

# Intramuscular and skin surface temperatures of the resting human superficial masseter muscle

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Karlsbad A, Kopp S. Intramuscular and skin surface temperatures of the resting human superficial masseter muscle. *Acta Odontol Scand* 1991;49:225–231. Oslo. ISSN 0001-6357.

The intramuscular and skin surface temperature of the central part of the superficial masseter muscle was measured with thermocouples in 25 individuals with none or mild signs of craniomandibular disorders. The intramuscular temperature averaged 35.7°C, varying between 34.6 and 36.5°C. The average difference between the right and left sides was 0.4°C. The skin surface temperature averaged 33.2°C, varying between 31.1 and 35.4°C. The average difference between sides for this temperature was also 0.4°C. The correlation between intramuscular and skin surface temperature was weak, and the average difference was 2.5°C, with a range from 0.4 to 4.6°C. The spatial variation in skin surface temperature 5 mm around the central measuring point was small. The reproducibility of both intramuscular and skin surface measurements, as assessed by the standard deviation for a single measurement, was acceptable. □ *Craniomandibular disorders; masticatory muscles; temperature; temporomandibular joint*

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The temperature of muscle tissue is a function of its energy production and blood flow. Owing to the constancy of metabolic rate and blood flow in healthy resting muscles, intramuscular temperature tends to be stable between about 33 and 35°C (1). Chronic pain and tenderness in the elevator muscles of the mandible have been associated with absolute or relative ischemia, assumed to be caused by isometric muscle tension (2). In addition, inflammation, with increase in blood flow, termed myositis or fibrositis, has been proposed as a cause of muscle pain, at least in an acute phase (3, 4).

Pathologic changes influencing muscle blood flow might be detected thermometrically within the tissue or on the overlying skin surface. The skin surface temperature over the anterior part of the origin of the superficial masseter muscle has been investigated in symptom-free individuals (5–7), in individuals with muscular disorders of the stomatognathic system, temporomandibular joint (TMJ) osteoarthritis, and TMJ arthritis (8), and in individuals with rheumatoid arthritis (RA) (7). In symptom-free individuals this temperature is on an average

34.4°C at a room temperature of 22°C, whereas it is significantly lower and about 33.0°C in individuals with rheumatoid arthritis. Patients with craniomandibular disorders of muscular origin have been claimed to show an increased temperature over the masseter (8–10). It would be of greater diagnostic value to be able to differentiate between inflammation and ischemia by the temperature within the muscle tissue than on the skin surface. However, the intramuscular temperature of the masseter muscle in health and disease is unknown.

The primary aim of this study was to assess the intramuscular temperature and the corresponding skin surface temperature of the central part of the superficial masseter muscle at rest in individuals without subjective symptoms of craniomandibular disorders. A second aim was to assess the spatial variation of the skin surface temperature.

## Materials and methods

Twenty-five individuals, 15 women and 10 men, aged 27–46 years (median, 36 years),

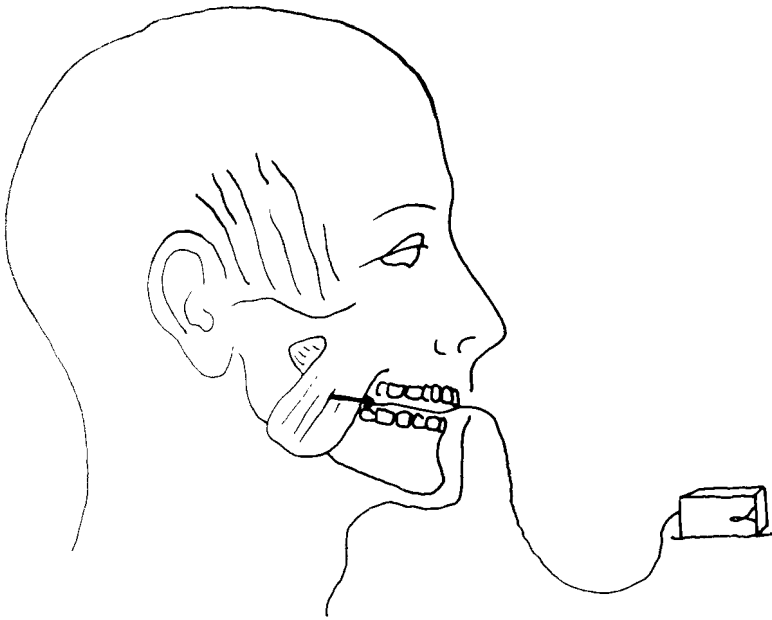


Fig. 1. Schematic drawing of the location of the needle for intramuscular temperature measurements in the central part of the superficial belly of the masseter muscle.

with no subjective symptoms and few mild signs of craniomandibular disorders were included in this study. Clinical signs such as TMJ clicking and tenderness to palpation of one or a few masticatory muscles were present in 11 individuals. The subjects were instructed not to smoke or exercise during a 3-h period before the examination. A history was taken concerning questions about pain in the craniomandibular system, including headache and chewing difficulties.

A clinical examination of the stomatognathic system was performed to assess tenderness to palpation of the TMJs and masticatory muscles, clicking, crepitus and locking of the TMJ, reduction in mobility of

the mandible, pain during mandibular movements, and deviation of the mandible (2 mm or more) on mouth opening.

Temperature recordings were performed on the skin surface over the central part of the superficial portion of the masseter muscle on a point corresponding to the intramuscular measurement site in all subjects, and 5 mm anterior, posterior, superior, and inferior to this point in 14 of the subjects. The skin surface recordings were performed with a thermocouple (Exacon C-S1). The average value of three independent measurements was calculated and used in the analysis. A standard disposable needle with an external diameter of 0.65 mm and a length

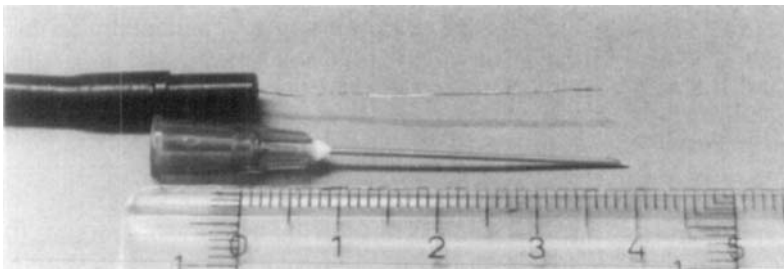


Fig. 2. The standard disposable 0.65 × 30-mm needle and the 0.25-mm-diameter thermocouple to be inserted intramuscularly.

Table 1. Intramuscular and skin surface temperatures, in degrees Celsius, of the central part of the superficial masseter muscle in 25 individuals

	Intramuscular			Skin surface		
	Range	Mean	SD	Range	Mean	SD
Right	34.6-36.5	35.5	0.51	31.1-35.4	33.2	1.24
Left	34.6-36.5	35.8	0.45	31.5-35.3	33.3	1.21
Mean	34.6-36.5	35.7	0.48	31.1-35.4	33.2	1.23

of 30 mm was inserted intraorally into the central part of the superficial portion of the masseter muscle (Fig. 1). A thin, sterilized thermocouple (Exacon C-N5) was then inserted into the needle until its tip reached the orifice of the needle (Fig. 2). The thermocouple was insulated except for its very tip. The temperatures were recorded by a digital thermometer (Exacon MC 9200) working with an accuracy of one-tenth of a degree Celsius (°C).

The temperature recordings were repeated within 4-5 weeks in 22 (intramuscular) and 20 (skin surface) subjects, to determine the reproducibility of the temperature measurements.

Sublingual and room temperatures were recorded before the skin and muscle recordings. The sublingual temperature was on an average 36.4°C, corresponding to a rectal temperature of about 36.9°C, and varied between 35.8 and 37.1°C. The room temperature was on an average 22.6°C and varied between 19.3°C and 25.0°C. Seventy-six per cent of the recordings were made at a room temperature between 21.0 and 24.0°C. The study was approved by the Ethical Committee at Lund University.

*Statistics*

Pearson's product-moment correlation coefficient (*r*) was used to estimate the strength of the correlation between skin surface and intramuscular temperature. Temperature differences between the sexes were tested for statistical significance with Student's *t* test. The reproducibility of the temperature measurements was assessed by the standard deviation for a single measure-

ment,  $S = \sqrt{\frac{\sum d_i^2}{2N}}$ , and the coefficient of variation in percentage,  $C = S \times 100/\text{mean}$ .

**Results**

*Skin surface temperature*

The temperatures are shown in Table 1. The interval of two standard deviations around the mean for the right and left sides combined was  $33.2 \pm 2.46 = 30.7-35.7^\circ\text{C}$ . The temperatures on the right and the left

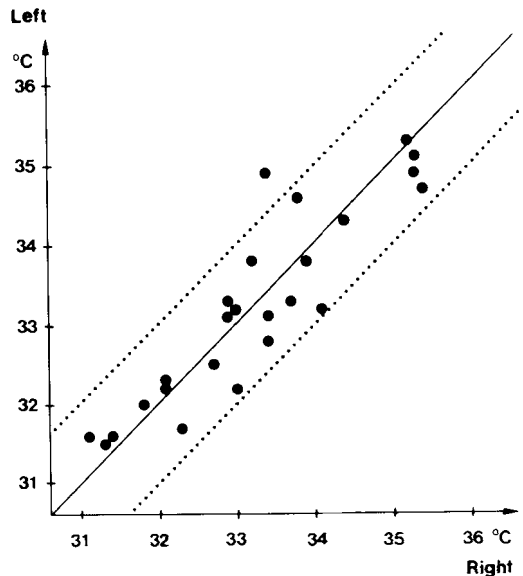


Fig. 3. Distribution of skin surface temperatures over the right and left masseter muscles in 25 individuals. Dotted lines indicate a deviation of 1.0°C between right and left sides.

Table 2. Skin surface temperature (in degrees Celsius) over the superficial masseter muscle in 14 individuals. Recordings over the central part (C) and 5 mm anterior (A), posterior (P), superior (S), and inferior to the central part (I). SD = standard deviation, R = right, L = left

		Skin surface temperature		
		Range	Mean	SD
C	R	30.9–34.8	33.1	1.13
	L	31.4–34.5	33.1	0.94
A	R	30.4–35.0	33.0	1.34
	L	31.4–34.4	33.0	1.03
P	R	30.9–34.8	33.2	1.10
	L	31.7–34.8	33.2	0.97
S	R	31.2–34.6	33.2	1.01
	L	31.6–34.8	33.2	0.99
I	R	30.6–34.9	32.9	1.21
	L	31.4–34.4	33.1	0.99

sides were correlated ( $r = 0.90$ ,  $p < 0.001$ ) (Fig. 3). The absolute difference between the right and left sides (temperature asymmetry) was on an average  $0.4^{\circ}\text{C}$  and varied between  $0.1$  and  $1.5^{\circ}\text{C}$ , with a standard deviation of  $0.32^{\circ}\text{C}$ . The range of the mean +2 standard deviations of this temperature asymmetry was also  $1.0^{\circ}\text{C}$ .

The women had a mean skin surface temperature on the right side of  $32.7^{\circ}\text{C}$ , and the men  $33.9^{\circ}\text{C}$ . This difference was statistically significant ( $p < 0.01$ ). On the left side the corresponding values were  $32.8$  and  $33.9^{\circ}\text{C}$  ( $p < 0.05$ ).

The skin surface temperature was not significantly correlated to either sublingual temperature (right,  $r = 0.16$ ; left,  $r = 0.11$ ) or room temperature (right,  $r = 0.20$ ; left,  $r = 0.33$ ).

The spatial variation in skin surface temperature over the masseter muscle is shown in Table 2.

#### Intramuscular temperature

The temperature is shown in Table 1. The interval of two standard deviations around the mean for right and left sides combined was  $35.7 \pm 0.96 = 34.7\text{--}36.7^{\circ}\text{C}$ . The tem-

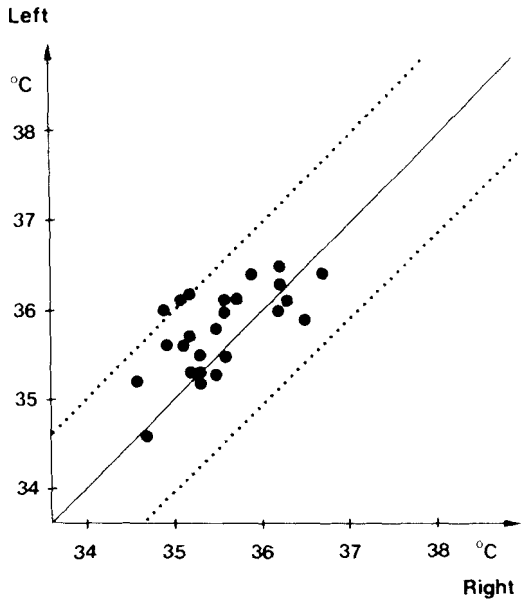


Fig. 4. Distribution of intramuscular temperatures of the right and left superficial masseter muscles in 25 individuals. Dotted lines indicate a deviation of  $1.0^{\circ}\text{C}$  between right and left sides.

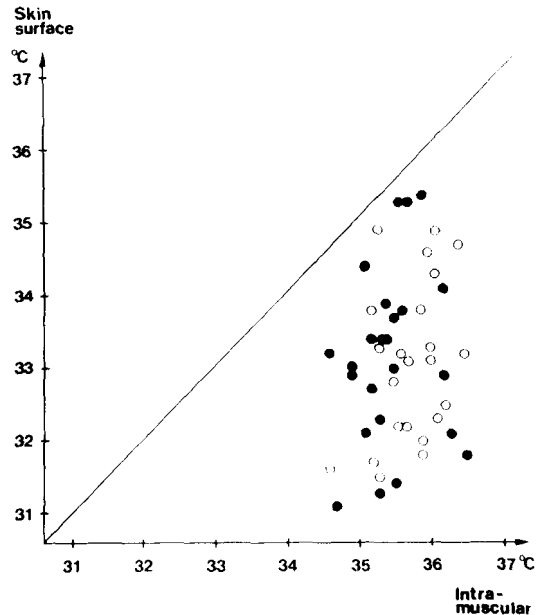


Fig. 5. Relationship between intramuscular and skin surface temperatures of the right and left superficial masseter muscles in 25 individuals. Right side, filled circles,  $r = 0.23$ ; left side, open circles,  $r = 0.46$ .

peratures on the right and left sides were correlated ( $r = 0.62, p < 0.001$ ) (Fig. 4). The absolute value of the difference between the right and left sides (temperature asymmetry) was on an average  $0.4^\circ\text{C}$  and varied between  $0.0$  and  $1.1^\circ\text{C}$  with a standard deviation of  $0.31^\circ\text{C}$ . The range of the mean  $+2$  standard deviations of this temperature asymmetry was  $1.0^\circ\text{C}$ .

The women had a mean temperature of  $35.4^\circ\text{C}$  and the men  $35.6^\circ\text{C}$  on the right side. On the left side the corresponding values were  $35.7$  and  $35.9^\circ\text{C}$ . These differences were not statistically significant.

The intramuscular temperature was correlated to the sublingual temperature (right,  $r = 0.50, p < 0.05$ ; left,  $r = 0.44, p < 0.05$ ) but not to room temperature (right,  $r = -0.14$ ; left,  $r = 0.23$ ).

#### Relationship between intramuscular and skin surface temperatures

The intramuscular and skin surface temperatures were significantly correlated on the left side (right,  $r = 0.23$ ; left,  $r = 0.46$ ;  $p < 0.05$ ) (Fig. 5). The average difference

between the intramuscular and skin surface temperature on the right side was  $2.3^\circ\text{C}$ , with a variation of  $0.3$ – $4.7^\circ\text{C}$ , and on the left side  $2.6^\circ\text{C}$ , with a variation of  $0.4$ – $4.4^\circ\text{C}$ . The standard deviations were  $1.24$  and  $1.08^\circ\text{C}$ , respectively.

#### Relationship between temperature and clinical signs

There was no difference between the totally symptom-free individuals and those with mild clinical signs with regard to intramuscular or skin surface temperature or temperature asymmetry between the two sides. There was no correlation between TMJ clicking, masticatory muscle tenderness, and the temperatures recorded.

#### Reproducibility of measurements

The reproducibility of the intramuscular temperature measurement as assessed by the standard deviation for a single measurement was  $0.33$  and  $0.32^\circ\text{C}$  on the right and left sides, respectively (Fig. 6A). The coefficient of variation (C) was  $0.9\%$  on both sides.

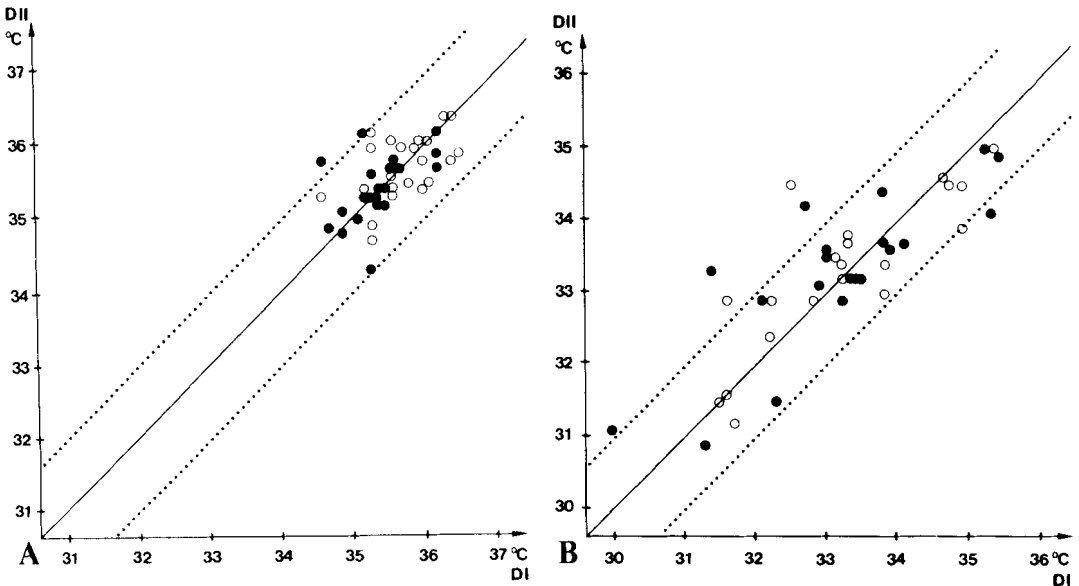


Fig. 6. Reproducibility for measurement of intramuscular temperature (A) and skin surface temperature (B) of the superficial masseter muscle in 22 and 20 individuals, respectively. DI = first measurement; DII = second measurement; right side = filled circles; left side = open circles. Dotted lines indicate a deviation of  $1.0^\circ\text{C}$  between the first and second measurement.

The standard deviations for a single measurement of skin surface temperature were 0.56 and 0.48°C on the right and left sides, respectively (Fig. 6B). The coefficient of variation (C) was 1.7% on the right side and 1.4% on the left.

## Discussion

The average intramuscular temperature of the central part of the superficial portion of the masseter muscle was 0.6°C lower than the intra-articular temperature of the TMJ (11). The range of the intramuscular temperature (2.0°C) was slightly wider than that of the intra-articular temperature (1.2°C) but much narrower than that of the skin surface temperature over the central part of the masseter (5.0°C).

In contrast to the skin surface temperature no significant sex difference was noted for the intramuscular temperature. A higher skin surface temperature among males has previously been reported over the anterior part of the origin of the superficial masseter muscle (5). The reason for this difference may be that the masseter muscle or skin in this area is more vascularized in males than in females or that the subcutaneous fat layer in females is thicker than in males.

The room temperature in this study varied substantially, but it was not significantly correlated to skin surface temperature. The values of the correlation coefficients, however, were similar to those of Tegelberg & Kopp (12). The wide variation in room temperature might have increased the variation in skin surface temperature in comparison with the intramuscular temperature and may possibly also have influenced the correlation between skin surface and intramuscular temperature. However, the differences between the right and left sides should be unaffected. The intramuscular temperature showed a weak and not significant correlation to room temperature in accordance with intra-articular TMJ temperatures (11, 13).

The intramuscular but not the skin surface temperature was significantly correlated to sublingual temperature, reflecting the difference between core and shell temperatures of the human body (14). It also shows that

sublingual temperature should be recorded and taken into account when judging intramuscular temperature for diagnostic purposes.

The average spatial variation in skin surface temperature over the masseter found in this study was small, which indicates a rather homogeneous vascular distribution in the skin and underlying tissues in this particular area of 1 cm<sup>2</sup>.

The skin surface temperature over the anterior part of the origin of the masseter has been reported to be 34.4°C, and over the TMJ 35.2°C (7), which is higher than the temperature over the central part of the masseter found in this study. One explanation would be the location of arteries and veins between the skin, the masseter, and the TMJ. The external carotid artery passes slightly posterior to the joint and branches off the zygomatic artery passing superior to the joint and the transverse facial artery passing inferior to the joint. The latter artery follows the zygomatic arch, reaching the area of the anterior part of the origin of the superficial masseter muscle. In contrast, only distal ramifications of the transverse facial artery are located over the central part of the superficial masseter muscle.

The correlation between intramuscular and skin surface temperatures was positive but weaker than the corresponding correlation between skin surface and intra-articular temperature of the TMJ in symptom-free individuals (11). The weak correlation means great variation of the differences between skin surface and intramuscular temperatures. However, the correlation between skin surface and intramuscular temperatures might be quite different in patients with muscular disorders, as has been found for skin surface and intra-articular temperature of the TMJ in RA (13).

The reproducibility of both the intramuscular and the skin surface temperature within 4–5 weeks, as assessed by the standard deviation for a single measurement, is considered acceptable.

The results of this study show that an intramuscular or a skin surface temperature asymmetry of more than 1.0°C should raise suspicions about an abnormal condition.

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Received for publication 17 September 1990