

A brief report on the normal range of forehead temperature as determined by noncontact, handheld, infrared thermometer

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Background: Noncontact forehead temperature measurement by handheld infrared thermometer was used as a screening tool for fever. However, the accuracy data and normal range of forehead temperature determined by this method were not available.

Methods: The temperature readings from 3 handheld infrared thermometers were validated against an electronic thermometer. Normal range of forehead temperature was determined by measuring the forehead temperature in 1000 apparently healthy subjects.

Results: Significant differences were detected in readings obtained by the 3 different handheld infrared thermometers (analysis of covariance, $P < .001$). The most accurate one was chosen, and the normal range of forehead temperature in 1000 subjects detected by this method was 31.0°C to 35.6°C.

Conclusions: Our study shows that commercially available, handheld infrared thermometers require individual validation. Forehead temperature in excess of 35.6°C is suggestive of fever. Further studies are required to confirm accuracy of this value in detecting fever. (Am J Infect Control 2005;33:227-9.)

Severe acute respiratory syndrome (SARS) poses a serious threat to the general population. Fever is the cardinal sign in SARS.¹ In 2003, noncontact forehead temperature (FT) measurement by handheld infrared thermometer (HIT) was introduced in Hong Kong hospitals for screening visitors for fever.² HITs were used extensively in industrial process for temperature monitoring. Because of the noncontact nature of an HIT, FT measurement by HIT became a very popular means of infection control measure in various institutions in Hong Kong.

We found no literature related to the usage of an HIT to measure FT as a method of fever screening nor the normal range of the FT as determined by HIT. Thus, the current study was undertaken to investigate

both the accuracy of using an HIT as a method of temperature measurement and to determine the normal range of FT.

MATERIALS AND METHODS

Accuracy of HIT as a thermometer of surface temperature

The HIT used in our hospital is a STANDARD ST-8812 (Standard Instrument, Guang Dong, China). We included 3 new HITs in this study. The 3 units of HITs were used to measure the surface temperature of a water bath, which ranged from 32°C to 42°C (98.6°F to 107.6°F), simultaneously against an electronic thermometer (MAXIMUMTHERMOMETER GT-131; Geratherm Medical AG, Geswchwenda, Germany). Measurement of surface temperature of the water bath by HIT and electronic thermometer was made directly from the surface of the water bath with no extra treatment (eg, addition of floating reflective device). The surface temperature of the water bath was estimated by HIT with assessment of the amount of infrared emission from the surface of water. All readings were obtained by a single observer. Regression analysis was done to determine the comparability of surface temperature measured by HIT and electronic thermometer.

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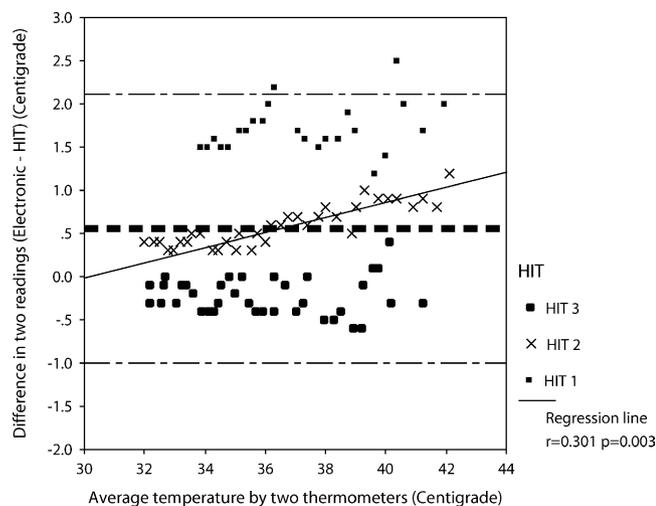


Fig 1. Difference against average of readings from HIT and electronic thermometer, with 95% limit of agreement (thin broken lines), mean difference (thick broken line), and regression line (solid line).

The units of HITs used for measurement were also entered into the regression model as a categorical covariate. The agreement of surface temperature determined by HIT and electronic thermometer was assessed by the method suggested by Bland and Altman.³ Ninety-five percent limits of agreement were reported.

Normal range of FT

After the validation of reading, we determined the normal range of FT measured by HIT. Staff and visitors of our hospital were invited to join the study. Subjects aged over 18 years and below 65 years were enrolled in this study. Individuals with a history of fever, ingestion of antipyretic, and immunization within the preceding 7 days or those with symptoms such as cough, runny nose, or sore throat were excluded. The HIT was placed 5 cm away from the center of the forehead and perpendicular to the forehead. FT was recorded when a steady reading was shown. We recorded the FT, sex, and race of the subjects. All temperature readings were measured by a single observer with the same HIT in an air-conditioned environment. The unpaired Student's *t* test was used to compare group means. Statistical analysis was performed with SPSS 10.0.1 (SPSS Inc., Chicago, IL). Approval was granted by the ethnic committee, and verbal consent was obtained from the subjects.

RESULTS

Accuracy of HIT as a thermometer of surface temperature

The number of readings obtained by HIT 1, HIT 2, and HIT 3 were 24, 35, and 37, respectively. In these 96

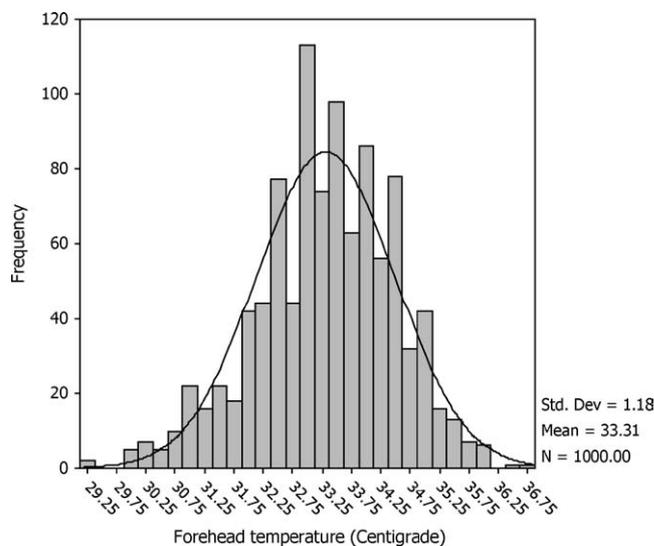


Fig 2. Histogram showing the frequency distribution of forehead temperature in 1000 apparently healthy adults.

pairs of readings, readings from HIT and electronic thermometer were convertible. (Simple linear regression, $R^2 = 0.892$, $P < .001$) However, we detected a significant difference in HIT readings obtained by different HITs for a given surface temperature (analysis of covariance, $F = 651.63$, degree of freedom = 2, $P < .001$). For example, the surface temperatures detected by HIT1, HIT2, and HIT3 were 37.4°C (99.32°F), 35.4°C (95.72°F), and 36.0°C (96.80°F), respectively, for a known temperature of 35.6°C (96.08°F).

By using the method suggested by Bland and Altman³ for assessing agreement (Fig 1), the average difference of electronic thermometer readings and HIT readings was 0.56°C (1.01°F) (95% limits of agreement were -1.00°C to 2.12°C or -1.8°F to 3.82°F). The difference of these 2 readings tended to increase with an increase of surface temperature as indicated by the significant positive correlation between the difference and the average values of these 2 readings. (Pearson's correlation, $r = 0.301$, $P = .003$) Each HIT tested in the current study had a different offset as shown by the lack of overlap of the 3 HIT delta-plots (Fig 1).

Normal range of FT

We selected an HIT with an average offset of 0.2°C (-0.36°F) from actual temperature to determine the normal range. We made 1000 observations with equal sex distribution. All subjects were Chinese.

The mean FT was $33.3^\circ\text{C} \pm 1.18^\circ\text{C}$ ($91.94^\circ\text{F} \pm 2.12^\circ\text{F}$). The histogram showing the frequency distribution of FT measured by HIT was showed in Fig 2. The normal range for FT was 31.0°C to 35.6°C (87.8°F to

96.1°F) (mean \pm 1.96° standard deviation). Those with FT higher than 35.6°C were statistically abnormal. Mean FT of female group (33.4°C, 92.1°F) and male group (33.3°C, 91.94°F) were similar (Unpaired Student's *t* test, *P* = .22).

DISCUSSION

Despite its popularity, no normal values or accuracy data of noncontact measurement of FT by HIT were published in literature. In previous studies, FT was measured by different methodologies that required physical contact with the forehead. Nearly all studies found that FT was not accurate enough for fever detection.⁴⁻¹⁰

For the same surface temperatures detected by electronic thermometers, the discrepancies of surface temperatures detected by the 3 HITs could be as high as 2°C (3.6°F). Such discrepancies could lead to inaccurate and misleading recordings during disease surveillance. Institutions using similar equipment for fever screening should check the offsets before introducing them to clinical usage because each HIT may have a unique offset (Fig 1). The problems with the inaccurate readings in our study were not likely because of observer error because a single observer was deployed in this study. Hence, our study data suggested that the current brand of HIT was not accurate enough for clinical purpose. Further improvement in the quality of the product is required, and other similar HITs for assessment of FT require further studies.

With the most accurate HIT in our possession, the current study came up with a normal range of FT (31.0°C to 35.6°C or 97.8°F to 96.1°F). We suggest further studies with a larger population with different brands of handheld thermometers to confirm that forehead temperatures >35.6°C (>96.1°F) are indicative of fever. We caution readers to extrapolate this

normal range to other age populations because different normal ranges of tympanic temperature in neonates, children, and adults were previously reported.¹¹

In conclusion, our study shows that commercially available, handheld infrared thermometers require individual validation. Forehead temperature in excess of 35.6°C (96.1°F) is suggestive of fever. Further studies are required to confirm accuracy of this value in detecting fever.

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