·93 ± 5·68 | **<0·001 (0·536)** | n.s (<0·001) | n.s (0·001) | n.s | n.s | n.s |
| DMA (−/100) | n.o | n.o | − | − | − | − | − | − |
| WUR | 4·38 ± 3·32 | 3·33 ± 1·98 | **0·006 (0·035)** | **<0·001 (0·149)** | n.s (0·008) | n.s | n.s | n.s |
| PPT (kPa) | 178·6 ± 54·7 | 133·5 ± 50·8 | **<0·001 (0·227)** | **<0·001 (0·184)** | * | n.s | * | * |

The ethnic differences in somatosensory functions between Danes and Chinese were evaluated by 12 QST parameters, which measured thermal and mechanical sensory and pain functions. $\triangle T$ = difference from the baseline temperature 32 °C. n.o = PHS and DMA did not occur. n.s = $P > 0.05$. *Pressure pain threshold (PPT) was performed only in masseter muscle bilaterally. The mean and s.d. were presented with original data, which was later log-transformed by $\log_{10}X$ to obtain normality before the three-way ANOVA. The VDT was not involved in the comparison as the different devices used in the two test centres. Chinese were more sensitive than Danes for CDT, WDT, TSL, HPT, CPT, MPS, PPT parameters and less sensitive than Danes for MDT, WUR. Gender and site differences were also significant for several parameters. CDT, cold detection threshold; WDT, warmth detection threshold; TSL, thermal sensory limen; PHS, paradoxical heat sensation; HPT, heat pain threshold; CPT, cold pain threshold; MDT, mechanical detection threshold; MPT, mechanical pain threshold; MPS, mechanical pain sensitivity; DMA, dynamic mechanical allodynia; WUR, wind-up ratio; PPT, pressure pain threshold. Bold values indicate significant differences, $P < 0.05$.

to be the main mediator for the ethnic disparities (6, 10). In the present study, we did not investigate the contribution of psychological factors, which is an important study limitation. Also, the influence of the ethnic discordance between the Chinese examiner and Danish participants at the Aalborg site versus the Chinese examiner examining Chinese participants at the Beijing study site is an important difference between study sites. A significant effect of examiner–examinee racial discordance on neuropsychological performance has been reported (19). African-Americans who reported high levels of perceived discrimination performed significantly worse on memory tests when tested by an examiner of a different race (19). Hence, the effect of examiner–examinee racial discordance on QST tests need further study. However, thresholds and suprathreshold rating parameters may be more strongly associated with sensory-discriminative aspects of the somatosensory experience (20). Even though the ethnicity-associated differences in responses to thermal and mechanical stimuli had been discussed with limited test parameters, it still need further study by standardised and comprehensive QST methods (9), and reference data should be created for all ethnic groups.

*Threshold differences*

Chinese participants were more sensitive to thermal detection (CDT, WDT, TSL), thermal pain (CPT, HPT), mechanical deep pain (PPT) stimuli compared with Danes, which indicated Chinese had a higher small fibre function. The Danes were more sensitive than Chinese for mechanical tactile modality (MDT, especially for men), which is related to large fibre functions (13). Regarding the MDT at cheek skin, a significant ethnicity effect was also found between Belgian Caucasian and Japanese with the Japanese showing higher sensitivity to tactile stimuli, while no ethnicity × gender interaction was found in that study (9). The significant ethnicity × site interaction for CDT, HPT and MDT in the present study indicated that the ethnic differences existed in both test regions. The gender × site interaction for CDT showed that the gender difference (women more sensitive than men) was limited to the mental region, which might be a result of different

**Table 2.** Interaction analysis after the three-way ANOVA

| Interaction | Danes (mean ± s.d.) | Chinese (mean ± s.d.) | P |
|---|---|---|---|
| Ethnicity × gender | | | |
| MDT (mN) | | | |
| Female | 0·083 ± 0·020 | 0·092 ± 0·028 | n.s |
| Male | 0·084 ± 0·014 | 0·111 ± 0·034 | <0·001 |
| Ethnicity × site | | | |
| CDT (ΔT °C) | | | |
| Infraorbital | −1·61 ± 1·26 | −0·86 ± 0·68 | <0·001 |
| Mental | −1·13 ± 0·63 | −0·84 ± 0·33 | 0·016 |
| HPT (°C) | | | |
| Infraorbital | 40·1 ± 3·4 | 36·1 ± 1·3 | <0·001 |
| Mental | 42·7 ± 4·1 | 37·1 ± 2·0 | <0·001 |
| MDT (mN) | | | |
| Infraorbital | 0·085 ± 0·023 | 0·107 ± 0·028 | <0·001 |
| Mental | 0·082 ± 0·009 | 0·095 ± 0·036 | 0·033 |

| Gender × site | Female (mean ± s.d.) | Male (mean ± s.d.) | P |
|---|---|---|---|
| CDT (ΔT °C) | | | |
| Infraorbital | −1·29 ± 1·11 | −1·18 ± 1·05 | n.s |
| Mental | −0·82 ± 0·38 | −1·16 ± 0·60 | 0·004 |

The significant interactions were assessed by Tukey *post-hoc* test after the three-way ANOVA analysing the ethnicity, gender and site differences. MDT, mechanical detection threshold; CDT, cold detection threshold; HPT, heat pain threshold; PPT, pressure pain threshold.

receptor and nerve fibre density in different regions in the body (21). One study reported that South Asians demonstrated lower CPT than British White people (8). The finding of the ethnic differences between Belgian Caucasians and Japanese indicated that Japanese participants had lower filament-prick pain threshold in the cheek skin (9). Our results support the previous findings, with Caucasians generally demonstrating lower sensitivity compared with Asians (6, 8, 9). Ethnicity-related variation in endogenous pain modulatory systems may partly account for these differences. For instance, subgroups of African-Americans and White people have exhibited differences in circulating beta-endorphins in response to stress (22). Black hypertensive men had significantly lower beta-endorphin levels during a stressor than white hypertensive men (22). Another study suggested that differences in skin properties between different ethnic groups with respect to epidermal receptors may in part explain the observed differences (23). The ethnic variations in thermal and mechanical sensitivity could also be explained by genetic variables (24). However, the ethnic differences to heat and thermal pain stimulus did not emerge between African-American and White people in another study (25), mainly because they were born and grown in the same country and shared the proximate culture factors. More studies are
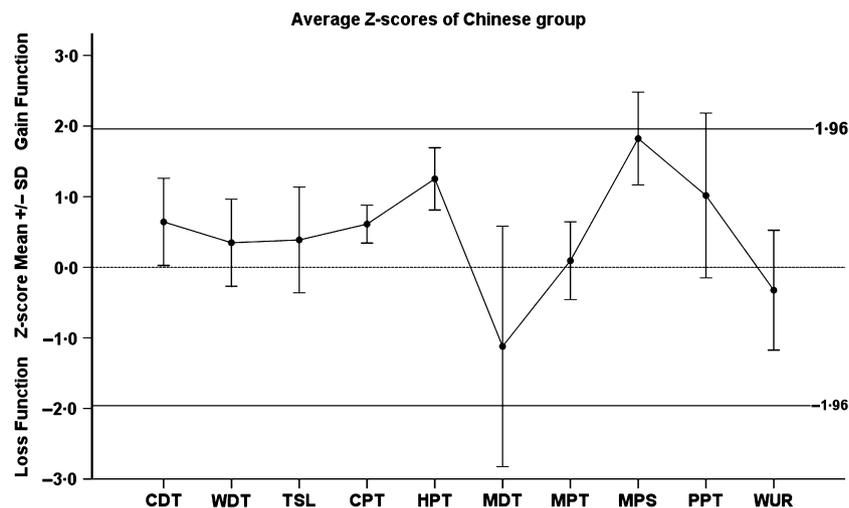


**Fig. 2.** The ethnic somatosensory differences between Chinese and Danes were evaluated by Z-scores. The data of Danish participants were considered as the population reference. The Chinese individual logarithmic data were normalised using the Danish reference data for each parameter. The Z-scores within the range of 0 ± 1·96 were considered in the 95% confidence interval of Danish reference. CDT, cold detection threshold, WDT, warmth detection threshold; TSL, thermal sensory limen; PHS, paradoxical heat sensation; HPT, heat pain threshold; CPT, cold pain threshold; MDT, mechanical detection threshold; MPT, mechanical pain threshold; MPS, mechanical pain sensitivity; DMA, dynamic mechanical allodynia; WUR, wind-up ratio; PPT, pressure pain threshold.

needed to determine the mechanisms by which selective differences occur between Chinese and Danish Caucasians in response to thermal and mechanical stimuli.

### Pain rating differences

A prominent ethnic effect was also observed in the mechanical pain sensitivity scores (MPS) in the trigeminal region. Chinese participants reported significantly higher scores compared to Danes when the painful pinprick stimuli was given, which may reflect an ethnic or cultural difference in the response and attitude to pain. This result was contradictory to the study, which reported that Asians (Japanese) were less prone to overt pain expression in comparison to Euro-Americans (10) and that traditional stoicism was a common characteristic of many Asian cultures (26). However, even between different regions within Asia, great differences in somatosensory sensitivity and response to painful stimuli may possibly occur, for example between Japanese and Chinese. Although pain is a universal phenomenon, results from several studies suggest that a person's cultural values or pain attitude influences the expression of pain. For instance, there was no difference in stoicism and cautiousness between Chinese and European Canadian (27), while compared to Euro-American, Japanese rated pain behaviours in both sexes to be less acceptable (10).

Chinese participants had a significantly lower temporal summation to repeated painful pinprick stimulus than Danes. Wind-up is regarded as one of several aspects of central sensitisation (28), which is regarded as a main experimental model for studying the synaptic plasticity underlying learning and memory as well as persistent pain (29). In healthy humans, temporal summation to electrical, mechanical and thermal painful stimuli has been demonstrated (30). Some studies suggested the temporal summation be influenced by several variables, such as gender and age (31). This is, to the author's knowledge, the first study to report difference in temporal summation between ethnic groups. The temporal summation differences suggest different post-synaptic membrane capability to repetitive C-fibre stimulation (Wind-up) between Chinese and Danes in this study (28). Interestingly, comparison of reports of chronic pain occurrence between Danes and Chinese indicates

higher chronic pain prevalence in Denmark (32, 33). The higher degree of temporal summation in Danes compared with Chinese reported in this study may be one of many possible contributing factors.

### Z-scores

The DFNS suggested Z-score as an easily applicable standard presentation for comparison of data from a single case to reference data. This approach accounts for the fact that different QST parameters come in different units of measurement, and possible data ranges differ vastly across variables. Moreover, a definition of hyper- and hypo-phenomena was clearly described (13). In this study, the Z-score was used to compare the differences between age- and gender-matched Chinese and Danish participants and primarily to create a mean z-score profile of the Chinese group using the Danish group as a reference to supply a quick visual image of the group differences (Fig. 2). Interestingly, the mean Chinese group Z-scores of all the parameters were inside the 95% confidence intervals of Danish reference data (Fig. 2), which demonstrated that the Z-score approach is more conservative than comparing group means with ANOVA (Table 1). However, the reference mean and SD should preferably be based on a large sample, but in the present study, there were only 29 participants in the reference group. Even so, the Z-scores figure allowed an easy judgement on loss or gain of function in Chinese compared to Danish participants.

### Limitations of this study

The present study had some limitations, which may restrict the generalisability of the results. First, the parameters just involved the sensory-discriminative factors. The affective-motivational parameters, such as tolerance and unpleasantness scores and an evaluation of the importance of ethnic concordance/discordance between examiner and participant, could be included in future studies to make a more complete assessment. Second, it is unclear whether observed ethnic differences in QST amongst young, healthy participants would be present in a sample of middle-aged, elderly or chronically ill individuals. Third, the number of participants was limited to 58, which means that some of the non-significant findings may have resulted from inadequate statistical power.

Nevertheless, the data provide a good platform for further controlled studies on somatosensory differences between ethnic groups.

## Conclusions

Chinese participants were generally more sensitive than Danes for most of the thermal and mechanical modalities related to small fibre function, whereas less for mechanical detection modality evaluating large fibre function and wind-up ratio. The results highlight the need for establishment of ethnicity-specific somatosensory reference data and further exploration of the underlying mechanisms.

## Acknowledgments

## References

1. Dimsdale JE. Stalked by the past: the influence of ethnicity on health. Psychosom Med. 2000;62:161–170.

2. Zborowski M. Cultural components in response to pain. J Soc Issues. 1952;8:16–30.

3. Reyes-Gibby CC, Aday LA, Todd KH, Cleeland CS, Anderson KO. Pain in aging community-dwelling adults in the United States: non-hispanic whites, non-hispanic blacks, and hispanics. J Pain. 2007;8:75–84.

4. Lavernia CJ, Alcerro JC, Contreras JS, Rossi MD. Ethnic and racial factors influencing well-being, perceived pain and physical function after primary total joint arthroplasty. Clin Orthop Relat Res. 2011;469:1838–1845.

5. Sheffield D, Biles PL, Orom H, Maixner W, Sheps DS. Race and sex differences in cutaneous pain perception. Psychosom Med. 2000;62:517–523.

6. Rahim-Williams FB, Riley JL, Herrera D, Campbell CM, Hastie BA, Fillingim RB. Ethnic identity predicts experimental pain sensitivity in African American and Hispanics. Pain. 2007;129:177–184.

7. Edwards RR, Moric M, Husfeldt B, Buvanendran A, Ivankovich O. Ethnic similarities and differences in the chronic pain experience: a comparison of African American. Hispanic and White patients. Pain Med. 2005;6:88–98.

8. Watson PJ, Khalid Latif R, Rowbotham DJ. Ethnic differences in thermal pain responses: a comparison of south asian and white British healthy males. Pain. 2005;118:194–200.

9. Komiyama O, Kawara M, De Laat A. Ethnic differences regarding tactile and pain thresholds in the trigeminal region. J Pain. 2007;8:363–369.

10. Hobara M. Beliefs about appropriate pain behavior: cross-cultural and sex differences between Japanese and Euro-Americans. Eur J Pain. 2005;9:389–393.

11. Anderson KO, Green CR, Payne R. Racial and ethnic disparities in pain: cause and consequences of unequal care. J Pain. 2009;10:1187–1204.

12. McCracken LM, Matthews AK, Tang TS, Cuba SL. A comparison of blacks and whites seeking treatment for chronic pain. Clin J Pain. 2001;17:249–255.

13. Rolke R, Andrews Campbell K, Magerl W, Birklein F, Treede RD. Quantitative sensory testing: a comprehensive protocol for clinical trials. Eur J Pain. 2006;10:77–88.

14. Geber C, Klein T, Azad S, Birklein F, Gierthmühlen J, Huge V et al. Test-retest and interobserver reliability of quantitative sensory testing according to the protocol of the German Research Network on Neuropathic Pain (DFNS): a multi-centre study. Pain. 2011;152:548–556.

15. Matos R, Wang K, Jensen JD, Jensen T, Neuman B, Svensson P et al. Quantitative sensory testing in the trigeminal region: site and gender differences. J Orofac Pain. 2011;25:161–169.

16. Svensson P, Baad-Hansen L, Pigg M, List T, Eliav E, Ettlin D et al. Guidelines and recommendations for assessment of somatosensory function in oro-facial pain conditions – a taskforce report. J Oral Rehabil. 2011;38:366–394.

17. Pigg M, Baad-Hansen L, Svensson P, Drangsholt M, List T. Reliability of intraoral quantitative sensory testing (QST). Pain. 2010;148:220–226.

18. Yutrzenka BA. Making a case for training in ethnic and cultural diversity in increasing treatment efficacy. J Consult Clin Psychol. 1995;63:197–206.

19. Thames AD, Hinkin CH, Byrd DA, Bilder RM, Duff KJ, Mindt MR et al. Effect of stereotype threat, perceived discrimination and examiner race on neuropsychological performance: simple as black and white? J Int Neuropsychol Soc. 2013;19:583–593.

20. Price DD. Psychophysical measurement of normal and abnormal pain processing. In: Boivie J, Hansson P, Lindblom U, eds. Touch, Temperature, and Pain in Health and Disease. Vol 3: Mechanisms and Assessments, Progress in Pain Research and Management. IASP Press, Seattle; 1994:3–25.

21. McArthur JC, Stocks EA, Hauer P, Cornblath DR, Griffin JW. Epidermal nerve fiber density. Arch Neurol. 1998;55:1513–1520.

22. McNeilly M, Zeichner A. Neuropeptide and cardiovascular responses to intravenous catheterization in normotensive and hypertensive blacks and whites. Health Psychol. 1989;8:487–501.

23. Wesley NO, Maibach HI. Racial (ethnic) differences in skin properties: the objective data. Am J Clin Dermatol. 2003;4:843–860.

24. Kim H, Neubert JK, San Miguel A, Xu K, Krishnaraju RK, Iadarola MJ et al. Genetic influence on variability in human acute experimental pain sensitivity associated with gender,

ethnicity and psychological temperament. Pain. 2004; 109:488–496.

25. Edwards RR, Fillingim RB. Ethnic differences in thermal pain responses. Psychosom Med. 1999;61:345–354.

26. Brena SF, Sanders SH, Motoyama H. American and Japanese chronic low back pain patients: cross-cultural similarities and differences. Clin J Pain. 1990;6:118–124.

27. Hsieh AY, Tripp DA, Ji LJ, Sullivan MJL. Comparisons of catastrophizing, pain attitude and cold-pressor pain experience between Chinese and European Canadian young adults. J Pain. 2010;11:1187–1194.

28. Eide PK. Review: wind-up and the NMDA receptor complex from a clinical perspective. Eur J Pain. 2000;4:5–17.

29. Klein T, Magerl W, Hopf HC, Sandkühler J, Treede RD. Perceptual correlates of nociceptive long-term potentiation and long-term depression in humans. J Neurosci. 2004; 24:964–971.

30. Koltzenburg M, Handwerker HO. Differential ability of human cutaneous nociceptors to signal mechanical pain and to produce vasodilatation. J Neurosci. 1994;14:1756–1765.

31. Fillingim RB, Maixner W, Kincaid S, Silva S. Sex differences in temporal summation but not sensory-discriminative processing of thermal pain. Pain. 1998;75:121–127.

32. Sjøgren P, Ekholm O, Peuckmann V, Grønbæk M. Epidemiology of chronic pain in Denmark: an update. Eur J Pain. 2009;13:287–292.

33. Fu NK, Tsui J, Lun S, Sang CW. Prevalence of common chronic pain in Hong Kong adults. Clin J Pain. 2002; 18:275–281.

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