

April 17, 2009

The effect of tooth clenching on the sensory and pain perception in the orofacial region of symptom-free men and women

Keywords: sensation, pain, perception, sensory thresholds, cheek skin, masseter muscle

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Abstract

The aim of this study was 1) to examine the effect of light tooth contact as in diurnal tooth clenching on the tactile detection threshold (TDT), the filament-prick pain detection threshold (FPT) and the pressure pain threshold (PPT) in the orofacial region and 2) to examine the possible gender difference in this effect on the tactile and pain perception.

Twenty healthy volunteers participated. The TDT and the FPT were measured by means of Semmes-Weinstein monofilaments, on the cheek skin (CS) overlying the masseter muscles (MM), and on the skin overlying the palm side of the thenar skin (TS). The PPT was measured at the central part of the MM using a pressure algometer. Each parameter was measured before and after keeping light tooth contact for 5 minutes (session 1) and after keeping the jaw relaxed for 5 minutes (session 2) as a control.

Although there were no significant session effects on any of the parameters, there were significant effects of experimental condition on the TDT in both males and females ($P < 0.001$). Males had a significant higher FPT of the left CS ($P < 0.05$) and TS ($P < 0.01$) and a significant higher PPT of the MM than females ($P < 0.001$).

These results illustrate that sensitivity to pain (FPT, PPT) was more present in women than men. Although there were no significant gender differences in habituation of sensory perception, the increase of TDT after clenching/no clenching was larger in women, which warrants further study.

Introduction

To objectify and understand the pathophysiology of pain, and contribute to its diagnosis, quantitative sensory testing is of importance (1, 2). Svensson et al. (3) suggested that the pressure pain threshold (PPT) could be a valuable tool for quantitative description of chronic and experimental jaw muscle pain. Reid et al. (4) and Carlson et al. (5) reported that chronic muscle pain patients had lower PPT than normal controls. De Laat et al. (6) evaluated prospectively the effectiveness of a treatment regimen involving counseling and physical therapy in a homogenous group of patients with myofascial pain of the masticatory system through the use of PPT.

Because pain afferents from muscles converge with deep pain and cutaneous afferents on the dorsal horn, Kosek et al. (7,8,9) suggested that determining the degree of sensory modulation in muscle and skin in chronic pain syndromes such as fibromyalgia and low back pain could become an important functional method for patient assessment in diagnosis, treatment evaluation, and follow-up. Although the mechanisms are not clear, there is some evidence of disturbed skin sensitivity in a human experimental model of jaw muscle pain (10) and TMD patients (11). Komiyama and De Laat. (12) also suggested that, especially in patients, the combined measurement on both skin and muscle sensitivity might elucidate to what extent the pain perception results from deep tissues or also from an abnormal superficial perception. Therefore, the present study aimed to evaluate both the tactile detection threshold (TDT), the filament-prick pain detection threshold (FPT), and the PPT.

It is known that many factors may modulate sensory and pain perception, e.g., attentional influences (13, 14), descending inhibitory influences from higher brain regions, motor activity (7,8,15), movement (16-21) and/or exercise (22-26). Recently, the relation between stress and parafunctions has been better elucidated, and awake clenching is considered a possible risk factor in the development of orofacial pain: myofascial pain patients tended to have 4 times more nonfunctional tooth contacts than controls (27). However, the effect of tooth clenching or non-functional tooth contact on the sensory and pain perception has not been investigated up to now.

Consequently, the aim of this study was 1) to examine the effect of light tooth contact as in diurnal tooth clenching on the tactile detection threshold (TDT), the filament-prick pain detection threshold (FPT) and the pressure pain threshold

(PPT) in the orofacial region of symptom free subjects and 2) to examine possible gender differences of this effect on the tactile and pain perception.

Materials and Methods

Subjects

Twenty healthy volunteers (ten males, ten females, age range 23 to 45 years, mean age \pm s.d.: 33.0 ± 5.9 years for males and 34.8 ± 4.8 years for females) were recruited. All were asymptomatic for pain in the head and neck region. Since a previous study (28,29) indicated that pain thresholds were lower in the menstrual phase, females were not tested during their menstrual phase, and smokers were excluded. The subjects were informed about the study in a standardized way and signed an informed consent form. The institutional ethics committee approved the study.

Tactile detection threshold and filament-prick pain detection threshold

The tactile detection threshold (TDT) and the filament-prick pain detection threshold (FPT) were measured 1) on the cheek skin (CS) overlying the central part of the left and right masseter muscles midway between the upper and lower borders and 1 cm posterior to the anterior border, 2) on the skin overlying the palm side of the thenar muscle on the point connecting the longitudinal axis of the thumb and index finger (Thenar Skin: TS). The sequence of the measurement sites was randomized. Semmes-Weinstein monofilaments with 20 different diameters were used (Premier Products, USA). The numbers of the filaments (1.65 to 6.65) correspond to a logarithmic function of the equivalent forces of 0.0045 to 447 gram.

At first, TDT was examined. The subjects were instructed to close their eyes during the whole test procedure and to raise their hand as soon as they felt the stimulus on the test site. The filament was applied vertically to the test site and slowly pressure was applied until the filament bowed. The time needed to bow the filament was standardized to approximately 1.5 seconds. The stimulus was maintained for approximately 1.5 seconds and then removed in 1.5 seconds. Quick applications and bouncing of the filaments against the skin were avoided. At each site, the test started with the number (No.) 4.74 filament. If the subject

raised his/her hand, it was considered a positive response, and the next filament applied was one step lower (No. 4.56). This procedure was repeated with decreased filament diameters until the subject no longer felt the pressure. This was considered as a negative answer. Again, the filament with a higher pressure was applied. This procedure continued until five positive and five negative peaks were recorded and the threshold (TDT) was calculated as the average of these values (number of the filament). If the subject still had a positive response while applying the lowest fiber (No. 1.65), this filament was considered the threshold. Two "blank" (placebo) trials were performed after peaks 5 and 10. During these control trials, the filament did not make contact with the tissue. If the subject reported a positive answer, the test was discontinued and the subject was questioned about what kind of stimulus was perceived. The whole procedure was explained again to the subject and afterwards the test was restarted (1).

After the TDT measurements, the FPT was examined. The stimuli were applied in the same way as for the TDT, but the subjects were instructed to open their eyes and to raise their hand as soon as they felt not only pressure but also pain in the test area. If the subject had no positive response for the thickest fiber (No. 6.65), this number was recorded as the threshold. No placebo stimulus was applied. There was a time lag of 3 minutes between the measurements on a similar site in order to avoid sensitization. Furthermore, after the examination, the pain intensity experienced at the FPT was assessed on a numeric rating scale (NRS) where 0 cm indicated 'no pain' and 10 cm indicated 'worst pain imaginable'.

Pressure pain threshold

A pressure algometer (Somedic, Sweden) was used to test the sensitivity to stimuli applied to the masseter muscles. The pressure pain threshold (PPT) was defined as the amount of pressure (kPa), which the subjects first perceived to be painful (3). The PPT was determined with a constant application rate of 30 kPa/s and a probe diameter of 1 cm. The subject pushed a button to stop the pressure stimulation when the threshold was reached. These measurements were done at least 5 minutes after the FPT measurement. Measuring point was the central part of the masseter muscle (MM) midway between the upper and lower borders and 1 cm posterior to the anterior border. This point was identical to the one used for measuring TDT and FPT. At the start of the session, the subjects were

familiarized with the measurement procedure and the equipment via a demonstration on the forearm, and they were instructed to keep their teeth slightly apart to avoid contraction of the jaw-closing muscles during stimulation. While the PPT was being assessed, the subject's head was supported by counter-pressure from the opposite hand of the examiner. The measurements of the PPT were done three times. There was a time interval of 2 minutes between the measurements. The mean value of the three measurements was used for further statistical analysis. After the examination, the average during PPT measurement was assessed on a NRS where 0 cm indicated 'no pain' and 10 cm indicated 'worst pain imaginable'.

Measurement sessions

The experimental protocol is illustrated in Figure 1. Each parameter was measured before and after keeping light tooth contact for 5 minutes (session 1) and keeping the jaw relaxed for 5 minutes (session 2) as a control. The two measurement sessions were separated by 1 week and the order randomized.

Statistical analysis

Mean values and standard deviations (s.d.) were calculated. Two-way ANOVA with repeated measures was used to analyze intervention (before and after clenching/ no clenching), session (clenching or no clenching) and gender effects for all the parameters (TDT, FPT, PPT). The significance was accepted at $P < 0.05$.

Results

Tactile detection threshold

There were no significant differences between tested sites, i.e. left CS, right CS and TS (male: $F = 2.459$, $P = 0.104$; female: $F = 0.323$, $P = 0.727$), or session effects regarding TDT at all tested sites, i.e. left CS (male: $F = 1.104$, $P = 0.307$; female: $F = 2.831$, $P = 0.110$), right CS (male: $F = 0.093$, $P = 0.764$; female: $F = 3.303$, $P = 0.086$) and TS (male: $F = 0.265$, $P = 0.613$; female: $F = 1.648$, $P = 0.216$).

There were no significant gender differences but there were significant effects of experimental condition on the TDT of left CS (gender: $P = 0.277$, intervention: $P < 0.001$, interaction: $P = 0.143$), right CS (gender: $P = 0.353$, intervention: $P < 0.001$, interaction: $P = 0.153$) and TS (gender: $P = 0.872$, intervention: $P < 0.001$, interaction: $P = 0.559$). The relative increases from before to after clenching or no clenching at left CS, right CS and TS corresponded to 10%, 9%, 6% for male, and 14%, 13%, 8% for female, respectively (Figure 2).

Filament-prick pain detection threshold

In the same way as for TDT, there were no significant differences between tested sites (male: $F = 0.144$, $P = 0.867$; female: $F = 0.067$, $P = 0.935$), or session effects on FPT at all tested sites, i.e. left CS (male: $F = 1.548$, $P = 0.229$; female: $F = 0.252$, $P = 0.622$), right CS (male: $F = 0.798$, $P = 0.384$; female: $F = 0.296$, $P = 0.593$) and TS (male: $F = 1.806$, $P = 0.196$; female: $F = 0.145$, $P = 0.708$).

There were significant effects of experimental condition on the FPT of TS in females (session: $P = 0.708$, intervention: $P < 0.01$, interaction: $P = 0.753$) but the relative increase from before to after clenching or no clenching was only 4%. Males had a significantly higher FPT of the left CS (gender: $P < 0.05$, intervention: $P = 0.939$, interaction: $P = 0.538$) and TS (gender: $P < 0.01$, intervention: $P < 0.01$, interaction: $P = 0.551$) than females (Figure 3).

Pressure pain threshold

There were no significant session effects or effects of experimental condition on the PPT (male: session: $P = 0.892$, intervention: $P = 0.250$, interaction: $P = 0.372$; female: session: $P = 0.722$, intervention: $P = 0.163$, interaction: $P = 0.611$).

The only significant factor was gender. Males had a significant higher PPT of the MM than females (gender: $P < 0.001$, intervention: $P = 0.077$, interaction: $P = 0.868$) (Figure 4).

Discussion

The use of sensory tests for both tactile and pain sensation could be helpful in the diagnosis and assessment for orofacial pain. In clinical practice, the

mechanical sensitivity of skin and muscles is tested by standardized palpation and recording of the graded responses from the patient. Out of the variety of stimulus modalities, e.g., mechanical, electrical, thermal and chemical stimuli, we used Semmes-Weinstein monofilaments and a pressure algometer in the present study, those are more natural stimuli and are comparable to palpation used in the diagnosis of clinical pain.

Many factors like attention, descending noxious inhibitory controls (DNIC) or movement/motor activity, appear to modify the sensory and pain perception. Kempainen et al. (18, 19) examined the effect of jaw movement on facial skin sensitivity, tooth pulpal pain detection and pain thresholds to electrical stimulation. However, the effect of tooth clenching or non-functional tooth contact (which are considered possible risk factors in the development of masticatory myofascial pain) on the sensory and pain perception has not been investigated up to now. Morimoto et al. (30) examined the effect of chewing efforts for 5 min on facial skin temperature. According to this study, chewing task for 5 min produced a significantly higher temperature increase in facial skin, and did not return to the initial state even after 30 min. In the present experiment, we examined the effects of 5 min non-functional tooth contact, as in diurnal tooth clenching on the TDT, FPT and PPT in the orofacial region. All measurements were taken within 30 min after the task.

In our symptom-free subjects, the pain threshold (FPT) was not modulated by the clenching/no clenching exercise, except for TS in females. Since TS does not have a direct relationship with the jaw system, one can conclude that the pain thresholds were not influenced by the clenching efforts, and we presume that the increased FPT at TS is due to habituation. In contrast to FPT, the detection thresholds (TDT) of CS and TS significantly increased from before to after clenching or no clenching, i.e., from the first to the second measurement. The increase was even higher than found in the FPT of TS in female. A previous study of Chapman et al. (16) using electrical stimulation found that detection thresholds and not pain thresholds were modulated by motor activity or movement. Similarly, Feine et al. (15) used thermal stimuli applied to the limbs and tested the effect of movement on the perception of pain. They found that motor activity decreased the ability to discriminate weak low-threshold cutaneous inputs, but had no effect on the perception of warmth and heat pain. In the present study, the change of the detection threshold was observed both in the clenching session and in the control setting without clenching, which

indicates that habituation seems to be a more plausible explanation. Although there were no significant gender differences in this habituation effect, the increase of TDT after clenching or no clenching were more pronounced in females, which warrants further study.

One could argue that the delay after the clenching effort before the PPT measurement was taken, compromised the evaluation of a possible effect of the low-level clenching on this parameter. However, a recent study (31) focusing on jaw muscle fatigue and PPT, in which clenching efforts of 60 min were utilized, also found no differences in PPT, while significant small decreases of mouth opening and maximal voluntary contraction were reported. The present findings, therefore, are in line with that study.

Regarding gender differences, Komiyama and De Laat. (12) previously reported that females showed a significantly lower TDT, FPT and PPT at the CS than males. The present data confirmed the lower FPT and PPT in females, but there were no significant differences in the TDT measurements. Possibly the limited sample examined in the present study may explain that different finding. It has been pointed out already that female skin appears to have a higher elasticity and extensibility (32), which might partly explain a gender difference regarding TDT, but hardly can account for the differences observed for FPT and PPT. Of course, many other factors like psychosocial variables, hormonal influences are involved in the gender difference regarding pain perception (for review 33), and probably also here a learning curve exists which might influence the subjects' report after experiencing the stimuli or the first time.

In conclusion, the main findings of the present study were that in symptom-free subjects, a clenching exercise of 5 minutes does not result in extra modulation of TDT, FPT and PPT than what could be ascribed to habituation. Sensitivity to pain (FPT, PPT) was more present in women than men. Although there were no significant gender differences in habituation of sensory perception, the increase of TDT after clenching/no clenching was larger in women. Further exploration of these findings, also in patients with masticatory myofascial pain, might help to clarify the physiological reactions in patients developing pain and dysfunction (34).

Acknowledgements

We gratefully acknowledge Dr. Bart Craane for the use of the algometer.

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Figure legends

Figure 1. Experimental protocol.

Figure 2. Mean and s.d. of tactile detection threshold (TDT) before (open squares) and after (solid squares) clenching (a) and/or no clenching (b). ** $P < 0.01$ when compared between the experimental conditions.

Figure 3. Mean and s.d. of filament-prick pain detection threshold (FPT) before (open squares) and after (solid squares) clenching (a) and/or no clenching (b). ** $P < 0.01$ when compared between the experimental conditions. † $P < 0.05$, † † $P < 0.01$ when compared between the genders.

Figure 4. Mean and s.d. of pressure pain threshold (PPT) before (open squares) and after (solid squares) clenching (a) and/or no clenching (b). † † $P < 0.01$ when compared between the genders.

Figure 1.

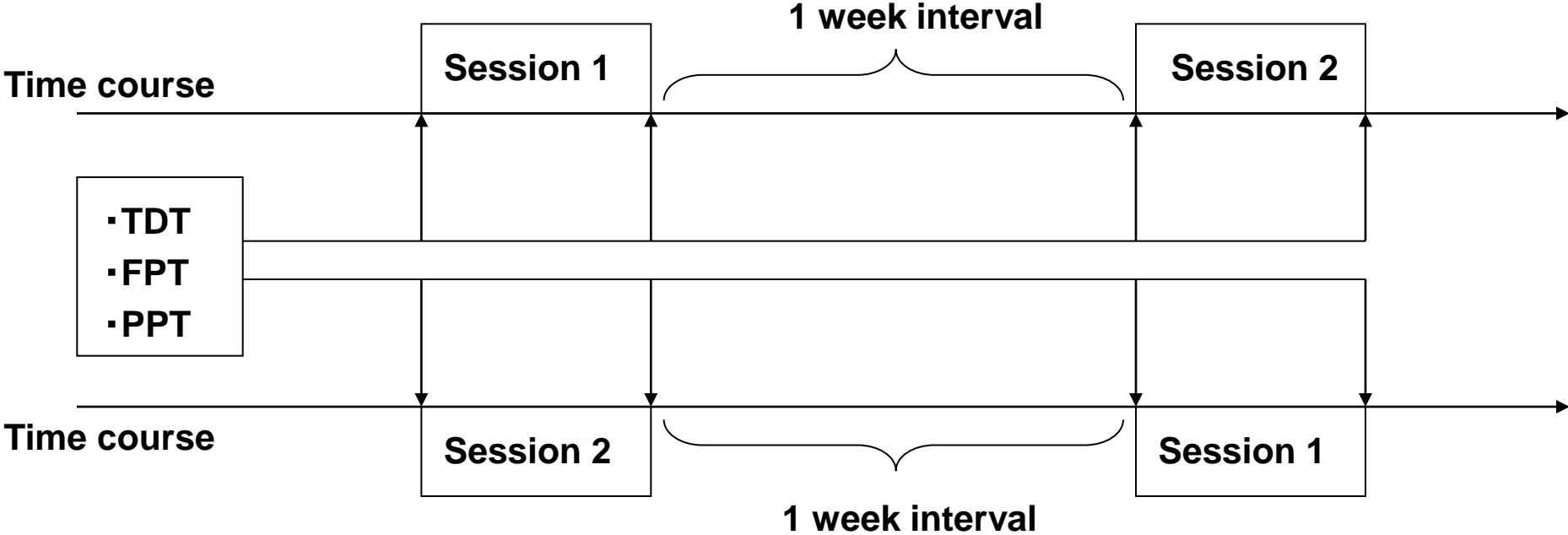


Figure 2.

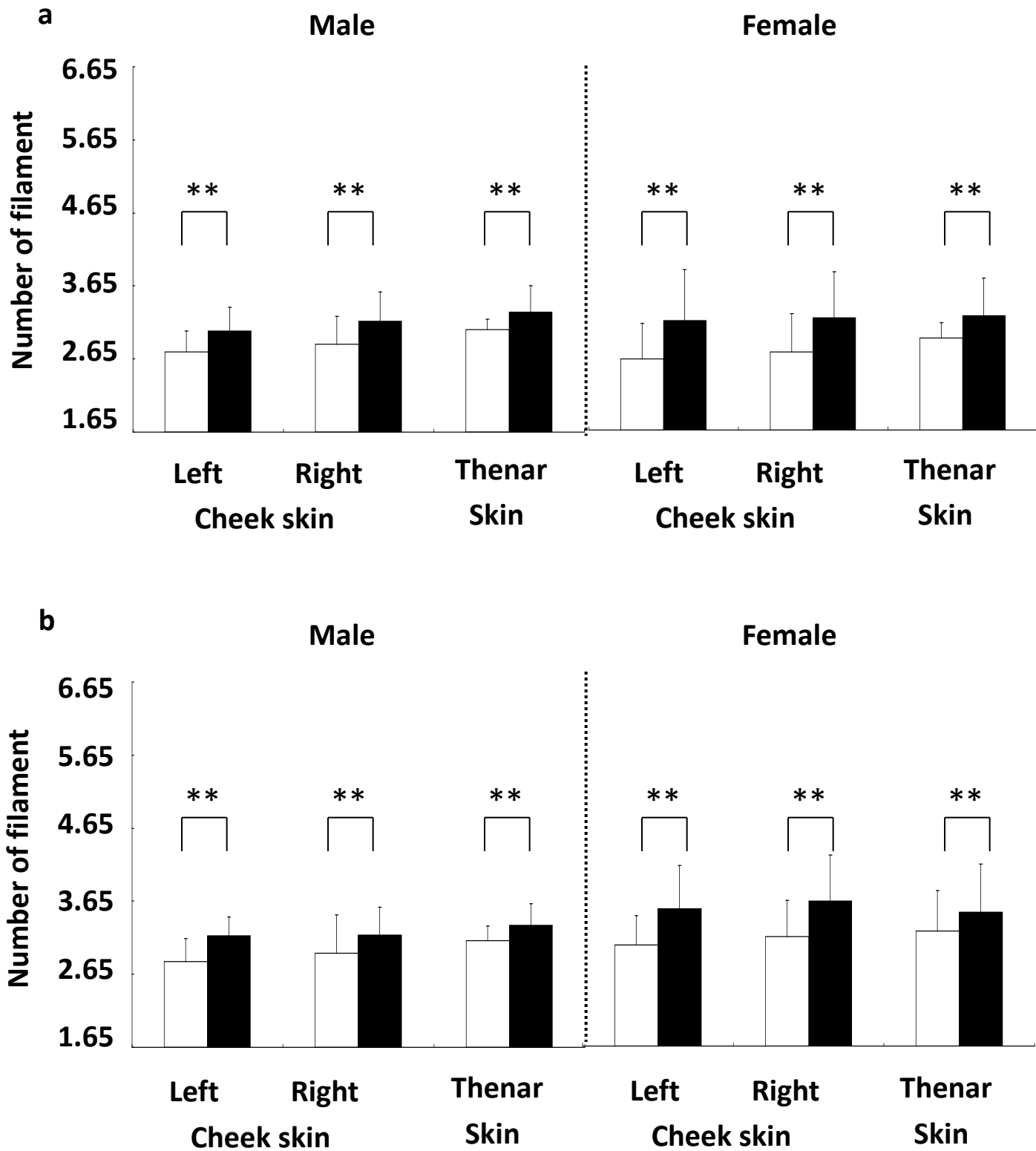


Figure 3.

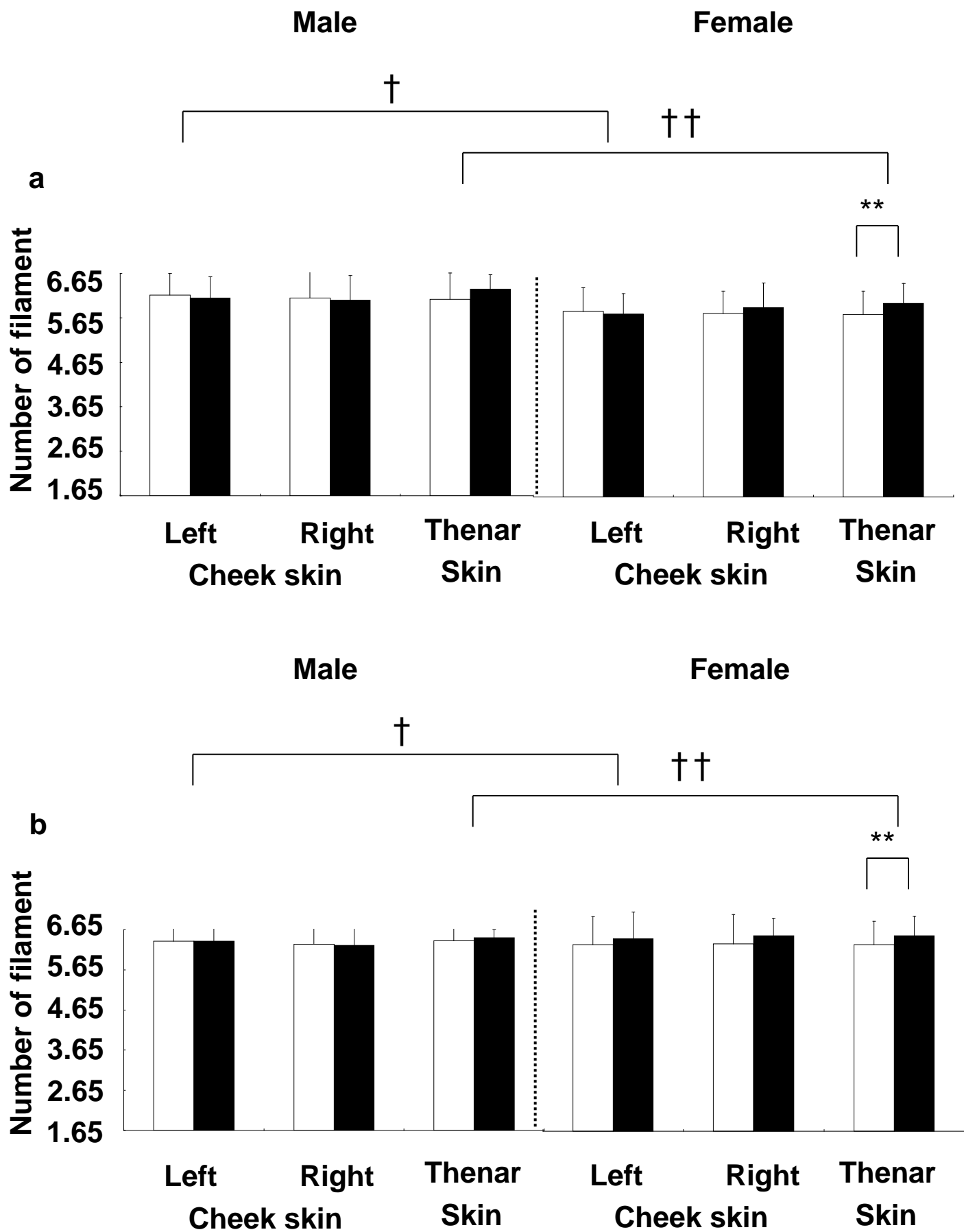


Figure 4.

