

# Reproducibility and variation of skin surface temperature over the temporomandibular joint and masseter muscle in normal individuals

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Temperature, temperature differences between right and left sides, temperature variation with time, and temperature measurement reproducibility were investigated in 42 normal individuals over the origin of the superficial portion of the masseter muscle and the temporomandibular joint (TMJ) with fast- and slow-reacting thermistors. The average temperature was higher with the fast-reacting thermistor than with the slow-reacting thermistor for all measured locations. The temperature difference between the left and right side was in about 90% of the performed measurements less than or equal to 1°C in both locations. The temperature also differed between the two locations and was highest at the skin surface over the TMJ. The reproducibility of the method according to the standard deviation of a single measurement was satisfactory. □ *Humans; masticatory muscles; methods; thermography*

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Pathological conditions in joints and muscles are often associated with circulatory disturbances and/or inflammatory reactions located in the synovial membrane of the joint, the tendons, and the connective tissue in muscles and bone (1, 2). When these processes are close to the surface of the body, they influence the skin temperature, which can be measured by thermography (3, 4). Measurements of skin surface temperature may be useful in the assessment of disease activity and progress and in evaluation of treatment results, which otherwise is largely based on subjective observations (5). An objective instrument to record skin surface temperature could be useful in evaluation of temporomandibular joint (TMJ) disorders, as has been proposed previously (6–9). However, before the technique can be introduced for practical use in the clinic, its reliability must be studied.

This study is aimed at elucidating inter- and intra-individual temperature variations, variations in temperature differences between the right and left side, and the

reproducibility of temperature measurements on the skin surface over the TMJ and superficial masseter muscle in normal individuals.

## Materials and methods

Temperature measurements were performed on 42 individuals who were all free of tenderness to palpation of the TMJs and masticatory muscles and had a normal mandibular mobility. The mean age was 28 years (range, 20–61 years); 23 were women and 19 men. Two different thermistors were used to measure the temperature, one fast-reacting (35 individuals; Exacon SF-2A) and one slow-reacting (7 individuals; Exacon S18), which recorded stable temperatures after 1 min and 10–15 min, respectively. The thermistors were connected to a thermometer (Exacon MC 8900). The temperature was read to a tenth of a degree Celsius twice on both sides on the skin surface over the TMJ and over the most anterior

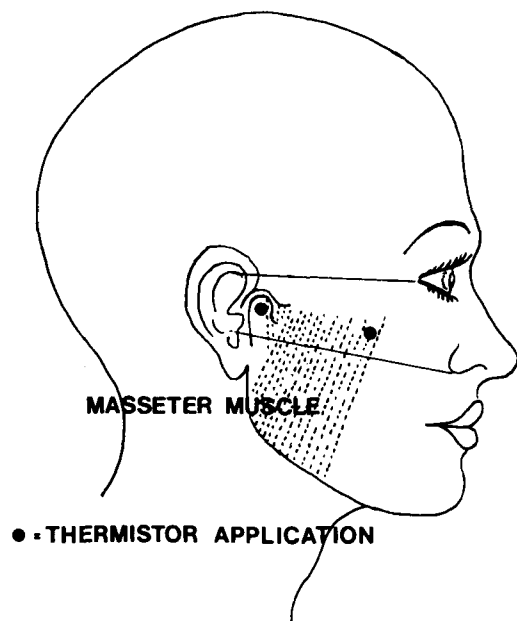


Fig. 1. Anatomic drawing of thermistor application over the superficial portion of the masseter muscle and over the temporomandibular joint.

part of the origin of the superficial portion of the masseter muscle just below the zygomatic arch (Fig. 1). The thermistor was replaced between the first and second measurement (reproducibility). In 10 individuals the temperature was also measured 6 weeks after the initial recording to estimate the intra-individual temperature variation with time. The room temperature varied between 21.4°C and 24°C ( $\bar{x} = 22^\circ\text{C}$ ,  $\text{SD} = 0.75$ ).

### Statistics

Differences between distributions were tested with Student's *t* test, and differences between variations with the variance ratio test,  $F = \frac{S_1^2}{S_2^2}$ . The reproducibility of measurements was estimated by the standard deviation of a single measurement,  $S = \sqrt{\frac{\sum d_i^2}{2n}}$ , and by the coefficient of variation in per cent,  $C = \frac{S \cdot 100}{\bar{x}}$ .

### Results

The average skin surface temperature (Table 1) was significantly higher over the TMJ than over the masseter muscle ( $p < 0.05$ ). The inter-individual variation of the temperature was significantly greater for the masseter muscle than for the TMJ when measured by the fast-reacting thermistor ( $p < 0.05$ ).

The reproducibility (Table 2, Fig. 2) of the two consecutive measurements was higher for the masseter muscle ( $0.18 \leq s \leq 0.34$ ) than for the TMJ ( $0.26 \leq s \leq 0.36$ ). This difference was statistically significant for the fast thermistor ( $p < 0.05$ ).

The temperature difference between the right and left side was  $< 1^\circ\text{C}$  in 89% of the individuals for the TMJ and in 84% for the masseter muscle. There was no statistically significant difference between masseter

Table 1. Averages, ranges, and standard deviations (SD) of skin surface temperature (in°C) over the masseter muscle and TMJ (second measurement)

		Average	Range	SD
<b>Masseter</b>				
Fast thermistor, <i>n</i> = 30	Right side	34.6	31.4–36.1	1.09
	Left side	34.4	32.3–36.3	0.96
Slow thermistor, <i>n</i> = 7	Right side	33.7	30.7–35.1	1.51
	Left side	33.7	31.6–34.8	1.18
<b>TMJ</b>				
Fast thermistor, <i>n</i> = 30	Right side	35.0	33.9–36.0	0.55
	Left side	35.0	34.0–36.2	0.54
Slow thermistor, <i>n</i> = 7	Right side	34.8	33.4–35.5	0.73
	Left side	34.9	33.8–36.0	0.67

Table 2. Reproducibility of measurement of skin surface temperature over the masseter muscle and TMJs. Averages of temperature differences between duplicate measurements (in °C), standard deviation of a single measurement (S), and the coefficient of variation (C) in percentage

		Average	S	C
<b>Masseter</b>				
Fast thermistor, n = 30	Right side	0.19	0.18	0.52
	Left side	0.18	0.19	0.55
Slow thermistor, n = 7	Right side	0.37	0.31	0.92
	Left side	0.44	0.34	1.00
<b>TMJ</b>				
Fast thermistor, n = 30	Right side	0.25	0.26	0.74
	Left side	0.31	0.30	0.90
Slow thermistor, n = 7	Right side	0.33	0.28	0.80
	Left side	0.37	0.36	1.00

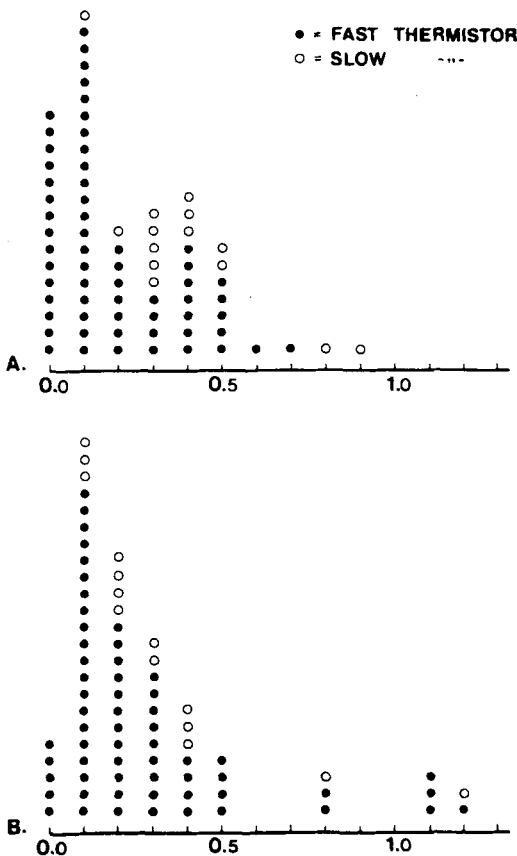


Fig. 2. Reproducibility of temperature measurement over the masseter muscle (A) and over the TMJ (B). Differences (in °C) between two consecutive independent measurements with slow and fast thermistors (n = 37).

muscle and TMJ with regard to difference between sides (Table 3, Fig. 3).

The absolute temperature variation in 6 weeks differed between the masseter muscle and the TMJ (Table 4), as did the temperature difference between the right and left side. The temperature differences were more constant than the absolute temperatures, especially for the TMJ. The differences were not statistically significant.

### Discussion

The normal skin surface temperature over the masseter muscle and the TMJ showed

Table 3. Averages and standard deviations (SD) of temperature differences between the right and left side of the masseter muscle and TMJ. Differences between averages of the two measurements on each side

	Average	SD
<b>Masseter</b>		
Fast thermistor, n = 30	0.61	0.41
Slow thermistor, n = 7	0.40	0.29
<b>TMJ</b>		
Fast thermistor, n = 30	0.44	0.35
Slow thermistor, n = 7	0.37	0.29

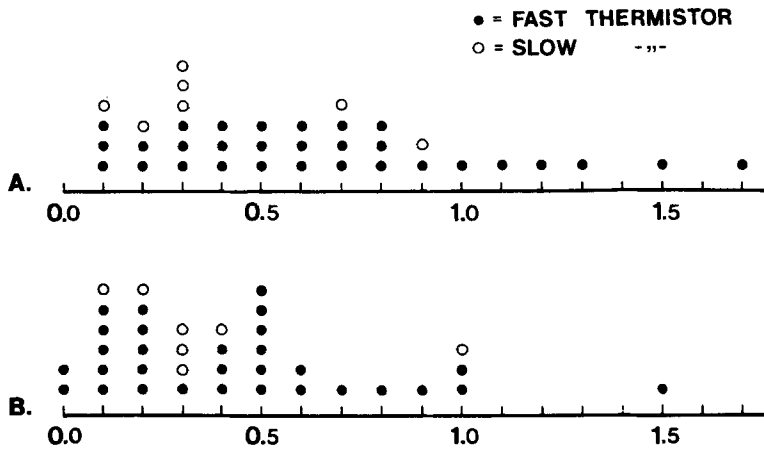


Fig. 3. Temperature difference (in °C) between the right and left side over the masseter muscle (A) and over the TMJ (B). Measurements with fast and slow thermistors (n = 37).

considerable inter- and intra-individual variation, although the TMJ temperature was more stable than masseter muscle temperature. Possible reasons for the variations are, for example, variation in room temperature, resting time before measurement, time the person has been indoors, and, of course, biological differences between the individuals. The experimental conditions with regard to the factors mentioned above have been standardized, except for room temperature, which varied within a range of 2.6°C, whereas 1°C would be preferable. Part of the intra- and inter-individual variation is thus caused by variation in room

temperature. The application site and the pressure of the thermistor against the skin also influence the temperature. For instance, an application cranial to the TMJ will locate the thermistor close to the superficial temporal artery and will result in a higher temperature than a correct application over the TMJ. Some of the differences between the right and left side might be explained by such incorrect application. Likewise, a hard pressure of the thermistor against the skin will cause a higher temperature than a light pressure (10). The pressure used should therefore be standardized in future studies. Other important factors influencing the

Table 4. Variation between measurements performed 6 weeks apart of skin surface temperature over the TMJ and superficial masseter muscle and of temperature differences between right and left side (in °C) in 10 individuals, measured by a fast-reacting thermistor

	Variation in temperature				Variation in temperature difference between right and left	
	Masseter		TMJ		Masseter	TMJ
	Right	Left	Right	Left		
1	1.3	2.0	1.1	1.2	0.8	0.1
2	0.4	0.0	1.0	0.7	0.4	0.1
3	0.8	0.6	0.9	0.1	0.2	0.0
4	1.2	1.2	1.0	0.4	0.3	0.2
5	0.9	0.2	0.2	0.1	0.3	0.3
6	0.7	0.4	0.8	0.6	0.3	0.2
7	0.3	0.5	0.0	0.3	0.2	0.3
8	0.4	0.2	0.9	0.9	0.2	0.0
9	0.6	1.5	0.3	0.4	0.9	0.1
10	0.8	0.7	0.2	0.3	0.1	0.1
$\bar{x}$	0.74	0.73	0.64	0.50	0.37	0.14
Range	0.3-1.3	0.0-2.0	0.2-1.1	0.1-1.2	0.1-0.9	0.0-0.3

inter-individual variability in temperature may be anatomic-physiologic differences in the absolute and relative amount of muscle, fat, connective tissue, and vascularization of the surrounding tissues.

The absolute temperature seems to be less useful as a diagnostic criterion of a normal or pathological condition depending on its great inter-individual variation (11). On the other hand, the intra-individual temperature difference between the right and left side may be of clinical importance when diagnosing unilateral pathological conditions that affect circulation, such as muscular hyperactivity and rheumatoid arthritis (9, 12). In this study almost 90% of the individuals showed a difference of less than or equal to 1°C between sides for the masseter muscle, in accordance with a previous study (13). For the TMJ only one difference between the sides exceeded 1°C. The intra-individual differences found between sides in normal subjects depend at least partly on the above-mentioned methodological factors and can probably be decreased by further improvement and standardization of the method, especially of room temperature, but at the present stage a difference should be 1°C or more to be judged clinically significant. The reproducibility of the technique, although satisfactory, can probably also be further improved by three or four measurements instead of one or two. Thermistor skin temperature measurement has been compared with measurement with an infrared camera (Bofors), and it was found that the two methods showed equal results (12).

Considering the intra-individual variation in temperature in 6 weeks in this study, there is further reason to believe that measurement of absolute skin surface temperature is of doubtful clinical value. The difference between the right and left sides, however, showed lower variability with time and could therefore be useful in this respect.

When the two types of thermistors are compared, the fast one is judged to be the most practical, partly depending on the gain of time and partly on better reproducibility of measurements.

The results of this study indicate that skin surface temperature measurements have an acceptable reproducibility and that the differences in skin surface temperature between the right and left TMJ/masseter muscle also have an acceptable constancy with time to be used in future clinical studies.

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