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# Gender Differences in Pressure Pain Thresholds during Sustained Jaw Muscle Contraction

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**Purpose:** To determine whether a fatiguing clench significantly affects the changes in pressure pain threshold (PPT) in men compared to women.

**Methods:** The changes of PPTs from before to after a sustained clench in 12 men and 12 women were obtained. We used a decrease in median frequencies of surface electromyography (EMG) power spectra from the start to the end of the sustained clench as evidence of fatigue. Endurance time for the clench was used as a covariate.

**Results:** The median frequencies decreased after the clench in both the anterior temporalis and masseter muscles, did not differ with the muscle or the gender of the subjects, and none of the interaction terms were significant. The PPTs were lower for women for both muscles, were decreased after the sustained clench, but failed to show the hypothesized gender by time interaction.

**Conclusions:** Our results show that women have lower PPTs than men, but do not respond differently than men to jaw muscle fatigue.

**Key Words:** Electromyography; Masseter muscle; Power spectrum; Pressure pain threshold; Temporalis muscle

## INTRODUCTION

Little consensus exists on the origins of the interaction of pain and gender differences.[1)] Women do not react differently to sustained clench as measured by motor unit potentials[2)] nor do they have different pressure pain thresholds (PPTs) on osseous sites.[3)] However, a preponderance of evidence does exist for differences between reports from men and women about temporomandibular disorder muscle pain,[4)] PPTs over muscle sites,[5-8)] reactions to kappa opioid anesthesia,[9)] tolerance to thermal pain,[10)] response to heat pain,[10,11)] to mechanically evoked pain,[12)] to exertional jaw pain,[13)] and to chewing a hard bolus.[14)] Other studies have analyzed blood flow,[15)] fatigue,[16)] clenching,[17)] and chewing,[18,19)] but no attention was paid to the gender of the subjects.

Based on reports where PPT responses of men and women were compared,[13,14)] we hypothesized that muscle fatigue produced by a sustained clench and assessed by determining the shift in the median frequency (MF) of the power spectrum[20-22)] would lead to a greater decrease in PPT in women than in men. Few data are available to support this hypothesis.[13)] Therefore, we have replicated and extended this paradigm. In the present study we have taken into account the confounding problem of different endurance times for men and women of the sustained clench. Our aim was to determine whether a sustained clench significantly affects the changes in PPT in men compared to women.

## MATERIALS AND METHODS

### 1. Subjects

Twenty-four subjects, 12 men (24.9±0.3 years) and 12 women (23.6±2.5 years), without past history or present symptoms of pain or discomfort in the temporomandibular joints or masticatory muscles, and with normal bilateral posterior occlusion were included in this study. The subjects were volunteers recruited from dental college students. The men and women were studied during the same period of time, and at similar times of day.

A pilot study on a subset of these subjects confirmed the published evidence of no significant differences of MF of electromyography (EMG) power spectra[20,21] or PPT[23] between right and left sides of the masticatory muscles so measurement of EMG power spectrum and PPT were obtained from the right anterior temporalis and right masseter muscles. The project was approved by Gangneung-Wonju National University's institutional review board and each subject gave informed consent.

### 2. Protocol

The maximum voluntary contraction level was estimated by asking each subject to clench for 3 seconds three times with maximum force in maximal intercuspal position. The highest EMG amplitude among the three trials was defined as the maximum voluntary contraction level. After 5 minutes rest, each subject performed a sustained clench at 70% of maximum voluntary contraction with visual feedback of the integrated surface EMG signal until they could no longer maintain the contraction at that level.

The EMG machine had only one channel so data were collected at two sessions each separated by two or more days. At the first session, the masseter muscle was used to provide surface EMG activity, endurance time, and PPT. At the second session, the anterior temporalis muscle provided surface EMG activity, endurance time, and PPT.

The PPTs were measured just before and just after the contraction. The PPT is not a measure of ongoing pain and is confounded by the nociceptors in the overlying tissue. However, we wanted a measure of the threshold to muscle pain rather than cutaneous pain so we chose a mechanical stimulus, and since we wanted to focus on the threshold, the PPT seemed like a natural choice since it is a common and accepted measure of pain threshold.[24]

### 3. Power Spectral Analyses

The beginning and ending of the contraction were used to calculate the power spectra as described below. Decreases in the MF of the EMG power spectrum correlate well with, and are accepted as evidence of, muscle fatigue.[20,22,25]

Surface EMG signals were obtained from the anterior temporalis muscle and masseter muscle with pre-gelled, silver/silver chloride surface electrodes connected to the Nicolet Viking IV electrodiagnostic system (Nicolet Biomedical, Madison, WI, USA).

During the jaw clenching, EMG activity from anterior temporalis or masseter muscle was recorded. Power spectral analysis determined the individual frequency components and the power contained within the EMG signal. Fifteen MFs were calculated automatically by the electrodiagnostic system during the contraction. The first and last (start and end of the sustained contraction) MFs during contraction were analyzed.

### 4. Pressure Pain Thresholds

The PPT was measured with the Electric Algometer Type II (Somedic Production AB, Stockholm, Sweden) which has a 1-$cm^2$ circular probe. The force was applied to the anterior temporalis or masseter muscle perpendicular to the surface at a rate of force increase of 40 kPa/sec. The machine had a control knob that allowed the operator to select the rate of application, and there was a bar panel display to indicate how well the operator succeeded. The subject was instructed to press the button he or she was holding when the sensation changed from pressure to pain.

Each application was repeated twice[26] with an interval between the first and second of at least five minutes, and the mean value was obtained. In order to avoid experimental bias neither the examiner nor the subject could see the digital display. All PPT data were collected by one operator to minimize variability.

### 5. Statistical Analyses

Descriptive data are presented as mean±standard deviation.

Since we measured the parameters for each muscle at different sessions, we performed a two-way ANOVA involving the gender (men, women) and muscle (masseter, temporalis) with the dependent variable of endurance time.

Repeated measures analyses of covariance (ANCOVA) involving time (before, after) and muscle (masseter, temporalis) as within-groups factors, and gender (men, women) as a between-groups-factor, with endurance time (averaged over the two muscles) as a covariate were used with the dependent variables MF of the power spectrum and PPT. A separate ANCOVA was run for each dependent variable. The interaction test of endurance time with time (before, after), which tested the assumption of equal slopes, was not significant for any of the tests so this assumption was not violated.

The Mauchly test for sphericity was performed for each ANCOVA and none was found to be significant.

## RESULTS

### 1. Endurance Times

In the masseter muscle the mean endurance time for was 53.5±14.4 seconds for the men and 39.9±12.1 seconds for the women. In the temporalis muscle the mean endurance time for the men was 55.9±14.2 seconds and for the women was 41.9±16.7. A two-way ANOVA suggested that the mean endurance times did not differ between muscles ($p>0.33$, within-subjects) nor was the muscle by gender interaction significant ($p>0.92$). However, the mean endurance time for the women was less than for the men ($p<0.02$). The Pearson correlation of the endurance times between the masseter and the temporalis was 0.77 ($n=24$, $p<0.001$).

### 2. Median Frequencies of Power Spectra

The MFs of power spectra decreased from before to after the clench (Table 1). None of the interaction tests for MFs reached statistical significance (Table 2). The main effect for time was that the mean MF was significantly lower after the sustained clench. The main effect for gender was not statistically significant. We interpret these results to mean that the sustained clench was successful in evoking fatigue in both the men and women.

### 3. Pressure Pain Thresholds

The PPTs were lower in women than in men and lower after the sustained clench (Table 1). Three-way ANCOVA (Table 2) showed that (a) none of the interaction tests were significant; (b) the main effect for gender was that the average PPT for women was significantly lower than that for men; and (c) the main effect for time was that the average PPT was significantly lower after the sustained isometric contraction than before.

**Table 2.** Statistical results (p-values) of analyses of covariance

| Independent variable | Median frequency | Pressure pain thresholds |
|---|---|---|
| G×M×T | 0.340 | 0.853 |
| G×T | 0.846 | 0.172 |
| M×T | 0.063 | 0.127 |
| G×M | 0.762 | 0.848 |
| E×M×T | 0.156 | 0.125 |
| E×T | 0.303 | 0.654 |
| E×M | 0.500 | 0.361 |
| G | 0.356 | 0.014 |
| M | 0.281 | 0.683 |
| T | 0.001 | 0.005 |

G, gender (men, women); M, muscle (masseter, temporalis); T, time (before, after); E, endurance time (covariate).
The E×T, and E×M test the equal slopes assumption of ANCOVA.

**Table 1.** Median frequencies and pressure pain thresholds before and after the sustained contraction

| Muscle | Gender[a] | Median frequency (Hz) | | Pressure pain thresholds (kPa) | |
|---|---|---|---|---|---|
| | | Before | After | Before | After |
| Temporalis | Men | 180.0±28.3 | 115.8±45.8 | 242.6±51.8 | 209.4±42.1 |
| | Women | 185.8±42.9 | 120.0±38.6 | 189.7±37.2 | 160.0±36.0 |
| | Both | 182.9±35.7 | 117.9±41.5 | 216.2±51.7 | 184.7±45.8 |
| Masseter | Men | 155.8±42.1 | 107.5±49.7 | 225.3±44.6 | 188.3±33.3 |
| | Women | 163.3±25.0 | 109.2±30.0 | 172.9±37.6 | 148.4±31.1 |
| | Both | 159.6±34.1 | 108.3±40.2 | 199.1±48.4 | 168.3±37.5 |

Values are presented as mean±standard deviation.
[a]All rows of men=12, all rows of women=12, and all rows of both=24.

None of the interaction tests for PPTs reached statistical significance (Table 2). If the sustained clench had affected the mean PPTs of men and women differently then the gender by time interaction tests would have been significant. The power of this test we get to be about 0.27. However, for the changes averaged over the two muscles, the decrease was a bit less for the women (14.9%) than for the men (15.0%). Thus, increasing the sample size would not be expected to lead to a significantly greater decrease in the women.

## DISCUSSION

Our MFs confirmed aspects of other studies. First, the MFs were significantly lower at the end of the sustained contraction in both muscles.[20,27] A decrease in MF during a sustained contraction is evidence of fatigue in the muscle.[2,6,20,28,29] Second, the MFs in men compared to women were not significantly changed by the sustained clench.[2] Taken together, we believe these findings permit the interpretation that both men and women experienced fatigue to a similar extent.

When the PPTs were considered, the main effects for time and sex were both significant, but the decrease in PPT from before to after the clench did not differ between men and women (the interaction of gender by time was not significant). Thus, the analysis failed to reveal an interaction between gender and time which would have supported the hypothesis that the PPT of women respond differently than men to the fatigue arising from the sustained clench. An explanation for the lack of greater decrease in the women is not likely to be in the size of the sample since the percentage PPT decrease in our sample was nearly the same in the men and the women. In our sample the men decreased more than the women both in raw PPT scores (35.1 vs. 27.1) and in percentages (15.0% vs. 14.9%) so the direction seems wrong for showing a greater change in women by simply increasing the sample size.

While some reports have not found significant differences between men and women,[30,31] our results that PPTs are lower in women and lower after exercise are consistent with most previous findings in the jaw muscles[6,13,23,29,32] but we have extended them by assessing the fatigue, using statistical tests that include interactions, comparing the response between men and women, and accounting for the endurance time.

Plesh et al.[13] have also investigated the sex difference with regard to jaw pain induced by jaw clenching. Our study differed from their report in that we focused on the within-experiment changes in pain threshold whereas they did not measure the pain threshold immediately after the exercise but focused on post-exertional pain 24 hours later, and we accounted for the different endurance time of men and women by using it as a cofactor. Their results suggested that men and women differ in pain report a day after the exercise whereas our results suggest that the pain threshold does not differ immediately after the exercise.

The chain of events to explain our data presumably runs from clench or exercise to venous occlusion to nociceptor sensitization to lower PPTs to pain. The evidence for the links in this chain is not always clear cut. The link from exercise to venous occlusion appears to exist in some reports.[15,33] But there are contrary reports,[34] so this link may depend on muscle and method. The link from venous occlusion to pain requires exercise[35,36] and perhaps complete occlusion. Lower PPTs and clinical muscle pain are clearly associated.[7,37-39] The link from exercise to pain is positive for clenching[13,17,40] and mixed for chewing.[14,18,19,41] So the evidence for a simple causal chain appears to us to be contradictory in places and not clearly convincing.

A possible limitation of our data is that the stage of the menstrual cycle in the females was not measured. We do not know if the cycle would have affected our results. But if the time in the cycle did affect the PPT or MF, then we would expect a scatter of times in the cycle and that would lead to an increased scatter in the PPT and MF data. The effect of the menstrual cycle on the PPT is less than clear. Lower PPTs have been reported for the menstrual phase,[8,42] for the menstrual phase for TMD patients after two months,[31] for the follicular phase in women not using oral contraceptives,[30] and for the periovulatory phase for the bulkiest part of the masseter.[41] No significant differences among the menstrual, follicular, and luteal phases have been reported for selected parts of studies or groups within studies.[30,31] So the menstrual cycle issue is sufficiently controversial that we can say that it may have added variability to our data but it was not likely to be a clear and distinct effect.

In summary, the sustained contraction provided shifts in MF which can be interpreted as fatigue. The women had lower PPTs than men but did not respond differently than men to the sustained contraction. Thus, we were unable to demonstrate in this paradigm that women are more sensitive than men to the changes in PPT arising from fatigue. Continued research will be needed to unravel these problems.

## CONFLICT OF INTEREST

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

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