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# NORMATIVE STUDY OF TYMPANIC INFRARED THERMOMETRY

## A non-invasive index of asymmetric cerebral activity

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**Abstract** – Human and primate studies have demonstrated that performance of tasks that induce asymmetrical physiological activation of the cerebral hemispheres leads to a reduction of tympanic temperature (TT) ipsilateral to the most active hemisphere. It is possible that diseases that interfere in an asymmetrical fashion with the degree of cerebral activity cause similar TT changes. There are not, however, normative studies of the acceptable interaural difference in TT in normal subjects at rest. This study was done to establish normative values for interaural TT values measured by means of infrared tympanic thermometry in resting normal subjects not engaged in any specific task. TT values were measured in 47 normal volunteers (20 men and 27 women, aged  $39.38 \pm 12.57$  years old) at rest; mean interaural differences of TT were calculated. Mean right ear TT was  $36.85 \pm 0.50^\circ\text{C}$  and mean left ear TT was  $36.74 \pm 0.57^\circ\text{C}$ ; these values are in agreement with those already reported in the literature. Mean interaural TT difference was  $0.25^\circ\text{C}$  (SD  $0.21^\circ\text{C}$ ). These findings indicate that maximal normal values for interaural TT differences, with confidence levels of 99% and 95%, are, respectively,  $0.88$  and  $0.67^\circ\text{C}$ . The value of interaural differences of TT as a marker of asymmetrical hemispheric activity in neurological patients will have to be established by additional studies.

**KEY WORDS:** tympanic temperature, cerebral hemispheric asymmetry, neuropsychiatric disorders, infrared tympanic thermometry.

### Normatização da termometria timpânica por infravermelho: um indicador não-invasivo de atividade cerebral assimétrica

**Resumo** – Estudos em humanos e outros primatas demonstraram que a realização de tarefas que causam ativação assimétrica fisiológica dos hemisférios cerebrais resulta em redução da temperatura timpânica (TT) ipsilateral ao hemisfério cerebral mais ativo. É possível que patologias que interfiram de modo assimétrico com o grau de atividade cerebral causem alterações similares da TT. Não existem, entretanto, estudos normativos da diferença normal aceitável de TT entre os tímpanos de um mesmo indivíduo em repouso. Este estudo teve como objetivo estabelecer uma normatização dos valores bilaterais da TT, e principalmente das diferenças interauriculares desse parâmetro, obtidas por termometria timpânica por infravermelho, em indivíduos normais, na ausência de execução de tarefas específicas. Foram obtidas medidas da TT em 47 voluntários normais (20 homens e 27 mulheres, com média de idade de  $39,38 \pm 12,57$  anos) em repouso e calculadas as diferenças interauriculares, sua média e desvio-padrão. A TT média foi de  $36,85 \pm 0,50^\circ\text{C}$  à direita e de  $36,74 \pm 0,57^\circ\text{C}$  à esquerda, o que está de acordo com dados da literatura. A média das diferenças de TT encontrada foi de  $0,25^\circ\text{C}$  e o desvio padrão (DP)  $0,21^\circ\text{C}$ . Com base nesses achados, os valores máximos considerados normais para a diferença interauricular da TT, com níveis de confiança de 99% e de 95%, são de  $0,88^\circ\text{C}$  e  $0,67^\circ\text{C}$ , respectivamente. A utilidade da medida da diferença interauricular da TT como marcador de assimetria da atividade cerebral em pacientes com patologias neurológicas deverá ser avaliada em estudos adicionais.

**PALAVRAS-CHAVE:** temperatura timpânica, assimetria hemisférica cerebral, doenças neuropsiquiátricas, termometria timpânica por infravermelho.

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Received 27 July 2007, received in final form 30 October 2007. Accepted 6 December 2007.

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Tympanic temperature (TT) is an indirect marker of cerebral activity, and has been used to detect asymmetrical activity of the brain<sup>1-4</sup>. The rise in cerebral activity is indicated by a drop in TT ipsilateral to the most active hemisphere<sup>4</sup>. Meiner and Dabbs pointed out that the increased blood flow to the more active hemisphere has the effect of cooling it, and that this also causes a lower tympanic membrane temperature on the same side<sup>4</sup>. Swift et al.<sup>5</sup> studied changes in TT in normal volunteers who engaged in tasks that are known to cause asymmetrical cerebral activity, activating more strongly one cerebral hemisphere than the other. These authors found that subjects who presented with a greater asymmetry in TT values during the task, suggesting strong lateralization, also showed better performance in the tasks.

It is conceivable that certain neurological diseases may result in significant abnormal functional asymmetry of the cerebral hemispheres, even at rest, and that this abnormality could be detected by precise TT measurements. In order to use infrared tympanic thermometry as a clinical tool, however, it is imperative to establish the normal limits of physiological interaural variability of TT in resting normal subjects.

In this study we have measured TT bilaterally in normal subjects at rest, without engaging them in any potentially lateralizing cerebral activity, in order to establish the normal range of variability in interaural differences of TT.

## METHOD

After approval of the experimental protocol by the University of Brasilia Ethics Committee, we measured TT in 47 normal volunteers (20 men and 27 women, mean age 39.38±12.57 years). Forty-three subjects were right-handed; 4 were left-handed. TT was measured with an infrared thermometer (ThermoScan Plus® IRT 3520, Braun®, Germany). TT was measured bilaterally; 3 to 5 temperature readings were obtained on each side, alternating between left and right ears; the volunteers remained seated in a comfortable armchair, with eyes open, in a quiet room. The mean of all the measurements done on the same ear was recorded as the temperature value for that side. No volunteer presented any present evidence or past history of neurological or psychiatric diseases. There was no history of carotid athero-

sclerosis or otitis. No subject had any signs or symptoms of fever at the time of examination.

TT values were recorded and analysed with the aid of computerized spreadsheets (Microsoft Excel®) for further statistical processing by the SPSS® version 13 software for Windows®.

Means and standard deviations were calculated for absolute values as well as for interaural TT differences.

## RESULTS

Statistical analysis of the data showed a normal distribution (Kolmogorov-Smirnoff test). Mean TT was 36.85°C ±0.50°C on the right ear and 36.74±0.57°C on the left. Mean interaural difference was 0.25°C (SD, 0.21). The smallest interaural difference found was 0 (zero) and the greatest, 0.66°C. There were no significant differences between men and women regarding TT values and age (Student's t test, p=1.206 and p=0.234, respectively).

With the aid of these normative data, we can establish that 99% of the population should have an interaural difference of TT below 0.88°C (mean +3 SD) and 95 % should have a difference below 0.67°C (mean +2 SD). The Interaural TT differences data are summarized in Table 1.

## DISCUSSION

Nowadays the neurologist can use several tests to study cerebral activity, from quite simple ones to sophisticated and expensive methods. Asymmetric cerebral activity can be detected by infrared tympanic thermometry<sup>1-4</sup>, by functional magnetic resonance imaging, by electroencephalography or magnetopencephalography, by SPECT-single photon emission tomography<sup>6-13</sup> or by PET- positron emission tomography.

Of all these methods, the only one for which there are no normative data available in the literature is the determination of interaural difference of TT, since all studies done so far in humans<sup>1,2,4</sup> and in animals<sup>3</sup> only show how TT changes in response to various experimental tasks that induce functional hemispheric asymmetry. In such experimental settings, the interaural TT difference during the task is compared to that obtained before the task, and the subject serves as his own control. Other normative studies of TT in humans, although including large numbers of

Table. Interaural TT difference values of all subjects.

Absolute difference		Sample (n=47)	Men (n=20)	Women (n=27)
TT (°C)	Mean	0.2530	0.2958	0.2213
	SD	0.2104	0.2579	0.165
	+2 SD	0.6738		
	+3 SD	0.8842		
Age (years)	Mean	39.38	42.85	36.81
	SD	12.571	12.795	11.994

normal subjects over a wide age range, typically recorded TT from just one ear, since the aim of such studies was to validate the technique for the detection of fever<sup>14</sup>.

In the experimental setting, Parr and Kopkins<sup>3</sup>, studying non-human primates (chimpanzees), demonstrated that animals exposed to stimuli with strong emotional content (videos depicting episodes of aggression) showed a significant relative rise in the temperature of the right tympanic membrane; this temperature did not change when the animals looked at videos with neutral emotional content (landscapes, animals at play).

Infrared tympanic thermometry was also successfully employed by Tomaz et al.<sup>15</sup> to show hemispheric specialization in New World primates (*Callithrix penicillata*).

Recently, Cherbuin and Brinkman<sup>1</sup> have validated the technique of tympanic thermometry in humans during the execution of verbal tasks that preferentially activated the left cerebral hemisphere, or visuo-spatial tasks that preferentially activated the right cerebral hemisphere. These authors were able to demonstrate predictable changes in TT, with a drop in the temperature of the left tympanic membrane during the verbal tasks and of the right tympanic membrane during the visuo-spatial tasks. These same authors<sup>16</sup> again demonstrated the utility of this technique using more complex experimental paradigms, pointing out its potential advantages over other more complex and expensive means of detection of asymmetrical cerebral activity, such as functional magnetic resonance imaging, eletroencefalography and magneto-encefalography.

Although infrared tympanic thermometry has been widely used as a means of assessing physiological asymmetry in cerebral activity, in both humans and other primates, its potential for use in the detection of pathological lateralization of cerebral activity remains to be established. Studies with other methods, such as electroencefalography, have demonstrated correlations between inter-hemispheric asymmetry of cerebral activity and diseases such as depression, anxiety and other emotional disturbances, but the greater complexity of these techniques has caused methodological problems that make it difficult to compare the results of different researchers<sup>17</sup>. An advantage of infrared tympanic thermometry is its extreme simplicity, making it suitable for standardization that would allow easy comparison of results obtained by different laboratories.

As far as we know, this is the first normative study of infrared tympanic thermometry with measurement of bilateral TTs and assessment of the normal range of interaural TT variability. Based on our findings, we propose that the upper limit of normal interaural TT difference is

0.88°C for a confidence level of 99% or 0.67°C for a confidence level of 95%. These values certainly apply to our local population, from which we have derived a sample with a normal distribution; however, given the ease with which the measurements can be made, we advise other researchers to use their own local normative data based on a study of at least 30 subjects.

Infrared tympanic thermometry is an easy technique that may be useful as a clinical or experimental procedure for the detection of assymmetric cerebral function in neurological and psychiatric conditions. This pilot study shows that it is reproducible and that the upper limits of normal variability in interaural differences of TT in resting normal subjects can be easily determined.

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