

Skin surface temperature over the temporomandibular joint and masseter muscle in healthy children and adolescents

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Skin surface temperature (SST) measurements were carried out over the temporomandibular joint (TMJ) and masseter muscle (MM) of 159 healthy children and adolescents aged 7, 11, 15 and 18 years. No current symptoms were found of impaired general health or from the masticatory system or recurrent headache. The recordings were done with a thermocouple in contact with the skin. The mean SST over the TMJ and MM increased with age, and from the youngest to the oldest group regarding the TMJ by 1.3°C (right) and 1.6°C (left), and for MM by 2.1°C (right) and 2.5°C (left). Variation in the mean difference between sides of the TMJ was 0.0–0.2°C and for the MM 0.1–0.3°C. The variation in SST between sides was reduced with increasing age, but was higher for MM than for TMJ in all age groups. In the 7-years group, there was a significant difference between right and left SST over TMJ and MM. It is concluded that SST increases with growth during childhood and that the SST for the TMJ is higher than MM in all age groups. The finding of a high degree of thermal symmetry between sides in all age groups may have diagnostic potential for pathological conditions involving blood flow and in evaluation of treatment of these conditions. □ *Adolescents; children; masticatory muscle; skin surface temperature; temporomandibular joint; thermal symmetry*

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In pathological conditions of the masticatory system, the skin surface temperature (SST) pattern may provide valuable information for diagnostics through thermal asymmetry. The central nervous control affects the skin temperature of both sides of the body uniformly and simultaneously, resulting in symmetry of thermal patterns (1–5). The thermal pattern of the skin surface over the temporomandibular joint (TMJ) and the masseter muscle (MM) has been described previously among adults (6–9).

Different methods have been used to monitor joint temperature both extra- and intra-articularly. Reports have been published about infrared thermographic examination of skin surface overlying the painful MM in adults with muscular disorder of the masticatory system (10, 11) and in diseases of the TMJ (12, 13). To our knowledge, there is a lack of information about the SST over the TMJ and MM in children and adolescents. Pain conditions of a nociceptive (inflammatory, ischemic) and neuropathic nature often influence the blood flow of the involved tissue (14), and increased sympathetic nerve activity may increase and perpetuate the pain condition (15, 16). In vascular pain conditions, the pain due to tissue ischemia may be either neuropathic or nociceptive (17). Ischemic pain is generally considered an independent entity which may occur as a result of chronic muscle isometric contraction and thereby increased intramuscular pressure (18–21). It may be amplified and perpetuated by neuropeptide release from, for example, peripheral sympathetic nerve fibers (22). In order to be able to diagnose, evaluate, and treat these conditions, a tool capable of estimating the regional blood flow is mandatory.

The aim of this study was to investigate the thermal pattern of the skin over these areas among healthy children and adolescents with symptom-free TMJ and MM and to provide answers to the following question: What is the normal variation in temperature of the skin over the TMJ and MM in different age groups?

Materials and methods

Study population

Out of 165 children and adolescents, 159 participated in this study. Age and gender of the study population are given in Table 1. Six individuals were excluded, 3 had current temporomandibular disorders (TMD) or recurrent headache, 2 had a cold, and another one refused to participate after being given information about the examination procedure.

The remaining individuals reported absence of symp-

Table 1. Age and gender distribution of the study population ($n = 159$)

Age groups	Numbers	
	Male	Female
7 years	20	20
11 years	21	20
15 years	21	17
18 years	20	20
Total	82	77



Fig. 1. Location of the thermocouple during measurement of the skin surface temperature (SST) over the temporomandibular joint. (Permission received from the individual to reproduce the picture).

toms of general disease or from the masticatory system, including recurrent headache. No clinical signs of TMDs were found upon examination, i.e. no tenderness to digital palpation over the TMJ or MM. They had normal occlusal conditions for their age.

Study procedure

The subjects included in the study were selected at random from four different public schools and from classes that were available for temperature measurements on the predetermined days. Before the measurements, all individuals were informed verbally about the procedure and accepted the described examination. The individuals had been requested not to eat a heavy meal or smoke the hour before the appointment and were asked about this before the examination. The individuals reported that they had not used any drugs on the examination day.

The measurements were carried out between 9 a.m. and noon in the schools in a separate room with stable temperature. Subjects rested in the examination room for 20 min prior to measurement. No operating light was used when the SST was measured.

Temperature measurement

The recordings were performed according to the same procedure in all individuals with thermocouples (Exacon standard measuring probes, series TH-103, type C-S1, C-OR2, and C-A12). The probes were connected to a thermometer (Exacon MC 9200) with direct measurement in °C. Temperature readings were performed with an accuracy of $\pm 0.1^\circ\text{C}$ in an ambient temperature of 25°C (6). The measuring probe was held by hand and the thermistor was lightly applied to the skin surface. When a steady value had been reached, i.e. after approximately 30 s, the recordings were performed on the skin surface over the lateral aspect of the TMJ (Fig. 1) and over the anterior part of the superficial belly of the MM close below the zygomatic arch. Recordings were also carried out intraorally in a sublingual position in order to estimate the body temperature.

Oral and room temperature

The oral temperature ranged from 35.1°C to 37.2°C . Two 7-year-old children presented a higher oral temperature than 37°C . The mean values for each of the age groups varied between 36.1°C and 36.3°C , respectively.

All recordings of the room temperature were performed within an interval of 20.0 – 23.9°C , with a mean of 22.3°C . Room temperature was about 1.0°C lower in the 7 years group compared to the other groups. In the 7 years group, a higher proportion (37.5%) of the measurements were performed in the room temperature interval between 20.0°C and 20.9°C than in the other age groups (0–10%).

Statistics

Differences between age groups and thermometric variables were tested for statistical significance using Student's *t* test for two means. Significance tests of correlation were performed with Pearson's product moment correlation coefficient (*r*). The level of statistical significance (*P* value) is shown if $P < 0.05$, otherwise it is denoted ns (not significant).

Results

Skin surface temperature

TMJ. Distribution of the SST over the TMJ (SST_{TMJ}) is given in Table 2. The mean SST_{TMJ} increased with age, 1.3°C on the right side and 1.5°C on the left side from the youngest to the oldest age group. The mean differences and variations in SST between the right and left TMJ are given in Table 3.

MM. Distribution of the SST over the MM (SST_{MM}) is given in Table 2. The mean SST_{MM} increased with age, 1.6°C on the right side and 2.1°C on the left side from the youngest to the oldest age group. The mean differences

Table 2. Distribution of skin surface temperature in °C over the temporomandibular joint (TMJ) and masseter muscle (MM) in healthy children and adolescents at ages of 7, 11, 15 and 18 years

	7 years <i>n</i> = 40	11 years <i>n</i> = 41	15 years <i>n</i> = 38	18 years <i>n</i> = 40
TMJ, right				
<i>X</i>	33.6	34.6	34.7	34.9
<i>s</i>	0.68	0.64	0.60	0.64
<i>X</i> ± 2 <i>s</i>	33.0–34.9	34.0–35.3	34.2–35.5	34.4–35.7
TMJ, left				
<i>X</i>	33.2	34.7	34.7	34.8
<i>s</i>	0.88	0.73	0.60	0.76
<i>X</i> ± 2 <i>s</i>	32.6–34.4	33.9–35.4	34.2–35.5	34.2–35.8
MM, right				
<i>X</i>	31.8	33.4	33.9	33.9
<i>s</i>	1.31	1.19	0.81	1.15
<i>X</i> ± 2 <i>s</i>	30.7–33.5	32.4–34.9	33.2–34.9	33.0–35.4
MM, left				
<i>X</i>	31.5	33.2	34.0	34.0
<i>s</i>	1.46	1.14	0.77	1.23
<i>X</i> ± 2 <i>s</i>	30.3–33.4	32.3–34.7	33.4–35.0	33.0–35.6

n = number of individuals; *x* = mean; *s* = standard deviation.

and variations in SST between the right and left MM are given in Table 3.

Side and site differences

There was a high correlation between right and left SST_{TMJ} and SST_{MM} in all age groups ($r = 0.70–0.94$, $P < 0.001$). In the 7-years group, the SST was significantly higher on the right side compared with left side, SST_{TMJ} ($P = 0.003$) and SST_{MM} ($P = 0.002$), respectively. In the 7-years group, there was a significant difference for the mean difference of the right and left MM temperature ($P = 0.045$) (Table 3).

Gender and age differences

The females in the 11-years group had a higher SST_{TMJ} than the males ($0.4^{\circ}C$, $P = 0.020$) and for SST_{MM} ($1.1^{\circ}C$, $P = 0.004$). The males in the 18-years group had a higher SST_{MM} than the females ($1.1^{\circ}C$, $P = 0.010$).

The only significant difference between age and SST was found in the 7 years group, which differed from all other age groups with lower mean SST_{TMJ} and SST_{MM} ($P < 0.001$).

Room temperature

SST_{TMJ} and SST_{MM} was correlated to room temperature in the 7-year-old children ($P < 0.05$ and $P < 0.001$). A similar relationship was noticed for SST_{MM} in the 11-year-old children ($P < 0.05$).

Discussion

The study showed increasing SST with age and a high

Table 3. Mean difference (mean_{diff}) and standard deviation (*s*) between right and left side skin surface temperature (°C) over the temporomandibular joint (TMJ) and masseter muscle (MM) in 159 healthy children and adolescents

	7 years <i>n</i> = 40	11 years <i>n</i> = 41	15 years <i>n</i> = 38	18 years <i>n</i> = 40
TMJ				
Mean _{diff}	0.20	0.01	0.001	0.14
<i>s</i>	0.45	0.38	0.33	0.55
MM				
Mean _{diff}	0.27 ^a	0.19	0.13	0.11
<i>s</i>	0.49	0.49	0.50	0.74

^a Statistically significant difference between sides ($P = 0.045$).

n = number of individuals.

degree of thermal symmetry between sides and sites. The SST_{TMJ} was higher than SST_{MM} in all age groups. There was more variation in SST_{MMs} than SST_{TMJs} in all age groups.

The medical rationale for temperature measurements is to detect neural and vascular disturbances that are part of ischemic or inflammatory nociceptive pain as well as neuropathic pain in order to provide diagnostic information. The aim of this study was to provide normal values and ranges of SST that can be used for comparison with values from sick children with orofacial pain conditions including neuropathic pain. The SST is also of clinical value when assessing treatment effects in young patients with TMD (23).

The investigated children and adolescents all reported that they were in good general health and had no symptoms from the masticatory system. The two youngest groups were at an age before puberty peak and the two oldest groups after according to studies of Scandinavian children (24). Puberty peak occurs on average at 12.5 years for girls (range = 11–15 years) and at 14 years for boys (range = 12–16 years).

In this study, we tried to standardize factors such as smoking, eating a heavy meal directly prior to measurement, no direct operating light on the examined areas, stable indoor climate and temperature, any of which could influence temperature measurements. Another factor is the time of contact between the skin and the thermistor before the temperature recording was standardized (the thermocouple/thermistor was held lightly against the skin), since this too has been shown to influence SST measurement (25, 26). In adults, the reproducibility of similar SST measurements has been investigated previously and was found to have a coefficient of variation less than 1%. Thermal symmetry between the right and left TMJ has been found to have an acceptable constancy with time (26, 27).

The results of this study indicate that the microcirculation of these tissues increases with growth. It has been reported that such changes continue through adolescence into adulthood (28). Generally, the SST_{TMJ} and SST_{MM} increased with growth in this study, but the absolute

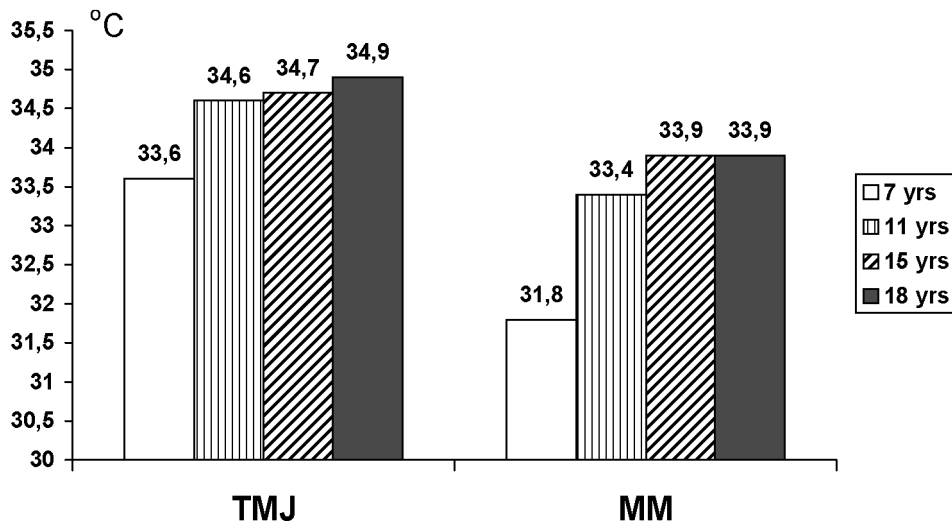


Fig. 2. Mean skin surface temperature over right temporomandibular joint (TMJ) and right masseter muscle (MM) in children and adolescents aged 7, 11, 15 and 18 years.

temperature values of the oldest age group were still lower than among adults (approximately 0.4 for both TMJ and MM) as reported from others studies (6–9, 27). The most marked increase in SST took place in the younger age groups, especially regarding temperature over the MM, which indicates that there is a marked development of this muscle between 7 and 11 years of age. It has been found that there is a higher surface area to mass ratio, higher oxygen uptake, lower cardiac output and more marked of adiposity in children, which may influence the thermoregulatory mechanisms more markedly than in adults (29). Surface area to mass ratio is 30% higher in the younger children compared with adults of medium size. The thermoregulatory mechanism in the child may be more sensitive for challenge by disease or external temperature variations than in young adults (29). Accordingly, in this study SST_{TMJ} was correlated to room temperature only in the 7-year group and SST_{MM} only in the 7 and 11-year groups. All measurements were performed at a room temperature less than 24°C, since temperatures above this level influence the skin surface temperature by evaporation.

The SST difference between sides was largest in the youngest group and smallest in the two older groups, probably due to a less developed thermoregulation in the youngest group (29).

The SST over the TMJ and MM depends on factors such as ambient temperature, blood circulation, and metabolism of the skin in addition to the metabolism and circulation of the joint and muscle. Circulatory changes due to inflammatory joint disease in the TMJ will be reflected in the SST. The SST was higher over the TMJ region than over the MM, which is in agreement with an earlier study of adults (7, 8). The most important factor underlying the SST is radiation from blood vessels.

The reason for higher SST_{TMJ} might be the proximity to large facial blood vessels, especially the external carotid artery, which passes slightly posterior to the joint and branches off into the zygomatic artery passing superior to the joint and the transverse facial artery passing inferior to the joint.

A stable but not constant room temperature was used for these measurements, so comparison between other studies should therefore be made with some caution, especially regarding the younger age groups (7 and 11 years). However, the intra-individual temperature differences between sides were not correlated to room temperature and could therefore be used in the diagnosis and evaluation of treatment without consideration of room temperature.

A normal thermometric asymmetry of up to 0.5°C has been reported for adults between sides of the TMJ (7), the corresponding value for MM being 1.0°C (8, 9), which is similar to the results of this study, since the mean difference between sides is 0.0–0.2°C ($2s = 0.66$) of the TMJ and 0.1–0.3°C ($2s = 1.0$) for the MM.

SST over the TMJ and MM is potentially a tool for indirect assessment of intramuscular blood flow in the masticatory system. The intramuscular blood circulation changes in many diseases and this is associated with functional impairments. Adult patients with rheumatoid arthritis at a late stage presented decreased SST_{TMJ} , which was associated with palpatory tenderness of the MM (7). Decreased SST_{MM} , on the other hand, was associated with functional disturbances such as deviation of mandibular movement and TMJ clicking. In another study of adult patients with rheumatoid arthritis, decreased SST_{TMJ} was associated with tenderness to palpation of the TMJ as well as with tenderness of the MM (30).

It is concluded that SST increases with growth during

childhood and adolescence. The SST_{TMJ} was higher than the SST_{MM} in all age groups. There was more variation in SST_{MM} than in SST_{TMJ} in all age groups. The finding of a high degree of thermal symmetry between sides in all age groups may have potential in the future diagnosis of pathological conditions involving blood flow and in evaluation of treatment of these conditions.

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