CLINICAL INVESTIGATION

Variation in Normal Ear Temperature

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ABSTRACT

Background: Variation in baseline ear temperature, taken in the unadjusted mode, has yet to be established in different age groups. Because normal body temperatures show large variations, the same may be expected for increased temperatures in fever. The aims were to study variations in normothermic body temperatures measured with an ear thermometer and to determine differences between actual and perceived body temperature during a febrile episode (referred to as difftemp) in apparently healthy children and adults.

Methods: Ear temperature was measured once in 2006 individuals (61.7% females): 683 children aged 2 and 4 years, 492 adolescents aged 10-18, 685 adults aged 19-65 and 146 elderly aged 66-89 years. Difftemp was estimated as the difference between individual ear body temperature, measured in the present study, and the respondent's reported temperature when feverish.

Results: Mean ear temperature was 36.4 ± 0.6°C overall and in the child and adult groups. In adolescents, it was 36.5 ± 0.5°C, and in elderly, 36.1 ± 0.5°C. Temperature in men was 36.3 ± 0.6°C, and in women, 36.5 ± 0.5°C. Difftemp was 1.1 ± 0.7°C in adolescents, 1.5 ± 0.7°C in children and adults, and 1.6 ± 0.7°C in those >65 years.

Conclusions: Ear body temperature is lower than traditionally reported and differs with age and sex. An individual difftemp of 1.0-1.5°C along with malaise might indicate fever.

Key Indexing Terms: Ear body temperature; Healthy individuals; Children; Adults; Elderly; Difftemp; Fever. **[Am J Med Sci 2017;▮(▮):▮▮▮–▮▮▮.]**

INTRODUCTION

Body temperature remains an important sign of health and disease in everyday life and in medical care. For example, fever is the main complaint in approximately 30% of patients attending pediatric care.[1-4] In the frail elderly, fever may help to verify an ongoing infection when there are no other specific signs and symptoms.[5,6] Normal body temperature was defined as 37°C, and fever as 38.0°C, by Wunderlish[7] in the middle of the 19th century, when physiological mechanisms such as body temperature regulation, hormonal effects, cellular metabolism, physical activity, immunology, the inflammatory response and microbiology were still undiscovered and the calibration of thermometers was not yet accurate. In addition, measurements were performed on patients who were ill, which suggests that a large number may have been febrile. Finally, axillary measurements were used, which give only an estimate of peripheral temperature,[8] and the measurements were performed in a nonstandardized way. Today, normal body temperature is generally accepted as more a range of variation than a fixed value[9] and to depend on circadian rhythm,[10] sex,[11-13] physical activity,[14] and age.[15] In general, children are considered to have a higher body temperature than adults because they are growing and have a faster metabolism,[9] while age-related factors and impaired thermoregulation[16-20] might result in elderly people having a lower body temperature.[21-23]

The infrared ear thermometer (IRET) is an alternative to other noninvasive methods to measure body temperature. As the probe of the IRET is placed approximately 1.5 cm away from the tympanic membrane, the reading is a mix of heat from the tympanic membrane and the aural canal.[24] The accuracy with which the sensing probe senses the infrared radiation emitted by the eardrum directly corresponds with the overall accuracy, repeatability and usability of the tympanic thermometer. The sensing probe must be sensitive to the infrared energy emitted by an eardrum while providing a high degree of accuracy, repeatability and thermal noise immunity. Hence, the measurement accuracy is dependent on the correct positioning of the probe such that the sensor is directed toward the membrane and placed in a way that no air leaks in from the environment. Noteworthy is that the other noninvasive sites, such as the rectal, oral and axillary, show limitations in measurement accuracy owing to placement of the thermometer.[9] The influence of cerumen,[25-28] and of otitis media[25,29] is inconsistent. Owing to observed differences between left and right ear and poor repeatability,[30,31] some advocate duplicate or triplicate ear temperature measurements and the use of ear tug technic,[12,32-34] whereas we and others report that one measurement and not using ear tug is sufficient.[13,35] IRET can be set to measure body temperature without adjustment (ear or equal mode) or adjusted with reference to another site (e.g., oral, rectal or pulmonary arterial).[36] However, Ring et al[37] emphasized the existence of not one, but several, core body temperatures dependent on temperature gradients within the body. Hence, no factor exists to allow the accurate use of temperatures recorded at 1 site to

estimate the temperature at another.[38] In clinical practice, though, this mistaken association between temperatures at different sites remains widespread, causing a great deal of uncertainty in assessing body temperature[39] especially when using the ear site. Chamberlain et al[12] reported right ear temperatures, measured in the ear or equal mode, of 36.78 ± 0.47°C in children aged 3 days to 10 years compared with 36.51 ± 0.46°C in people aged 11 years and older. They found that age was the strongest predictor of temperature, followed by sex. Earlier studies reported a mean ear temperature of 36.6 ± 0.6°C in healthy men and women, with a higher temperature in fertile women than in men and menopausal women,[13] a mean temperature of 36.9 ± 0.6°C in nursing home residents and a lower mean ear temperature (≤36.2°C) more common in individuals with impaired physical and cognitive function.[23] A previous systematic review concluded that studies in random samples are needed to confirm the effect of sex and age on the range of normal body temperature.[40] This suggests a need to establish the variation in baseline ear temperature, taken in the equal or unadjusted mode, for different age groups. However, if the random sample should reflect the everyday life in an apparently healthy population as true as possible, other individual "errors" that also might affect body temperature has to be considered.[9,13] We assume that the presence of chronic disease (such as diabetes, asthma, allergy, etc.), intake of drugs, sore throat, vomiting or diarrhea, runny nose, cough, allergy and recent vaccination might be such "errors," indicating "something is going on," but not the same as malaise and therefore no reason to see a doctor. In addition, physical activity and intake of paracetamol (acetaminophen or APAP) on the same morning before measurement may affect body temperature. Because normal body temperature shows large variations, it is also reasonable that the same should hold true for increased temperature in fever.[39,41] Considering how much knowledge and data we now possess, and our obligation to base clinical decisions on evidence-based and reflected knowledge,[42] it is appropriate to reconsider the definition of fever. In an attempt to address this, based on finding that the 99th percentile was 37.9°C for children younger than 11 years and 37.6°C for people 11 years or older, Chamberlain et al[12] suggested ear temperatures above these as appropriate age-related cutoffs for fever screening. Darowski et al[21] suggested 37.2°C for those >70 years old. However, instead of a fixed cutoff value, another method to define fever is the difftemp, the increase in temperature from the individual baseline. How great this increase might be requires further study. As a first attempt to define difftemp, we decided to ask people what temperature they assessed as fever and compare that with the body temperatures recorded in this present study. The aims were to study variations in normothermic body temperatures measured with an ear thermometer and to determine differences between actual and perceived body temperature during a febrile episode (referred to as difftemp) in apparently healthy children and adults.

METHODS

The study was a multicenter, cross-sectional survey with data collected in southeast Sweden in 2013-2014.

The study follows the Helsinki Declaration[43] and was approved by the regional ethics committee at the Linköping University (2011-08-10, No. 0117263-31). Individuals who participated in the study were informed that they could terminate participation at any time without giving reasons. Privacy was protected by coding, so no data could be traced to a single individual. The respondents gave written informed consent, stating that their participation was voluntary. The safety of the research process for patients undergoing elective surgery was certified by the chief physicians at the orthopedic clinic. The safety of the research process in the public child healthcare centers (CHCs) and in school healthcare (SHC) was assured by the County Council's School Health Physician.

Participants

The convenience sample was recruited through CHCs and SHC nurses. In total, 16 CHCs and 22 SHC centers were invited. Of these, 30 agreed to join the study (12 CHC and 18 SHC). Elective orthopedic hip and knee surgery patients from 1 county hospital were also recruited.

Data Collection

The management of participating CHCs, SHC nurses, and the orthopedic surgery center approved the study. Inclusion of participants and ear body temperature measurements were conducted from August 2013-June 2014. In all subgroups, individuals who had difficulty communicating in or reading Swedish or both were excluded. Background data were gathered through a written, coded questionnaire about the presence of disease (heart disease, asthma, diabetes type II and inflammation of the muscles and joints); regular intake of drugs related to disease; fever, sore throat, vomiting or diarrhea, runny nose, cough and allergy in the last 3 days; vaccination in the last 7 days; and intake of medication and exercise such as jogging, cycling, or gymnastics on the same morning before measurement. Adolescents and adults were asked about the presence of chronic obstructive pulmonary disease, chronic pain and thyroid disease, and women were asked about their menstruation and intake of contraceptives and hormones. All participants were also asked about their personal definition of the increased temperature, in °C, that indicates fever, and their preferred site for measuring body temperature.