

# Quantification of thermal asymmetry

## Part 1: Normal values and reproducibility

SUMIO UEMATSU, M.D., DAVID H. EDWIN, PH.D., WILLIAM R. JANKEL, PH.D.,  
JOSEPH KOZIKOWSKI, M.S.E.E., AND MICHAEL TRATTNER, R.T.

*Departments of Neurosurgery and Psychiatry, The Johns Hopkins Medical Institutions, Baltimore, Maryland*

✓ The use of thermography in evaluating nerve injury is based on the presence of temperature asymmetries between the involved area of innervation and the corresponding area on the opposite side of the body. However, interpretation of the thermographic image has been troubled by subjectivity. This paper describes a computer-calculated method of collecting data that eliminates subjective biases. Comprehensive normative data are presented on the degree of thermal asymmetry in the human body.

The degree of thermal asymmetry between opposite sides of the body ( $\Delta T$ ) is very small. For example, the value of  $\Delta T$  for the forehead (mean  $\pm$  standard deviation) was  $0.18^\circ \pm 0.18^\circ\text{C}$ , for the leg it was  $0.27^\circ \pm 0.2^\circ\text{C}$ , and for the foot it was  $0.38^\circ \pm 0.31^\circ\text{C}$ . These values were reproducible in both short- and long-term follow-up measurements over a period of 5 years. The  $\Delta T$ 's reported here were obtained from 40 matched regions of the body surface of 90 asymptomatic normal individuals. These values can be used as a standard in assessment of sympathetic nerve function, and the degree of asymmetry is a quantifiable indicator of dysfunction.

**KEY WORDS** • thermography • thermometry • nerve injury

### Normal Subjects and Methods

#### *Normal Subjects*

The participants in this study were 90 healthy volunteers (38 men and 52 women) ranging in age from 19 to 59 years. All participants gave informed consent for the procedure. None of the participants reported ongoing acute or chronic pain, such as low-back pain, sciatica, recent or old body injury, or surgical procedures.

#### *Study Procedure*

All tests were conducted in the thermography laboratory, which is located in a central part of the hospital building, has no windows, and is free from drafts and interruptions. There is only one door in the testing room and conditions are monitored to ensure year-round ambient temperature stability at  $23^\circ$  to  $26^\circ\text{C}$  and humidity between 45% and 60%. Recognized thermographic guidelines are strictly followed.<sup>4</sup> Volunteers disrobe and remain in the laboratory for approximately 20 minutes in order to equilibrate their body-surface temperature to the room temperature.

**T**HE skin, one of the largest organs of the body, is equipped with a network of vessels accompanied by dense nerve fibers. It serves as the body's thermoregulator, controlling blood flow within a few millimeters of the body surface.<sup>6</sup> The system is governed by autonomic nerve impulses generated from the hypothalamus and the brain as a whole. The system is both anatomically and physiologically symmetrical.<sup>5</sup> For this reason, localized, asymmetric temperature changes at the body surface have interested physicians as far back as Hippocrates.<sup>8</sup> The recent development of sophisticated thermographic measuring devices that can provide a map of the temperature of the body surface has increased this interest.<sup>7</sup> However, thermography has been criticized for its possible lack of objectivity, arising from interpretation of the colored thermogram. To minimize such subjectivity, it is proposed to use computer-calculated temperature differences ( $\Delta T$ 's) between homologous sections of the body as measures of the degree of thermal asymmetry.<sup>7</sup> This paper summarizes the  $\Delta T$ 's calculated for normal control subjects and discusses their use as a standard for evaluation of sympathetic nerve function in man.