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✣ **SCHOLARLY PAPER** ✣

Time for a change to assess and evaluate body temperature in clinical practice

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The definition of normal body temperature as 37°C still is considered the norm worldwide, but in practice there is a widespread confusion of the evaluation of body temperature, especially in elderly individuals. In this paper, we discuss the relevance of normal body temperature as 37°C and consequences in clinical practice. Our conclusion is that body temperature should be evaluated in relation to the individual variability and that the best approach is to use the same site, and an unadjusted mode without adjustments to other sites. If the baseline value is not known, it is important to notice that frail elderly individuals are at risk of a low body temperature. In addition, what should be regarded as fever is closely related to what is considered as normal body temperature. That is, as normal body temperature shows individual variations, it is reasonable that the same should hold true for the febrile range.

Key words: assessment, evidence-based, fever, normal body temperature, nursing.

INTRODUCTION

Evaluation of body temperature is one of the oldest known diagnostic methods[1,2] and is still an important sign of health and disease, both in everyday life and in medical care. The definition of normal body temperature as 37°C and fever as 38.0°C was formulated in the middle of the 19th century by the German physician Wunderlich,[3,4] when thermometers were also introduced into medical practice.[5] At that time, the physiological mechanisms of body temperature regulation, the influence of hormones, cellular metabolism, physical activity, knowledge about immunology and microbiology and methods for calibration of the thermometers were not known. In addition, the measurements were performed on patients, indicating that a large number might have been febrile. Moreover, the axillary site was used, which gives only an estimate of peripheral temperature,[6,7] and the measurement was performed in a non-standardized way. Also, Mackowiak and Worden showed that the thermometer used at that time measured 1.4–2.2°C higher compared with modern digital devices.[8]

Although today there is a general acceptance of body temperature as a range rather than a fixed temperature,[9] the definition of normal body temperature as 37°C and fever as ≥ 38°C still is considered the norm worldwide. As a consequence, there is a widespread confusion of the evaluation of body temperature in adults,[9] especially in

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elderly individuals.[10–12] Additionally, a systematic review showed a lack of studies performing temperature measurements in a standardized way.[13]

In clinical practice, assessment and evaluation of body temperature has great impact on decisions in nursing care as well as medical diagnosis, treatment and the laboratory test ordered. In addition, all decisions should be based on scientific knowledge and evidence-based experience.[14] Yet, in clinical practice, measurement and evaluation of body temperature is still based more on tradition than on scientific knowledge;[15,16] that is, the norm from the middle of the 19th century is still the basis for assessment and decisions about body temperature.[9] Therefore, the objective of this paper was to discuss the relevance of normal body temperature as 37°C, and some implications in clinical practice.

A literature search was performed in MEDLINE, CINAHL and manually from identified articles' reference lists. The concept body temperature related to different constellations of key words, such as measurement/normal/core/human/review/adult/gender/tympanic/rectal/oral/axillary/thermometers, and also hypothermia and elderly, thermoregulation, circadian rhythm, fever, febrile response and shivering was used to identify articles. The search included textbooks, original papers, reviews and scholarly papers. No restriction was made concerning when the paper was published, but the published papers were required to be published in English or Swedish.

FACTORS INFLUENCING BODY TEMPERATURE

When assessing body temperature, some basic aspects have to be considered, namely the influence of normal thermoregulation, gender, ageing and site of measurement.

Thermoregulation

Thermosensitive neurons in the preoptic anterior area of the hypothalamus integrate information from the surrounding blood and peripheral receptors in order to maintain the body temperature within an individual temperature range, the set point.[17,18] Neurons in the midbrain reticular formation and in the spinal cord respond to thermal stimulation of the skin,[19] and the vagus nerve acts as a signal-transfer pathway from the periphery to the brain.[20] In a thermally neutral environment, heat loss responses are activated when the preoptic anterior area of the hypothalamus is warmed above the set point, and heat production responses when the area is cooled below the set point. In a warm environment, the set point shifts to a lower level to increase heat loss responses and inhibit heat production, and in a cold environment the set point shifts to a higher level to evoke heat production, with shivering as the emergency response, and inhibit heat loss mechanisms.[17,18] Several factors influence thermoregulation, such as diurnal variation, cellular metabolism,[19,21] exercise[22] and ambient temperature.[23] The diurnal rhythm is consistent within the individual both in health and in disease. Temperatures in the morning vary less compared with afternoon–early evening, underscoring the influence of exogenous factors during the daytime.[21] Aside from the autonomous mechanisms, the skin and the subcutaneous tissues effectively insulate the body, and behavioural control re-establishes comfort through conscious adjustments.[24,25]

For each 4 mm of depth, from the body surface there is a rise in temperature of ≈1°C,[26] with the warmest temperatures in the thoracic and abdominal contents, some of the muscles and the brain, that is, core temperatures.[27]

Gender

It is established that women have a higher average body temperature than men,[28,29] because of female hormones[30] and a lower baseline metabolic rate.[31] It is suggested that women maintain thermal equilibrium at higher ambient temperatures than men, and that they have a higher sweat onset and lower sweating capacity compared with men when exposed to heat.[24] Furthermore, women generally have a thicker layer of subcutaneous fat, which helps to insulate the core from heat gain during hot conditions.[31] Also, resent research indicates that postmenopausal women have a lower body temperature compared with premenopausal women.[32]

Ageing

No differences in the average normal body temperature in healthy elderly women and men have been found.[33,34] Changes in temperature regulation with ageing have been studied with conflicting results,[33,35–37] but an increased frequency of hypothermia[38] and an altered shivering response have been reported.[39,40] The presence of dementia, dependence in activities in daily living and a body mass index $\leq$ 20 have been found to be related to an increased risk of a lower body temperature, whereas daily medication with analgesics was associated with a higher

temperature.[41] Thermoregulation is suggested to be impaired in older people because of age-related factors, such as reduced proportion of heat-producing cells, decrease in total body water, delayed and reduced vasoconstriction and vasodilation response,[40,42–44] a decreased sweating rate on body warming,[42] decreased metabolic rate,[45] and secondary to impairment and disease. The sedentary lifestyle of elderly might also lower heat production.[19]

Body temperature measurement

There are two different technical designs of temperature devices. The digital electronic thermometers, for example, catheters for invasive measurement and rectal, oral and axillary devices, have a thermistor or thermocouple sensor that produces electronic signals that change with differences in tissue temperature. The infrared radiation ear device (IRED) estimates the infrared heat waves from the tympanic membrane.[46]

The rectal site

The rectal site is an indication of the deep visceral temperature, modified by the temperature of the skin of the buttocks, the iliac artery and the iliac vein.[27] The rectal temperature is higher than at other places in steady state,[47–53] because of the low blood flow and high isolation of the area, giving a low heat loss.[54] As it significantly lags behind changes at other core sites, especially during rapid temperature changes such as warming and cooling during surgery, exercise and fever,[49,55–58] the rectal temperature might be both higher or lower than the core temperature.[46] Hard stool might obstruct adequate placement of the thermometer; inflammation around the rectum[59] and heat-producing activity of microorganisms in faeces influence the reading.[46,56] As the temperature increase by 0.8°C with each 2.54 cm the device is inserted,[49,58] a standardized depth of 4 cm in adults is recommended.[46]

The oral site

As a branch of the external carotid artery perfuses the area of the posterior sublingual pockets, the oral temperature follows changes in core temperature,[46] but the sublingual temperature differs between the posterior pocket and the front area,[60] as well as between the posterior pockets.[61] Also, vasomotor activity in the sublingual area affects the temperature;[62] for example, a fall in oral temperature during the onset of fever might occur due to a reduced blood flow.[55,63] Other influencing factors are salivation,[46] previous intake of hot or cold food and fluids,[46,64,65] gum chewing, smoking[65] and rapid breathing.[63]

The axillary site

Several factors affect the accuracy of axillary measurement, such as ambient temperature, local blood flow, underarm sweat, inappropriate placing of the probe or closure of the axillary cavity, and insufficient duration of the reading.[46] In addition, temperature differences between the right and left axilla of up to 1.4°C in steady state have been reported.[66] As axillary measurements, even with careful positioning, are slow to register changes in core temperature, the readings exhibit a wide deviation from other sites.[56] During fever, the skin temperature varies dynamically due to vasomotor activity. Therefore, monitoring the skin temperature is an insensitive technique for estimating the core temperature.[6,7]

The ear site

The tympanic membrane and hypothalamus share their blood supply from the internal and external carotid arteries[67,68] and the area is relatively devoid of metabolic activity. As the probe is placed ≈1.5 cm away from the tympanic membrane,[49] the reading is a mix of heat from the tympanic membrane and the aural canal.[69] The accuracy of IRED for the tympanic membrane temperature[70–73] and repeatability and accuracy for changes in the core temperature during physical exercise and warming[74] is reported to be good. Ambient temperature might alter IRED readings,[51,72,75] although no affect was found during facial cooling or fanning.[71,72] The influence of cerumen is inconsistent, with some studies reporting no influence,[61,76,77] whereas others observed a higher variability[65] and an underestimation by an average of 0.3°C.[78] The occurrence of otitis media has been associated with 0.1°C higher values,[76] whereas others reported no effect.[79] The value of IRED measurements in clinical practice is not consistent, with some authors in favour of them[29,51,56,58,70–74,80–88] and others not, because of observed differences between left and right ear and poor repeatability.[54,57,89–93]

Comparison of different sites

The temperature in the pulmonary artery is generally considered the gold standard of core temperature,[6,94] but in clinical practice the rectal site has been considered estimating the 'true' body temperature. Therefore, by tradition, the oral and axillary readings are adjusted to the

rectal temperature by adding 0.3°C and 0.5°C, respectively.[75] The ear temperature can be measured without adjustments to other sites, or readjusted in order to equalize the oral, rectal or pulmonary artery temperature.[75] These adjustments to other sites vary considerably between manufactures.[52,70,83,95,96] When comparing simultaneously measured rectal, oral, ear and axillary temperatures, without adjustments, in healthy adult subjects, the deviation was large: for rectal–ear −0.7°C to +2.8°C, for rectal–axillary −1.4°C to +2.3°C and for rectal–oral temperatures −1.5°C to +2.3°C.[32]

DISCUSSION

This paper is not a systematic review and we are aware of the fact that our reviewed literature does not cover all published papers and textbooks about factors influencing body temperature. Even so, we think our references give a balanced picture of the literature in this subject.

Taken together, the literature cited reveals that there is considerable knowledge about thermoregulation, factors influencing normal body temperature and methods for assessing body temperature. Taken together, the review supports that there is a lack of evidence for normal body temperature as 37°C, and that the variation is wide because of inter- and intraindividual variability.[97] As body temperature varies with age, gender and site of measurement, our interpretation is that body temperature should be evaluated in relation to individual variability, that is, a baseline value, and that the best approach is to use the same site, without adjustments to other sites. If the baseline value is not known, it is important to notice that frail elderly individuals are at risk of a low body temperature.[41] In addition, our conclusion is that what should be regarded as fever is closely related to what is considered as normal body temperature.[97] That is, as normal body temperature shows individual variations, it is reasonable that the same should hold true for the febrile range.[98]

Clinical implications

The fact that subgroups of elderly individuals have a lower baseline body temperature because of age-related changes and fragility[11,41,99,100] is of significant importance in clinical care. As atypical symptoms are common in infected elderly individuals,[101,102] increased body temperature becomes an important sign of infection. However, atypical symptoms and the fact that a lower baseline body temperature might be related to a lower febrile response[103,104] and that fever is not reported until the temperature is $\geq$ 38°C can contribute to a delayed diagnosis and therapy[7] and, thereby, mortality.[105] Hence, it would be wise to establish the individual baseline body temperature in the morning on admission to the nursing-home facility as a basis for assessing fever. Furthermore, an increased baseline body temperature in individuals on daily medication with paracetamol[41] reflects the possibility that pain, which is common in aged individuals,[106] is related to chronic low-grade inflammation with increased circulating levels of IL-6 and consequent fever.[107]

Many studies have focused on the degree of closeness between different sites of measurement in order to define the best choice for estimating the core temperature non-invasively.[97] However, there is no evidence for adjusting one site to another; that is, no factor does exist that allows accurate conversion of temperatures recorded at one site to estimate the temperature at another site.[32,108] It is not possible to interchange different temperatures[109] or to claim that there is *one* range of core body temperature.[110] To define acceptable accuracy[57] between sites or to use the term equivalence only contributes to misunderstandings and confusion.[75] In addition, the use of fixed cut-off values for fever depending on the normal range at different sites[100,111] is confusing and not significant. In addition, temperatures outside hypothalamus are themselves estimates of the core temperature with their own variability.[112] Hence, use of the rectal temperature as the reference might result in the ear reading as an inaccurate and insensitive method for detecting fever when the reading instead reflects the fact that a change to defervesce has already occurred, thus resulting in the recording of a lower ear temperature and a still high rectal temperature.[29] Also, as medication with analgesics is common in elderly individuals and antipyretics are frequently used in febrile patients,[113] the low reading might be due to antipyretics affecting the ear temperature while the rectal temperature is still increased.

All methods require careful handling and experienced users,[95,110] but training in operator technique ensures consistency in ear temperature measurement in particular. In addition, recently, Duberg *el al.* found that a narrow ear cavity showed poorer repeatability, probably related to difficulty to place the probe in a proper way.[114] Also, the temperatures measured in either the left[115] or the right ear[116] have been observed to be lower and more variable, indicating the possible impact of operator hand dominance on the temperature readings.[115]

At last, in order to lower body temperature, it is still common in nursing care to cool the skin when the patient is feverish,[16,113,117] especially in neurosurgery intensive care.[118] However, according to thermoregulation, an increased temperature gradient between the core and the peripheral temperature triggers shivering.[119] Although shivering is the body's emergency response to heat loss, it is extremely strainful on the body, increasing myocardial oxygen consumption, releasing stress hormones[120–122] and increasing the metabolism by up to 500%.[119] Shivering is also unpleasant and painful to the patient and related to fatigue, exhaustion and feelings of helplessness,[123] and can cause the core temperature to drift to the direction of the skin temperature.[124,125] In the febrile patient, antipyretics, therefore, is necessary before surface cooling starts to decrease the gradient between core and peripheral temperature and thereby prevent shivering. Consequently, as the set point is already lowered by antipyretics, the routine with surface cooling could be questioned.[113,126,127]

In order to promote evidence-based practice, we suggest that the following should be the base when assessing body temperature:

1. Evaluate body temperature in relation to the individual baseline temperature.

2. In elderly nursing-home residents, the baseline temperature is altered because of functional and cognitive impairment, loss of isolating tissue and chronic pain condition.

3. Individual baseline body temperature, at least in the nursing home, should as far as possible be noted.

4. Axillary body temperature measurement is not recommendable as an assessment of core body temperature in adults.

5. When measuring body temperature, the unadjusted mode should be used, without adjusting to another site.

6. The same site of measurement should be used as far as possible.

7. Time, site of measurement and medication antipyretics should be noted in the patient record.

8. Antipyretics is necessary before surface cooling starts to prevent shivering.

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