

Temperature Recording Sites in Infants, Children, and Adults

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Abstract

Background: Axilla, mouth, and rectum are the most common sites for thermometric measurement. There is no universally accepted belief about how to predict one of them from others.

Methods: In a cross-sectional hospital-based study at two educational hospitals in Qazvin Province, mercury in glass thermometers were used and then calibrated with digital thermometer within ± 0.1 °C. The axillary temperature was compared with oral or rectal ones in 50 infants, 100 children, and 100 adults.

Results: The mean difference between axillary and rectal temperature in infants was 0.366 °C (± 0.21), while those between oral and axillary in children and adults were 0.667 °C (± 0.37) and 0.494 °C (± 0.3), respectively. Among infants, 98% of the oral and rectal readings were stabilized at 5 and 3 minutes, respectively. In children, 98% of the oral readings were stabilized at five but for axilla, 99% by 6 minutes. For adults, 95% of the oral readings were stabilized at 5 minutes while for axilla, it was 96% by 6 minutes.

Conclusion: In less than 3 month old infants, axillary temperature accurately reflects the rectal temperature. Axillary and rectal thermometry in infants should be read after 5 and 3 minutes, while oral temperature in children and adults should be read after 6 and 5 minutes, respectively.

Keywords: Axilla; Body Temperature; Fever; Mouth; Rectum

Introduction

Axilla, mouth, and rectum are three common sites for thermometric measurement of the body temperature. The mouth is accessible, responds promptly to changes in the core temperature, and has a long tradition of use for monitoring body temperature in clinical practice. The temperature of the sublingual pocket may be especially relevant, because its main artery is a branch of the external carotid and, responds quickly to changes in the core temperature.¹ However, oral temperature measurements require cooperation of the patient. Young children, uncooperative adults, and

intubated individuals are not amenable to such measurements.² The rectal temperature site requires a thermometer placement in the patient's rectum, beyond the anal sphincter.

Rectum is a common site for temperature measurement in younger children and is considered accurate in children and infants. However, rectal readings may be imprecise, especially for older adults, due to presence of stool, heavy lower extremity size, decreased rectal circulation, and mobility variations.^{3,4} Rectal lag has been identified as the lag time or delayed response of rectal versus core body temperatures. This lag time is especially evident during core temperature fluctuations.^{3,5-7} Rectal and oral sites have the disadvantage of body fluid contact.

Axilla is commonly used for temperature recording in children, as it is safe (non-invasive) and convenient. The axillary skin site is commonly used and accepted by infants and adults too. Possible

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assessment errors are the influences of ambient temperature, hypothermic status, fatty layers, dominant arm muscle mass, skin folds, and circulatory differences due to asymmetric thoracic cavity organ placement.^{3,8}

However, conflict remains regarding its accuracy and there is no universally accepted equation to predict the core temperature from axillary temperature.⁹⁻¹³ In addition, there is not any agreement on the placement time of thermometer. The time that may accurately reflect stabilized body temperature varies from seconds to 15 minute in various studies.^{11,14-16} The present study was designed to compare the axillary temperature with oral or rectal ones in hospitalized infants (less than 3 months old), children (between 6 to 12 years old) and adults. In addition, we aimed to determine whether axillary temperature could be adjusted to provide a good estimate of oral or rectal temperature if a clear correlation between the two measurements was found. Determining the duration of recording to reach a stable temperature was one other objective of this study.

Materials and Methods

In a cross-sectional study, 50 infants less than 3 months old (21 girls and 29 boys), 100 children aged between 6 and 12 years (53 girls and 47 boys) and 100 adults (37 women and 63 men) were enrolled. All of the participants were hospitalized, mentally competent, and signed an informed consent by themselves or their legally responsible person. Children between 1 to 6 years were not included as they were unlikely to cooperate for recording rectal or oral temperature. Children who were uncooperative, crying, preterm (<37 weeks of gestation), low birth weight (<2.5 kg), unconscious, malnourished (weight for age <70% of median), or had tachypnoea were excluded. One of the researchers who received comprehensive training on obtaining oral, axillary, and rectal temperatures measured them. Temperatures were measured by ordinary clinical mercury in glass thermometer from the infants' rectum and axilla (Group I), from the oral cavity and axilla in older children (Group II) and adults (Group III). Both rectal and oral/axillary thermometers were calibrated in a water bath using a digital thermometer (TempSenc), and adjusted to 37 °C. Calibration was repeated periodically to ensure agreement within ± 0.1 °C of the standard laboratory thermometer.

For rectum, thermometer was lubricated by sterile

jelly and placed at a depth of 2 centimeters in the case of neonates and 3 centimeters for infants older than 4 weeks. For the axilla, the thermometer was placed in and for the mouth, in the right or left posterior sublingual pockets. Oral temperature measurements were performed at least after 30 minutes of last eating or drinking.¹⁷

The temperatures were recorded at one-minute intervals, starting from 2 minutes after insertion until the reading remained unchanged for three consecutive times. Temperatures in both sites were measured simultaneously. A single observer recorded both readings. The data were analyzed using SPSS 12.0 software. With linear regression analysis, an equation was derived to predict the rectal or oral temperature from the axillary. We used Pearson's correlation coefficient to determine the degree of correlation between the recorded temperatures for all the subjects. Data were collected in the spring and summer 2007 (April to September). Temperatures in Qazvin at these seasons ranged 15–25°C.

Results

In Group I (Infants ≤ 3 month of age), proportion of neonates (<1 month of age) was 66% with 42% were females and 58% males. Mean (±SD) rectal temperature was 37.2 °C (±0.34) and that for the axilla was 36.85 °C (±0.32). The mean difference between rectal and axillary temperatures was 0.366 (0.21) (CI 95%: 0.3 to 0.42). A significant positive correlation was observed between rectal and axillary temperatures in group I ($r = 0.802$; $p < 0.001$). A linear relationship between rectal and axillary temperatures was obtained using regression analysis:

Rectal temperature (°C) = 0.863 * axillary temperature (°C) + 5.408

In group II (children), mean (±SD) oral temperature was 37.45°C (±0.61) while for axilla it was 36.8°C (±0.62). The mean difference was 0.667 (0.37) (CI 95%: 0.59-0.74). A similar comparison for Group II (children) also showed a high degree of positive correlation between oral and axillary temperatures ($r = 0.82$; $p \leq 0.001$). The equation of linear relationship was:

Oral temperature (°C) = 0.804 * axillary temperature (°C) + 7.862

In group III (adult) with 63% males, the mean (±SD) oral temperature was 37.15°C (±0.68) while for the axillary it was 36.65°C (±0.77). The mean

difference was 0.494 (0.30) (95% CI: 0.43-0.55). Comparison in Group III showed a high degree of positive correlation between oral and axillary temperatures ($r=0.92$; $p<0.001$). The equation of linear relationship was:

$$\text{Oral temperature (}^\circ\text{C)} = 0.811 * \text{axillary temperature (}^\circ\text{C)} + 7.407$$

In our study, gender played no role in any groups, while fever in children was significant at 0.05 as the significance level (Table 1). In group I (≤ 3 month), the mean difference between rectal and axillary temperatures was significantly different between neonates (≤ 1 month) $[0.31(\pm 0.2)]$ and infants (1-3 month) $[0.45 (\pm 0.2)]$ ($p=0.024$) (Level of significance: 0.05).

For providing an accurate estimation of oral/rectal temperature, axillary temperature of the three groups

may adjust with addition 0.35, 0.65, 0.5, respectively (Table 2).

By utilizing simple equations, we can estimate the real measures of rectal temperature in neonates and infants, and of oral in children and adults from axillary temperature.

About the placement time required for stabilization of temperature recording at various sites, we found that 99% of the rectal temperature readings were stabilized at 3 minutes. For the axilla, 92% were stabilized by 5 and 98% by 6 minutes. Finally, 97% of the mouth recordings were stabilized at 4 minutes. The mean placement time for stabilization of the rectal temperature was 2.26 minutes (± 0.46); (95% CI: 1.4-3.2), for the axilla it was 4.74 minutes (± 0.84); (95% CI: 3.1-6.4) and for the mouth 3.1 minutes (± 0.8); (95% CI: 1.6-4.6) (Table 3).

Table 1: Mean differences (SD) of measured temperatures in each group of the study (in the order of genders and presence of fever)

Group	Gender		Fever	
	Male	Female	With	Without
≤ 3 month	0.39 (0.23) $p=0.292$	0.32 (0.16)	-- --	-- --
Children	0.71 (0.42) $p=0.189$	0.62 (0.31)	0.84 (0.44) $p=0.019^*$	0.62 (0.34)
Adults	0.48 (0.31) $p=0.623$	0.51 (0.28)	0.45 (0.30) $p=0.559$	0.5 (0.3)

*: Significant at 0.05 but not at 0.01 (level of significance)

Table 2: Estimation of oral and rectal temperatures from the axillary in each group

Age*	Estimation OT and RT from AT
Neonates (<1 month)	RT~AT+0.3
Infants (1 - 3 month)	RT~AT+0.45
Children	OT~AT+0.65
Adult	OT~AT+0.5

AT: Axillary Temperature, OT: Oral Temperature, RT: Rectal Temperature

* The Group I (Infant ≤ 3 month of age) was divided two subgroups [neonates (< 1 month) and Infants (1 - 3 months)].

Table 3: Time for stabilization of temperature in each group and site

Group	Site of measurement	Time for stabilization (%)				
		2 min	3 min	4 min	5 min	≥ 6 min
≤ 3 mo	Rectal	72	26	2	--	--
	Axillary	8	34	32	24	2
Children	Oral	16	36	37	9	2
	Axillary	14	14	24	38	10
Adults	Oral	15	30	38	12	5
	Axillary	10	16	17	47	10

Discussion

Prediction of core temperature from oral, axillary, and rectal measurements has always been a special interest to physicians. The intent of this study was to determine the relationship between different sites of temperature recording of the body in three different age groups: infants under 3 months of age, children (6-12 years), and adults as measured by calibrated oral/axillary and rectal thermometers.

Tradition has dictated to caregivers the "one degree Fahrenheit" ($\sim 0.5^\circ\text{C}$) rule. Rectal temperature is considered 0.5°C higher than that of the mouth, which is about 0.5°C higher than the axilla. As we showed, only in children group oral temperature is more than 0.5°C higher than axilla and in others we can estimate oral or rectal temperatures with less differences, so other groups have a better estimation than children do (for infants, the difference reaches only 0.3°C). The time of dwelling of thermometer for neonates and infants was relatively short (about three minutes), but for older children and adults it needed five minutes or more, especially in the axilla. Infants need more attention as to estimation and dwelling time.

We tried to keep a stable setting with minimal variations of measurement in all of the times of the study and described it carefully for further comparisons. This stable setting includes a fixed time of measurement, one person who records all the measurements (reduction of inter-rater variability) with comprehensive training, one type of thermometer that had been standardized by a digital and precise thermometer.

In the study designed by Shann,¹⁵ the axillary temperature was adjusted by adding 1°C , and it provided less accurate estimate of the rectal temperature in comparison to our study (the mean difference (SD) between the rectal and adjusted axillary temperatures [$A+1^\circ\text{C}$] was -0.04 (0.45) with the 95% CI of -0.94 to 0.86). In a recent study (Ahmed), there were very limited degrees of correlation between oral and axillary temperature.¹⁸ These differences can be explained by the difference in the method of measuring temperature. They measured the axillary temperature only after two minutes while we did so after five minutes, so we detected a smaller difference between the axillary and rectal temperatures (a narrower Confidence Interval), which is a reflection of increased accuracy. In a study designed by Asadi Pooya, the mean difference (SD) between the rectal and axillary readings was 0.55°C

(0.44) (95% CI: 0.490 - 0.615). When the axillary temperature was adjusted by adding 0.55°C , it provided a very good estimate of the rectal temperature.¹⁹ In another study (Kocoglu),²⁰ axillary temperature was assessed after five minutes and adjusted by adding 0.72°C to the rectal temperature, which is different from what we have found, showing fewer differences between the axilla and rectum. In this observational study, there were no significant temperature differences between the oral and axillary regions irrespective of age and sex.

In a recent study (Chaturvedi), the placement time for the stabilization of temperature was about three minutes for the rectum and six for the axilla, being similar to our study. They found that the mean (SD) temperature difference between the rectum and axilla was 0.3 (0.2) (95% CI: -0.8 to 0.76) in infants aged less than one year. They provided an equation [Rectal temperature= 0.98 (Axillary temperature)+ 0.8] which is different from ours.²¹ The study also showed a high degree of correlation between the rectal and axillary temperatures, similar to our study ($r=0.802$; $p<0.001$). Haddadin found that the axillary temperature correlated well with the rectal temperature in neonates but not in older children. They did not find a direct mathematical relationship between the axillary and rectal temperatures.²² Hissink Muller showed that there was no constant relationship between the rectal and axillary temperature.²³ These differences could be due to the difference in the placement time for the axillary measurements among studies.

Numerous variables are known to influence the body temperature measures. These variables include age,²⁴⁻²⁶ device dwell times^{3,27} and body site.²⁷⁻²⁹

Zare *et al.* showed that none of axillary, right and left tympanic techniques was more accurate than the others and suggested to use a technique that is more convenient, painless, and safer than rectal temperature. They propose using a modified parametric distribution-free ROC estimator as an easy and simple technique to implement with the existing softwares for comparing the accuracy of these medical tests.³⁰

In our study, age remained an important factor for temperature readings at the mouth, axilla, and rectum while gender played no role in any groups; these results were similar to the works of Nagy,³¹ Nichols, and Gillum.³² In their studies, body temperature of children aged 6 to 11 years were not related to demographic variables. All temperature readings by site were as follows: Rectal > Oral > Axillary. This result was as expected.^{13,33-35}

The placement time for stabilization of body temperature for the rectum in earlier studies varies from 1 minute²³ to 15 minutes.¹⁸ Many studies³⁶⁻³⁸ mention it to be 3 minutes as reported in the present study too. The axilla requires maximum placement time for stabilization of the body temperature. A range of 4-7 minutes of placement time for stabilization of the axillary temperature has been reported by some researchers³⁶⁻⁴⁰ whereas others have found it to be unacceptably high as much as 12 minutes.⁴¹ Nichols noted that whereas 90% of the rectal readings reached their zenith at 4 minutes, 28% of the oral and only 18% of the axillary readings reached a maximum at 5 minutes.⁴² Following a similar experience in children, Ogren has concluded that axillary readings may be misleading and should be abandoned in the outpatient setting.⁴³ Our study reported it to be 5-6 minutes that is more rational and practical in outpatient and specially inpatient settings. Many studies^{23,35,38} recommend that oral temperature placement time is about 4 minutes, which is comparable to our findings (5 minutes).

There were some limitations in our study. Our sample was a non-random convenient sample of hospitalized patients, although the participants demonstrated a wide range of age, weight, and temperature readings. In addition, the number of the cases in each group could be a reason for the low power of the study to detect all differences. A further limitation was the low-grade fever of many subjects (e.g. 20% children). To obtain more reliable results, a larger population of infants, children, and adults with high-grade fever are needed. In addition, one

researcher collected data in all the sites (not blinded to temperature readings in various sites of recording of one patient).

In conclusion, temperature measurement at the axilla of infants and adults is convenient, painless, safe and closely reflects the rectal temperature. In addition, there is a good correlation and agreement between the axilla and mouth temperatures in children. Equations derived from the present study might be useful to predict the oral or rectal temperatures from the axillary one. The accuracy of recording can further be enhanced by ensuring that the thermometer is placed in the rectum up to 3 minutes, in the mouth up to 5 minutes and in the axilla up to 5-6 minutes.

Furthermore, age, as identified in this study, may be a critically important indicator for healthcare professionals in defining and treating body temperature alterations. As we noted, either estimation "rule" could not be applied to all sites or ages especially to neonates (<1 month); therefore, all the temperatures should be reported and recorded with the added notation of the site. For adults/infants, and with consideration of the site differences, axillary temperature is considered as a good alternative for oral/rectal site.

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Conflict of interest: None declared.

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