Comparing body temperature measurements by mothers and physicians using mercury-in-glass, digital mercury and infrared tympanic membrane thermometers in healthy newborn babies

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SUMMARY: Çultu Ö, Yıldırım İ, Ceyhan M, Korkmaz A, Yurdakök M, Karaağaoğlu E, Seçmeer G. Comparing body temperature measurements by mothers and physicians using mercury-in-glass, digital mercury and infrared tympanic membrane thermometers in healthy newborn babies. Turk J Pediatr 2008; 50: 354-358.

While planning medical care, health care workers must consider the body temperature changes as measured by the mothers on most occasions. We evaluated the reliability of three different temperature measurement methods when they were used by the mothers by comparing with the measurements taken by the pediatrician.

In this prospective study, body temperatures of 50 healthy newborns during their 2nd day of life were measured by mothers and one physician with mercury-in-glass (MG), digital mercury (DM) and infrared tympanic membrane thermometers (ITMT). Measurements by the mothers and the physician were correlated for the three different methods. The effects of the educational level of the mothers and the presence of children at home on the reliability and the number of differences $\geq$0.5°C were also evaluated for each of the methods.

In comparing the measurements by the mothers and the pediatrician, correlation coefficient was 0.12 in MG thermometer readings, 0.23 in DM thermometer readings and 0.78 in ITMT readings, meaning that tympanic measurements by the mothers and the pediatricians were more correlated ($p<0.0001$). The means and ranges of absolute differences of MG, DM, and tympanic thermometer measurements were 0.43±0.42, 0-1.7; 0.36±0.45, 0-2.2; and 0.13±0.12, 0-0.7°C, respectively. The number of measurements with an absolute difference $\geq$0.5°C was 17 in MG readings, 11 in DM readings, and 1 in ITMT readings. The educational level of the mothers and the presence of children at home had no effect on the correlations. The intraclass coefficient for the three sets of measurements by the pediatricians was 0.91.

Body temperature measurements in newborn babies as taken by their mothers were more correlated with the readings by the pediatricians when the ITMT was used. Tympanic thermometers seem to be useful for the mothers of any educational level and are independent of having experience with a previous child. The ease of use and short calibration time for reading are also advantageous for these thermometers.

Key words: mercury-in-glass thermometer, digital mercury thermometer, infrared tympanic membrane thermometer, newborn.

Change in body temperature is one of the most important physical signs and symptoms of many important diseases, especially of infectious diseases, in children. Among several parameters, fever is the most alarming symptom for parents and health workers to determine if a child requires medical assessment. This is especially important in newborns, in whom fever can be indicative of infection without any other physical or laboratory findings,

because emergency therapeutic interventions are critical and life-saving in this period. It was shown that temperature out of the normal range is closely related to the survival of an infant[1]. Since most of the newborn babies are being cared for at home and since the period between the symptoms and therapy must be kept to a minimum, especially in newborns, to avoid morbidity and mortality, pediatricians make decisions about the need for medical investigations and hospital admission based on the temperatures that parents measure and report. Therefore, the correct measurement of body temperature by parents is critical to make correct indications for medical interventions.

Various methods to detect fever in newborn babies are available: axillary or rectal glass or digital mercury measurements, infrared measurements of the tympanic membrane and in intensive care units, core temperature measurements in the pulmonary or temporal arteries or esophagus. An ideal method to measure the body temperature should be reliable, non-invasive, non-traumatic, culturally acceptable, user-friendly, and hygienic. Since rectal temperature measurements are relatively more time-consuming, invasive, uncomfortable, less hygienic and unacceptable in many cultures[1], axillary measurements have been the method of choice in many countries. Recent developments in the technology of thermometry by measuring the infrared emissions from the tympanic membrane allow assessment of body temperature without a long equilibration time as in mercury methods[2].

Infrared tympanic membrane thermometry (ITMT) seems to be useful and practical at home and in health care settings in children, including newborns; however, the studies about its accuracy and reliability have produced conflicting results[3].

Therefore, we planned to compare the differences between the measurements of mothers and health care workers by using conventional glass and digital mercury measurements of axillary temperature and ITMT.

Material and Methods

This study was performed in nurseries located in the Obstetric Ward at Hacettepe University Hospital, a large tertiary center located in Ankara, Turkey, where the mothers and newborns are cared for in the same ward. One pediatrician, two residents in pediatrics and one pediatrician in the day time and one resident and one pediatrician during nights and weekends work at this clinic. Average birth number per month is 120 and all healthy full-term newborns are followed for 2 to 5 days in this clinic from their birth until the discharge with their mothers. Newborns with problems and requiring special medical care are transferred to the intensive care unit. Parents of the newborns were not included if it would be inconvenient for them to participate in the study, or if they did not understand the instructions for the thermometry.

This was a prospective observational study in which three temperature readings were taken sequentially from each newborn by the same pediatrician and mother during the second day of life. After informed consent was obtained, the mothers were informed about the instruction for FirstTemp (Tyco Health Care, Istanbul, Turkey) tympanic thermometer, MC-203-E (Omron Health Care, Europe) digital mercury and conventional mercury-in-glass thermometers. When the pediatrician felt that the mother understood the procedure, she was asked to measure the child's axillary temperature with mercury-in-glass thermometer and the same measurement was done by the pediatrician. Then, axillary temperature was again measured initially by the mother and then by the pediatrician with the digital mercury thermometer. Thirdly, tympanic measurement was made following the same procedure firstly by the mother and by the pediatrician. Each measurement was made and recorded first by the mother on a sheet of paper. Then, without looking at this paper, the pediatrician measured the child's temperature using the same thermometer following each measure of the mother and recorded his own measures. All readings were done in the same axillary area and same ear with a new probe cover on the Celsius (°C) scale.

All measurements were made on the second day of life when infants showed no important medical problem. A time of 3 minutes was needed for axillary measurements with mercury-in-glass thermometer, approximately 3 minutes with digital mercury thermometer and nearly 3 seconds with tympanic thermometer for the equilibration of the device. All measurements were finished within 12-15 minutes.

The presence of a former child or children at home and the educational level of the mother were recorded. The mean absolute difference between the parent's reading and the consecutive reading by the pediatrician using the same thermometer was calculated. The percentage of times that the measurements differed by 0.5°C or more was calculated as it was considered a clinically significant difference.

Statistical Analysis

For the database and statistical analysis, SPSS 12.0 pocket program was used. The correlation coefficients for the measurements made by mothers and the pediatrician and the intraclass correlation for the three sets of readings were calculated. All measurements were plotted using scatter graphs. A p value less than 0.05 was accepted as statistically significant.

Results

Fifty healthy newborn infants born at Hacettepe University Hospital were included in the study and 22 of them were female.

The comparison of the readings done by the mother and the pediatrician using the same thermometers is seen in Figure 1. There was no correlation between the measurements when the mothers and the pediatrician used mercury-in-glass thermometers (Fig. 1a, Rsq 0.12). The measurements by mothers were also not correlated with the pediatrician's measurements with digital mercury thermometer (Fig. 1b, Rsq 0.23). The temperatures measured by mother and the pediatrician were significantly correlated when the ITMT was used (Fig. 1c, Rsq 0.78, $p<0.0001$).

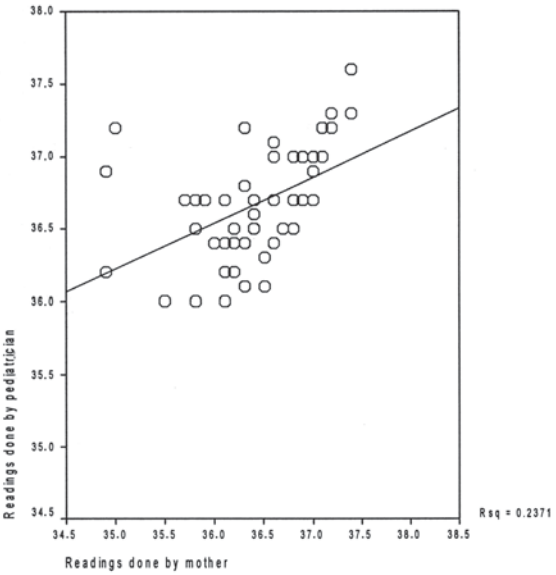

Fig. 1b. Scatter plot of the difference between temperatures measured by mothers and the pediatrician using the same digital mercury thermometer.

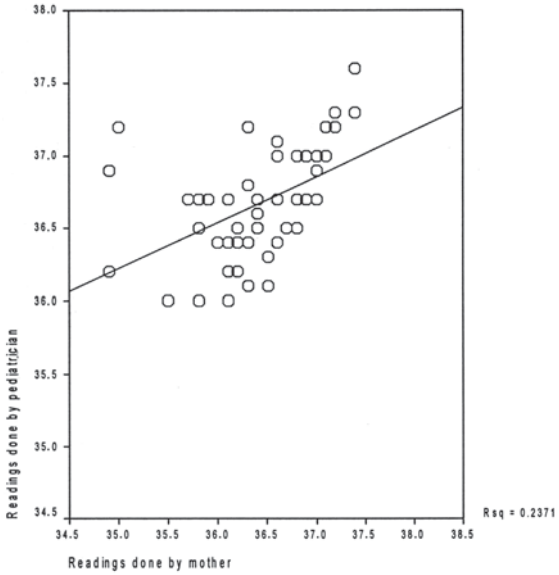

Fig. 1a. Scatter plot of the difference between temperatures measured by mothers and the pediatrician using the same mercury-in-glass thermometer.

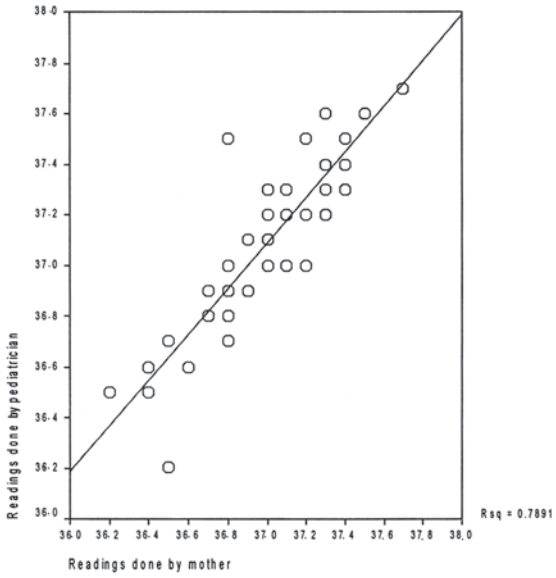

Fig. 1c. Scatter plot of the difference between temperatures measured by mothers and the pediatrician using the same tympanic thermometer.

The mean absolute differences between the readings of the mothers and the pediatrician are summarized in Table I. The mean absolute difference between the temperatures measured by the mothers and the pediatrician using the mercury-in-glass thermometer in the axillary region was 0.43±0.42 with a range of absolute difference of 0.0-1.7°C, and 34% of the readings differed by ≥0.5°C. The mean and range of absolute difference were 0.36±0.45, 0.0-2.2°C and 0.13±0.12, 0.0±0.7°C in the measurements of the mothers and the pediatrician using the digital mercury and ITMT measurements, respectively. The proportion of the measurements that differed by a clinically significant amount was 22% and 2% when digital mercury thermometer and ITMT were used, respectively (Table II).

The educational level and the presence of former children were compared for tympanic thermometer measurement, which was found to be the most correlated method between mothers and the pediatrician. The readings were correlated for each educational level and there was no difference in degree of correlation according to the number of children in the family (Fig. 2). The intraclass coefficients for the three sets of measurements were 0.91 and 0.57 by the pediatrician and the mothers, respectively.

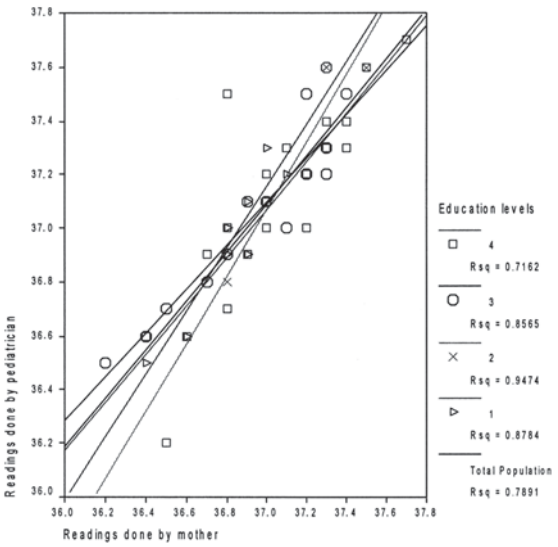

Fig. 2. Comparison of correlation between the tympanic measurements done by mothers and the pediatrician according to the mothers' educational level (1=illiterate, 2=primary school graduate, 3=high school graduate, 4=university graduate).

Discussion

Mercury-in-glass thermometers have been the common devices for measurement of body temperature. Because of the difficulty in reading and the long time needed for calibration, more practical digital thermometers began to be used commonly for the same purpose. In recent years, a new method, ITMT, has become more popular in both hospital and community practice[1,2]. Although mercury-in-glass thermometers are still in use, especially in developing countries, the use of digital and tympanic thermometers is gradually increasing. However, there are conflicting results in comparisons of different methods for body temperature measurement[2,4-6]. The temperatures measured by health care providers and parents have not been completely compared and previous studies have shown wide variation in accuracy for the different

Table I. Comparison of Temperature Measurements by Mothers and Pediatrician Using Mercury-In-Glass, Digital Mercury and Tympanic Thermometers

	Mean absolute difference (°C)	Range of absolute difference (°C)
Mercury-in-glass	0.43±0.42	0.0-1.7
Digital mercury	0.36±0.45	0.0-2.2
Tympanic thermometer	0.13±0.12	0.0-0.7

Table II. Number of Measurements with a Significant Absolute Difference (≥0.5 °C)

	Number of measurements with absolute difference ≥0.5 °C (%)
Mercury-in-glass thermometer	17 (34)
Digital mercury thermometer	11 (22)
Tympanic thermometer	1 (2)

methods. Sensitivity and specificity of digital axillary thermometers were found as 14% and 100%, respectively, by Schmitz et al.[7] and 83% and 20% by Wilshaw et al.[8]. Similar conflicting results were reported for the same ratios in Lanham's study[9] (for ITMT 51% and 99%, respectively), and in Wilshaw's study[8] (for ITMT 81% and 31%, respectively).

On the other hand, in the presence of fever, the first measurement is done by the parents, in most cases by mothers, and it is a common idea that the measurement of the body temperature by health care professionals is more reliable than the parent's. Although there are several studies comparing different methods for body temperature measurement, only one published study compared the temperatures taken by pediatricians and parents in children aged 6 months to 16 years[10]. We compared the readings by a pediatrician and mothers with three commonly used methods (mercury-in-glass axillary thermometry, digital axillary thermometry and ITMT) and found that ITMT measurements by mothers were the most correlated with the readings by the pediatrician. Although we did not aim to calculate the sensitivity and specificity of the methods, we think that parallel measurements with an educated pediatrician are also important for accepting the results of the mothers' measurements as reliable. The reasons for mothers' obtaining closer measurements to those of the pediatrician with ITMT than with mercury-in-glass axillary thermometry and digital axillary thermometry are possibly its easier use and reading. We also found that ITMT measurements were not affected by the education of the mother or the presence of a former child of the mother, so ITMT seems to be useful for all mothers without a dependence on level of education or previous experience with child care.

In conclusion, mothers seem to be able to measure the body temperature of their newborn babies with ITMT more reliably than with mercury-in-glass axillary thermometry and digital axillary thermometry.

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