ORIGINAL ARTICLE

Normal oral, rectal, tympanic and axillary body temperature in adult men and women: a systematic literature review

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Scand J Caring Sci; 2002; 16; 122–128

Normal oral, rectal, tympanic and axillary body temperature in adult men and women: a systematic literature review

The purpose of this study was to investigate normal body temperature in adult men and women. A systematic review of data was performed. Searches were carried out in MEDLINE, CINAHL, and manually from identified articles reference lists. Studies from 1935 to 1999 were included. Articles were classified as (1) strong, (2) fairly strong and (3) weak evidence. When summarizing studies with strong or fairly strong evidence the range for oral temperature was 33.2–38.2 °C, rectal: 34.4–37.8 °C, tympanic: 35.4–37.8 °C and axillary: 35.5–37.0 °C. The range in oral temperature for men and women, respectively, was 35.7–37.7 and 33.2–38.1 °C, in rectal 36.7–37.5 and 36.8–37.1 °C, and in tympanic 35.5–37.5 and 35.7–37.5 °C. The ranges of normal body temperature need to be adjusted, especially for the lower values. When assessing body temperature it is important to take place of measurement and gender into consideration. Studies with random samples are needed to confirm the range of normal body temperature with respect to gender and age.

Keywords: oral, tympanic, rectal, axillary body temperature, systematic literature review.

Submitted 17 January 2001, Accepted 11 July 2001

Introduction

The degree of body temperature is an important indication of health as well as illness and often constitutes the basis for deciding whether or not to initiate treatment. The first person to use instruments to determine body heat was Sanctorius (d. 1638) followed by others during the eighteenth century (1). At that time the focus was on the generation of body heat rather than developing an instrument to measure body temperature. The concept of a single normal body temperature originated from studies by Becquerel and Breschet in 1835 and Wunderlich in 1868 (2). The work of Wunderlich was the real break-through for the use of the thermometer as an evaluation of body temperature (3). Wunderlich introduced a mercurial axillary thermometer in 1851. He measured the axillary temperature in 25 000 patients, and stated the normal body temperature to be 37.0 °C, with a range of 36.2–37. 5 °C. Above 37.5 °C he defined as 'the territory of fever', and ≥ 38.0 °C as fever. He also declared that women might have higher normal body temperature than men, even if he conceded that this could be questioned as other investigators had found the opposite (1). Although there is a general acceptance of normal body temperature as a range rather than a fixed value today, there is a widespread confusion concerning the definition of normal body temperature in adults (4). The question of body temperature related to gender still remains to be answered (5).

The aim of the study was to investigate the range of normal oral, rectal, tympanic and axillary body temperature related to gender in healthy adult men and women.

Methods

A systematic literature review was conducted, and searches were carried out in MEDLINE, CINAHL and manually from identified articles reference lists. The review covered literature from 1935 to December 1998. Studies were classified according to the recommendations by the Swedish Council of Technology Assessment in Health Care (SBU) (6). More specifically these comprise the following definitions: Prospective clinical study with random sample

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(C), prospective clinical study with convenience sample (P), retrospective study (R), literature review (L) or other type of study (O). The concept body temperature related to different constellations of keywords was used to identify articles (Table 1).

Analysis of the literature comprised the following three-step process

Step 1. The search and examination of the first identified abstracts was performed by one of the authors (M S-L). To qualify for inclusion, the research had to be reports of studies focusing either on normal body temperature or the comparison of different methods of temperature measurement in healthy adults (18 years or older) or nonfebrile patients in the same age. Studies were also required to be published in English or Swedish.

Step 2. Of the reports read, some were excluded based on whether children or patients with febrile illness were included in the sample, or if the study was experimental without reporting normal body temperature, or, lastly, whether the study was published only as an abstract.

Step 3. The remaining reports were reviewed and critiqued by two of the authors (M S-L and C F), independently of each other, consistent with a predefined protocol, in accordance with the RCN Institute (7). The following questions were asked: Are inclusion and exclusion criteria for accepted and rejected subjects and the drop-outs clearly described? Is reliability testing (calibration) of the thermometers carried out, clearly described and compared with a 'golden standard'? Are the measuring methods adequately defined, including specification of the number of persons involved? Is the temperature described by means of mean values and standard deviation, and can the results be generalized to a healthy population?

The two authors classified the evidence in each study according to recommendations by SBU (6) in three categories. (1) *Strong evidence:* prospective study with random sample or review of prospective studies with random samples, sample size more than 30 and accurate reliability and validity and statistics. (2) *Fairly strong evidence:* prospective study with convenience sample, sample size more than 30 and accurate reliability and validity. (3) *Weak evidence:* retrospective or other study, sample size less than 30, weak design or inaccurate reliability or validity. Most of the studies were classified similarly, yet some reports were required some discussion until mutual agreement was reached. A number of papers were rejected because of weak evidence (less than class 3), or the sample was unclear, or the results were impossible to generalize, or as they were published as letter to the editor. Other reasons for rejection were that subjects were treated with antipyretic/anti-inflammatory agents, or that the focus was on thermal comfort, or that the ambient temperature was extreme. Two narrative reviews were also excluded.

Analysis of data

For comparison °F was translated into °C by deducting 32 from the Fahrenheit reading and then multiplying by the fraction 5/9 (0.555) (8). New mean values for oral, rectal, tympanic and axillary temperature, respectively, were re-calculated by using the following formula: $(x_1n_1 + x_2n_2)/(n_1 + n_2)$. Furthermore, when average body temperature was reported in age groups or for white and coloured separately, new mean values were calculated by using the

Table 1 Number of identified articles found by search in MEDLINE, CINAHL, and manually from reference lists in identified articles. All articles found in CINAHL were also present in MEDLINE

	Number of included abstracts		
Keywords in title	*MEDLINE*	*CINAHL*	*Manually*
Normal body temperature	21		9
Body temperature and review	5		1
Body temperature and adult	19		
Body temperature and gender	2		
Human body temperature	53		
Core body temperature	49	5	
Core body temperature and adult	3	1	
Hypothermia and elderly	76	12	3
Measurement of body temperature	47	2	
Tympanic temperature and measurement	19	4	
Rectal temperature and measurement	27	1	
Oral temperature and measurement	16	3	
Thermometers and measurement of body temperature	1		17
Thermoregulation			9
Circadian rhythm			4
Total	338	28	43

same formula. When the body temperature was measured in the morning and afternoon on the same subject or when oral temperature was measured on both sides of the mouth, new values were calculated by using the formula $(x_1 + x_2)/2$. When the range was not reported, the mean value ± 2 SD was applied for estimating the range. The actual temperature from studies with strong and fairly strong evidence is presented in the results.

Results

Of the 27 critiqued studies, 18 used one method for temperature measurement, e.g. oral, rectal, tympanic or axillary (2, 5, 9–24), and nine combined different sites (25–33). Therefore, 24 studies reported oral (2, 5, 9, 11–14, 16–22, 24–33), nine rectal (15, 26–33), three tympanic (10, 32, 33), and three axillary temperature (23, 25, 33). Four studies used random samples (11, 13, 14, 21). The majority of included research was prospective cross-sectional studies with convenience samples. Sixteen studies reported calibration of thermometers, 21 discussed the validity of the method, and 15 described how the measurement was performed. An inter-reliability-test was not described in any study.

Twenty of the included studies were assessed as having strong (n = 10) or fairly strong (n = 10) evidence, and seven as weak evidence. Most studies with strong evidence were found in investigations dealing with oral temperature measurement. Reports on men showed a higher number of studies with strong evidence than for women (Tables 2 and 3).

When summarizing the results from studies with strong and fairly strong evidence oral temperature was measured on 2749 individuals, rectal on 347, tympanic on 1604, and axillary on 50 subjects. The mean values were 36.4 °C (oral), 36.9 °C (rectal), 36.5 °C (tympanic) and 36.3 °C (axillary). The total range/m ± 2 SD was 33.2–38.2 °C. The mean, 1st and 3rd quartiles and range/m ± 2 SD at different sites of measurement are presented in Fig. 1.

Fourteen studies reported body temperature by gender (5, 9, 10, 13, 15, 17, 20, 23–25, 27, 29–31), of which nine were classified as having strong or fairly strong evidence. In these studies oral temperature was measured on 934 men (five studies) and 166 women (four studies), rectal on 52 men (three studies) and 37 women (one study), and tympanic on 564 men (one study) and 861 women (one study). The mean and range/m ± 2 SD for men and women, respectively, are presented in Table 4. No study with strong or fairly strong evidence reported axillary temperature by gender.

Discussion

The present review indicates that the normal body temperature has a wider range than the 36.2–37.5 °C previously reported by Wunderlich (1). Even when only studies with strong evidence, e.g. class 1, were summarized the wider range was obvious, especially in the lower limit. It shall be noted that Wunderlich stated his definition from measurements in the axilla of patients, i.e. nonhealthy subjects (1). It can thus be concluded that probably measured temperature in both nonfebrile and febrile individuals, which may be an explanation to the difference in range. Furthermore, Mackowiak et al. found that the thermometer Wunderlich used resulted in higher values compared with modern digital thermometers in a laboratory experiment (1.4–2.2 °C) (34). The results may also be influenced by several confounding factors, e.g. age differences, and ovulation, which can greatly affect female body temperature. Furthermore the accuracy of measurement techniques as well as the devices used and insertion times were not always clearly described. Only six studies used either one trained investigator or investigators. Also, Collacott (22) equalized oral and rectal measurements, Eriksson (13) reported oral temperature adjusted by 0.3 °C to equalize rectal temperature, and Marion (18) and McGann (5) analysed the same sample but reported different ranges (cf. Table 2). The time of day as well as ambient temperature and season was rarely indicated, which may further influence the recorded value. In addition, the results may have been effected by indoor temperature and clothing. For example Nakamura (19) and Thatcher (21) reported higher body temperature in summer than during winter, whereas Eriksson (13) stated the opposite. Lastly, it should be noted that temperatures measured in the axilla cannot be equalized with temperatures from the rectum, the mouth or the tympanic membrane according to the physiological basis of thermoregulation (35, 36).

Only a few studies reported average values of body temperature equal to or above 37.0 °C, e.g. more specifically rectal temperature in six studies and tympanic temperature in one study (15, 26, 27, 31–33). When summarizing the results no mean value exceeded 37.0 °C, irrespective of place of measurement (cf Fig. 1). The results of tympanic temperature are difficult to interpret as this is still a rather new technique, and that different modes are used. Chamberlain (10) used an infrared emission detection (IRED) thermometer with equal mode, Darowski (33) a zero-gradient auditory canal thermometer and Terndrup (32) did not report the chosen mode at all. Equal mode means that the actual temperature from the tympanic membrane is measured. Translating the tympanic value to oral or rectal temperatures requires that the manufacturer has readjusted the value beforehand with an offset, which differs between thermometers (37). When the tympanic temperature is converted to oral mode at least 0.4 °C is added to the measured value (37).

The results also indicated that women have a lower mean oral body temperature compared with men. This is in

Table 2 Twenty studies with strong or fairly strong evidence of normal body temperature in mean (m), temperature (°C) and range/m ± 2 SD* are presented. Prospective clinical study with random sample (C), prospective clinical study with convenience sample (P), literature review (L). Quality was rated according to a three-grade scale: (1) strong evidence, (2) fairly strong evidence and (3) weak evidence

Reference	*Design (Q)*	*Number, male, female (age)*	*Method*	*m*	*Range/m ± 2 SD**
Baker (9)	P (2)	24 female (students)	Oral	36.8	35.8–37.8*
Castle (26)	P (1)	85 (42–102)	Oral	36.3	35.7–36.9*
			Rectal	37.0	36.2–37.8*
Chamberlain (10)	P (1)	1532 (16–102) of which	Tympanic	36.5	35.4–37.4*
		564 male (age not reported)		36.5	35.5–37.5*
		861 female (age not reported)		36.6	35.7–37.5*
Collins (11)	C (2)	47 (69–90)	Oral	36.4	35.4–37.2*
Darowski (33)	P (1)	50 (>70)	Oral	36.6	35.6–37.0
			Rectal	37.2	36.7–37.5
			Tympanic	36.8	36.5–37.2
			Axillary	36.3	35.5–37.0
Erickson (12)	P (1)	50 (18–42)	Oral	36.6	35.9–37.6
Eriksson (13)	C (1)	760 male (57–75)	Oral	36.7	35.9–37.6*
Fox (27)	P (2)	12 male (17–28)	Oral	36.7	36.3–37.1*
			Rectal	37.2	37.0–37.4*
Fox (14)	C (1)	1020 (>65)	Oral	36.2	34.6–37.5*
Horwath (15)	P (2)	53 (19–35) of which	Rectal	36.9	36.7–37.1*
		16 male		36.7	36.7–36.8*
		37 female		37.0	36.8–37.1*
Keilson (16)	P (1)	117 (22–90)	Oral	36.3	35.4–37.2*
Kolanowski (28)	P (2)	101 (65–97)	Oral	36.0	33.4–37.2*
			Rectal	36.6	34.4–37.6*
Linder (29)	P (2)	24 male (21–45)	Oral	36.6	36.3–36.9
			Rectal	37.1	36.7–37.5
Mackowiak (17)	P (1)	148 (18–40) of which	Oral	36.8	35.6–38.2
		122 male		36.7	35.7–37.7*
		26 female		36.9	35.7–38.1*
Marion (18)	P (1)	92 (64–96)	Oral	36.9	36.3–37.5
McGann (5)	P (2)	92 (64–96) of which	Oral	36.9	36.4–37.4*
		16 male		36.7	36.3–37.1*
		76 female		36.8	36.4–37.4*
Nakamura (19)	P (2)	57 (76 ± 4,6)	Oral	36.5	34.9–37.6*
Salvosa (20)	P (2)	40 female (60–93)	Oral	35.9	33.2–37.4*
Terndrup (32)	P (2)	22 (mean 33.4 years)	Oral	36.4	36.2–36.6*
			Rectal	37.1	36.9–37.3*
			Tympanic	37.4	37.0–37.8*
Thatcher (21)	C (1)	100 (60–94)	Oral	36.6	35.7–37.3

*range estimated as m ± 2 SD.

disagreement with Mackowiak (17), who found a significant higher oral temperature in women compared with men. However, McGann (5) observed no significant difference between genders. These contradicting results may arise from age differences in the included subjects. With respect to rectal temperature there was no difference between men and women, which opposes the study of Horwath (15), which displayed a significant higher rectal temperature in women than men. However, in the study of Horwath as well as in this review, the number of subjects interested in rectal measurement was small. The only study reporting tympanic temperature by gender (10), showing significantly higher tympanic body temperature in women, did not consider the influence of ovulation. Furthermore, the two studies by Howell (23, 25) reporting axillary temperature by gender displayed weak supporting evidence.

Even if Wunderlich did not provide a profile of the range of normal body temperature (38), his definition of normal body temperature, as well as the limit of fever, has had great impact on the opinion generally accepted today. The concept of the range of normal body temperature is important in assessing fever, especially in the elderly. A subgroup of frail elderly, who appear not to manifest fever with an infection, may actually be exhibiting fever obscured by low normal body temperature (39).

References	*Design (Q)*	*Number, male, female (age)*	*Method*	*m*	*Range/m ± 2 SD**
Collacott (22)	P (3)	77 (70 > 90)	Oral	36.0	33.3–37.2
Howell (25)	P (3)	326 male (65–95)	Oral	36.5	35.1–37.9
			Axillary	35.9	35.0–37.4
		50 nurses (age not reported)	Oral	36.5	35.3–37.0
			Axillary	36.1	35.0–37.0
Howell (23)	P (3)	105 female (61–100)	Axillary	35.8	34.2–37.4
Howell (24)	P (3)	105 female (61–100)	Oral	35.4	30.0–37.2
Ivy (2)	L (3)	276 students (age not reported)	Oral	36.7	35.8–37.4
Royston (30)	P (3)	54 female (age not reported)	Oral	36.4	36.2–36.6*
			Rectal	36.6	36.4–36.8*
Tanner (31)	P (3)	46 male (18–36)	Oral	36.7	36.6–36.8*
			Rectal	37.1	37.0–37.2*

Table 3 Seven studies with weak evidence of normal body temperature in mean (m), temperature (°C) and range/m ± 2 SD* are presented. Prospective clinical study with random sample (C), prospective clinical study with convenience sample (P), literature review (L). Quality was rated according to a three-grade scale: (1) strong evidence, (2) fairly strong evidence and (3) weak evidence

*range estimated as m ± 2 SD.

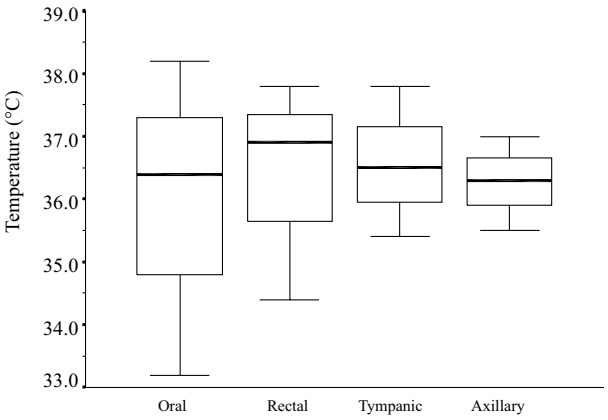

Figure 1 The results from 20 studies with strong or fairly strong evidence of normal oral, rectal and tympanic temperature (°C) in adult men and women are presented. Temperature is obtainable as mean value (bold lines), 1st and 3rd quartiles (unfilled bars) and range (thin lines).

The definition of normal body temperature in the elderly is still unclear as reported by others (19, 21, 40, 41). A high mean value of normal body temperature in the elderly may actually be caused by the presence of infection (33). Another risk of not detecting a true difference in age-related body temperature involves a sample of nursing home residents, as it may incorporate both healthy and frail elderly, Changes in temperature regulation with ageing may cause a decline in either mean temperature (mesor) or amplitude in the older age groups (11, 21, 39, 42, 43), which may manifest in difficulties maintaining basal body temperature, especially in hot or cold stress conditions (11, 14, 44, 45). Impaired thermoregulation, low activity level in daily life (ADL) and disease-related changes in circulatory and nervous systems may also contribute to lower body temperature in the elderly (19). When discussing the definition of fever, Dubois declared in 1951, 'Would it not be wise to remove the little red arrows from the thermometer'? (3). This is valid for the definition of normal body temperature as well.

Since the research of Wunderlich, only a few studies have attempted to appraise his observations critically. Most were performed 40 years ago or more and involved either a small sample or a large number of subjects from whom only single temperature readings were obtained (17). The work of DuBois (3), Horwath (15), Howell (23–25) and Ivy (2) are probably the most well known studies published discussing the definition of normal body temperature, and often referred to in literature. However, the scientific and statistical methods of performing research have developed since then, so it would be of interest to reinvestigate the range of normal body temperature.

Conclusions

This study emphasizes that the range of normal body temperature is wider, especially in the lower limit, com-

	Men			*Women*		
	Number	*Mean*	*Range*	*Number*	*Mean*	*Range*
Oral	934	36.7	35.7–37.7	166	36.2	33.2–38.1
Rectal	52	37.0	36.7–37.5	37	37.0	36.8–37.1
Tympanic	564	36.5	35.5–37.5	861	36.6	35.7–37.5

Table 4 The mean (m) and range/m ± 2 SD (in °C) of studies with strong or fairly strong evidence in normal oral, rectal and tympanic body temperature in men and women are presented. No study with strong or fairly strong evidence reported axillary temperature by gender

pared with the definition of today. When assessing the normal range it is important to consider both site of measurement as well as gender. More studies with random samples are needed to confirm the range of gender-related normal body temperature. The influence of age also has to be further investigated, as ageing may be connected to declining normal body temperature.

Acknowledgement

This study was funded with grants from The Scientific Committee of Jönköping County Council, The Swedish Heart and Lung Foundation, OPUS and Föreningen Upsala Sjuksköterskehem.

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