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Body temperature is a vital sign and it is important to measure it accurately. This article reviews and compares the various methods available to nurses

Measuring body temperature

In this article...

- The physiological processes that regulate body temperature
- The clinical indications for measuring temperature
- A review of various methods of temperature measurement

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Body temperature is one of the four main vital signs that must be monitored to ensure safe and effective care. Temperature measurement is recommended by the National Institute of Clinical Excellence a part of the initial assessment in acute illness in adults (NICE, 2007) and by the Scottish Intercollegiate Guidelines Network guidelines for post-operative management in adults (SIGN, 2004). Despite applying in all healthcare environments, wide variations exist on the methods and techniques used to measure body temperature.

It is essential to use the most appropriate technique to ensure that temperature is measured accurately. Inaccurate results may influence diagnosis and treatment, lead to a failure to identify patient deterioration and compromise patient safety.

This article explains the importance of temperature regulation and compares methods of its measurement.

Body temperature represents the balance between heat production and heat loss (Marieb and Hoehn, 2010). If the rate of heat generated equates to the rate of heat lost, the core body temperature will be stable (Tortora and Derrickson, 2011).

All metabolising body cells manufacture heat in varying amounts. Therefore, body temperature is not evenly distributed across the body (Childs, 2011).

Core body temperature is found in the blood supplying organs such as the brain and those in the abdominal and thoracic cavities. Core temperature may be affected by intrinsic factors and, to a lesser degree, extrinsic (environmental) factors.

Peripheral temperature is recorded in tissues such as the skin, where environmental factors and a lack of insulating connective tissue influence temperature.

Box 1 sets out some intrinsic factors that influence temperature.

A healthy body maintains its temperature within a narrow range using homeostatic thermoregulation mechanisms (Pocock and Richards, 2009). The normal range for core temperature in the literature varies, although 36°C-37.5°C is acceptable in clinical practice (Childs, 2011).

Extremes of temperature are easier to interpret (Box 2). It is estimated that accompanying every 1°C rise in body temperature is a 10% rise in the rate of enzyme-controlled chemical reactions (Marieb and Hoehn, 2010). At 43°C and above, cells are irreparably damaged and enzymes denatured, rendering death a certainty (Marieb and Hoehn, 2010). Conversely, as temperature drops, cellular processes become sluggish and the metabolic rate falls. Pocock and Richards (2009) suggest that consciousness is lost 33°C. The body is generally more tolerant of lower than higher temperatures (Marieb and Hoehn, 2010).

Maintenance of body temperature

The thermoregulatory centre is located in the hypothalamus in the brain. It consists of the heat-loss centre, the heat-promoting centre and the pre-optic region, which

5 key points

1. Body temperature is one of the four main vital signs that must be monitored in a patient
2. Wide variations in practice exist across the healthcare system for measuring body temperature
3. Body temperature should be measured and recorded regularly with precision, consistency and diligence
4. It is vital to measure temperature accurately as it has an impact on diagnosis and treatment
5. Inaccurate temperature measurement may compromise patient safety

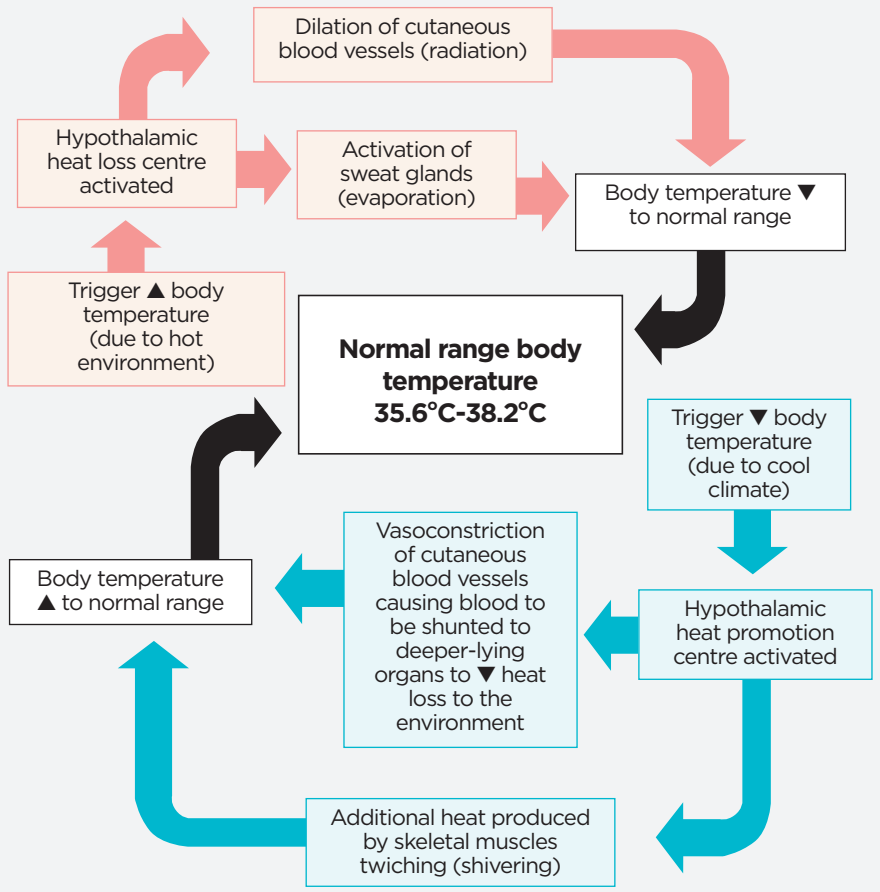
analyse and coordinate responses to maintain body temperature within the homeostatic range (Marieb and Hoehn, 2010).

Signals arrive at the thermoregulatory centre via afferent pathways from the sensory receptors in the skin and organs. The centre's response is propagated along efferent neural pathways to the target organ or blood vessel to elicit a response to gain or lose heat (Childs, 2011).

Behavioural mechanisms, such as removing or adding layers of clothing, also play an important role.

Fig 1 outlines the autonomic physiological mechanisms that are activated through the thermoregulatory centre to keep body temperature within the normal range.

FIG 1. **AUTONOMIC PHYSIOLOGICAL MECHANISMS**



Adapted from: Marieb and Hoehn (2010)

Indications for measurement

There are many clinical indications for measuring body temperature (Dougherty and Lister, 2011; Pocock and Richards, 2009). They include:

- To obtain a the baseline temperature to enable comparisons to be made with future recordings;
- To enable close observation in resolving hypothermia/hyperthermia;
- To observe and monitor patients for changes indicating an infection;
- To monitor the effect of treatment for antimicrobial therapy for infection;
- Before and during a blood transfusion to monitor for signs of a reaction.

Measuring body temperature

The measurement of core body temperature may seem simple, but several issues affect the accuracy of the reading. These include the measurement site, the reliability of the instrument and user technique (Pusnik and Miklavec, 2009). Practitioners must understand the advantages and disadvantages associated with the chosen method so they can explain the procedure to patients and obtain valid consent (Nursing and Midwifery Council, 2008).

True core temperature readings can only be measured by invasive means, such as placing a temperature probe into the oesophagus, pulmonary artery or urinary bladder (Childs, 2011). It is not practical, nor indeed necessary, to use such sites and methods in all cases; they tend to be reserved for patients who are critically ill.

Non-invasive sites such as the rectum, oral cavity, axilla, temporal artery (forehead) and external auditory canal are accessible and are believed to provide the best estimation of the core temperature (Pusnik and Miklavec, 2009). The temperature measured between these sites can vary greatly, so the same site ought to be used consistently and recorded on the chart with the reading (Davie and Amoore, 2010).

Oral cavity

The oral cavity temperature is considered to be reliable when the thermometer is placed posteriorly into the sublingual pocket (Hamilton and Price, 2007). This landmark is close to the sublingual artery, so this site tracks changes in core body temperature (Dougherty and Lister, 2011).

BOX 1. **INTRINSIC FACTORS THAT INFLUENCE TEMPERATURE**

Factor	Effect
Ovulation	▲Body temperature
Circadian rhythm	▲ In evening ▼ In early hours of morning
Age	Young and older inability to maintain equilibrium
Exercise	▲ Body temperature
Thyroid hormones	▲ Metabolic rate therefore... ▲ Body temperature

Electronic or disposable chemical thermometers may be used. Chemical thermometers should be avoided if the patient is hypothermic (<35°C) because their range of operation is 35.5°C-40.4°C (Fulbrook, 1997). Low-reading thermometers may be of some use. Mercury-in-glass thermometers can no longer be bought because of European Council rules (Medicines and Healthcare products Regulatory Agency, 2011).

Care must be taken to avoid the anterior region immediately posterior to the lower incisors because the temperature here is substantially lower (Dougherty and Lister, 2011).

Factors affecting accuracy include recent ingestion of food or fluid, having a respiratory rate >18 per minute and smoking (Dougherty and Lister, 2011). Oxygen therapy, particularly with high-flow rates, may influence temperature but this claim has been refuted by Stanhope (2006).

Tympanic temperature

The tympanic thermometer senses reflected infrared emissions from the tympanic membrane through a probe placed in the external auditory canal (Davie and Amoore,

2010). This method is quick (<1 minute), minimally invasive and easy to perform. It has been reported to estimate rapid fluctuations in core temperature accurately because the tympanic membrane is close to the hypothalamus (Stanhope, 2006).

Although its accuracy and reliability have been questioned in many studies in the past decade, with differing outcomes. Tympanic thermometry continues to be used. Operator error and poor technique are frequently cited problems (Farnell et al, 2005), so training is recommended. Ear wax is known to reduce the accuracy of readings, so it is recommended that the ear is inspected before measurement (Farnell et al, 2005).

Advantages of this site are that the measurement does not appear to be influenced by oral fluids or diet, environmental temperature or other extraneous variables (Robb and Shahab, 2001). If patients have been lying with their ear on a pillow, allow 20 minutes to elapse so the temperature can normalise (Bridges and Thomas, 2009).

Axillary temperature

Temperature is measured at the axilla by placing the thermometer in the central position and adducting the arm close to the chest wall.

The literature suggests that this is an unreliable site for estimating core body temperature because there are no main blood vessels around this area (Sund-Levander and Grodzinsky, 2009). These authors also argue that the axillary temperature can be affected by the environmental temperature and perspiration.

Fulbrook (1997) produced convincing evidence indicating that chemical thermometers are clinically unreliable for measuring axillary temperature. Giantin et al (2008) suggested that electronic digital thermometers can be used at this site as a reliable alternative in older people.

Rectal temperature

Rectal temperature is said to be the most accurate method for measuring the core temperature (Lefrant et al, 2003). However, obtaining this is more time consuming than other methods and might be considered unfavourable for some patients (Dzarr et al, 2009). Practitioners should pay particular attention to issues of privacy.

The presence of faeces prevents the thermometer from touching the wall of the bowel and may generate inaccurate readings (Sund-Levander and Grodzinsky, 2009). Sund-Levander and Grodzinsky (2009) suggested this method does not track immediate changes to core temperature because of the low flow of blood to the area, so core temperature may be under- or over-estimated at times of rapid flux.

BOX 2. TEMPERATURE INTERPRETATIONS

Term	Definition
Hypothermia	Core temperature <35°C Metabolic rate falls Subcategories: Mild: 32°C-35°C Moderate: 28°C-32°C Severe: <28°C
Fever	Fever is a rise in temperature >38°C and is a normal response to infection, inflammation or drug therapy. Hypothalamus is functioning normally but the set point is raised beyond the normal level by pyrogens.
Hyperthermia	Core temperature >40°C and body temperature is out of control. Associated with injury/damage to the head resulting in hypothalamic failure.

Temporal artery temperature

The temporal artery thermometer is quick to use. It is held over the forehead and senses infrared emissions radiating from the skin (Davie and Amoore, 2010). However, its reliability and validity have not been widely tested. A single-centre study comparing it with other methods found that, despite the infection control advantages of this non-touch method, it underestimated body temperature compared with the control (Duncan et al, 2008).

Conclusion

Body temperature should be measured and recorded regularly with precision, consistency and diligence. Practitioners should be acutely aware of patients' temperature because it serves as a useful indicator of change in their clinical condition.

A review has illustrated that none of the methods for measuring temperature at the bedside is perfect (Davie and Amoore, 2010). Once a site and a method have been selected, they must be used consistently to ensure accuracy and patient safety. **NT**

References

Bridges E, Thomas K (2009) Noninvasive measurement of body temperature in critically ill patients. *Critical Care Nurse;* 29, 94-97.
Childs C (2011) Maintaining body temperature. In: Brooker C, Nicol M (eds) *Alexander's Nursing Practice.* Oxford: Elesvier.
Davie A, Amoore J (2010) Best practice in the measurement of body temperature. *Nursing Standard;* 24: 42, 42-49.
Dougherty L, Lister S (2011) *The Royal Marsden Hospital Manual of Clinical Nursing Procedures.* Oxford: Blackwell Publishing.
Duncan A et al (2008) Can a non-contact infrared thermometer be used interchangeably with other thermometers in an adult emergency department? *Australasian Emergency Nursing Journal;* 11: 130-134.
Dzarr A et al (2009) A comparison between infrared tympanic thermometry, oral and axilla with rectal thermometry in neutropenic adults. *European Journal of Oncology Nursing;* 13, 250-254.
Farnell S et al (2005) Temperature measurement: comparison of non-invasive methods in critical care. *Journal of Clinical Nursing;* 14: 632-639.
Fulbrook P (1997) Core body temperature measurement: a comparison of axilla, tympanic membrane and pulmonary artery blood temperature. *Intensive and Critical Care Nursing;* 13: 266-272.
Giantin V et al (2008) Reliability of body temperature measurements in hospitalised older patients. *Journal of Clinical Nursing;* 17: 1518-1525.
Hamilton P, Price T (2007) The nursing process, holistic assessment and baseline observations. In: Brooker C, Waugh A (eds) *Foundations of Nursing Practice Fundamentals of Holistic Care.* London: Mosby Elsevier.
Lefrant J et al (2003) Temperature measurement in intensive care patients: comparison of urinary bladder, oesophageal, rectal, axillary, inguinal methods versus pulmonary artery core method. *Intensive Care Medicine;* 29: 3, 414-418.
Marieb E, Hoehn K (2010) *Human Anatomy and Physiology with Interactive Physiology 10-System Suite.* New York, NY: Pearson Publishing.
Medicines and Healthcare products Regulatory Agency (2011) *Mercury in Medical Devices.* London: MHRA. tinyurl.com/mhraMercurymedical
National Institute for Health and Clinical Excellence (2007) *Acutely Ill Patients in Hospital: Recognition of and Response to Acute Illness in Adults in Hospital.* London: NICE. www.nice.org.uk/CG50
Nursing and Midwifery Council (2008) *The Code: Standards of Conduct, Performance and Ethics for Nurses and Midwives.* London: NMC. ww.nmc-uk.org/code
Pocock G, Richards C (2009) *The Human Body: an Introduction for the Biomedical and Health Sciences.* New York, NY: Oxford University Press.
Pusnik I, Miklavec A (2009) Dilemmas in measurement of human body temperature. *Instrument Science Technology;* 37: 516-530.
Robb P, Shahab R (2001) Infrared transtympanic temperature measurement and otitis media with effusion. *International Journal of Pediatric Otorhinolaryngology;* 59: 3, 195–200.
Scottish Intercollegiate Guidelines Network (2004) *Postoperative Management in Adults: a Practical Guide to Postoperative Care for Clinical Staff.* Edinburgh: SIGN. www.sign.ac.uk/pdf/sign77.pdf
Stanhope N (2006) Temperature measurement in the phase I PACU. *Journal of PeriAnesthesia Nursing;* 21: 1, 27-36.
Sund-Levander M, Grodzinsky E (2009) Time for a change to assess and evaluate body temperature in clinical practice. *International Journal of Nursing Practice;* 15: 4, 241-249.
Tortora G, Derrickson B (2011) *Principles of Anatomy and Physiology.* New York, NY: John Wiley & Sons.