To the Editor: Fever detection is critical for the screening and control of highly contagious febrile diseases. Axilla or rectal temperatures, although considered to be the gold standard for fever detection in clinical practice,[1] are impractical for mass screening. Rapid, cost-effective, and non-contact temperature measurement tools with high sensitivity and accuracy are needed. Non-contact infrared thermometer (NCIT) is one of the most commonly used tools for screening of coronavirus disease 2019 in public settings in China, as fever is a typical and early manifestation. The distance between the sensor of NCIT and the skin surface might have a significant impact on the readings.[2] In addition, the fact of outdoor temperature being significantly lower than room temperature might lead to lower readings and therefore false-negative results. Previously, it was shown in a pediatric population that misleading temperature readings could happen if measurements were taken before the skin had adjusted to indoor temperature.[3] In this study, we aimed to assess the impact of distance of thermometer placement and exposure to cold outdoor environment on temperature measurement using a NCIT.

This study was approved by Peking University First Hospital Biomedical Ethics Committee and registered on the Chinese Clinical Trial Registry (chictr.org.cn, No. ChiCTR2000031811). All participants were between 18 and 35 years old without major previous diseases and provided informed consent. The exclusion criteria included: (i) pregnancy or breastfeeding; (ii) engagement in vigorous exercise before the study; and (iii) participants with thick bangs.

The temperature was measured using a NCIT (Berrcom Non-Contact Digital Thermometer JXB-180 Berrcom, Guangzhou, China). The indoor environment was set in a conference room with central heating to achieve a stable temperature of about 20°C. The temperature outside was about 10°C (obtained via the Weather Channel app, Version 12.8, IBM, New York, USA) during the study. All volunteers first sat indoors for 45 min. Then, both forehead and wrist temperature readings were taken from three different distances (direct contact, 3–5 cm, and 10 cm). They then spent 15 min outdoors, during which time they were required to avoid strenuous exercise. Finally, the volunteers returned indoors for forehead and wrist temperature measurement every 3 min for 30 min from a standard distance. During the study, volunteers were allowed to put on or take off clothes according to personal preference. Wrist temperature measurements were taken from a site covered by clothes.

The recommended measuring distance in the thermometer manual is 3–5 cm, and therefore set to be the “Standard”. Measurements when the thermometer was pressed against skin (“Close”) or 10 cm away (“Far”) were paired with “Standard” for Bland–Altman plotting with SPSS 26.0 (Version 26.0, IBM, New York, USA). We defined the difference between Far or Close, and Standard, of no more than 0.2°C as clinically acceptable, as the accuracy of the NCIT used is ±0.2°C. The temperature taken 45 min after the study started was considered the baseline. After 15 min spent outside, the body temperature at each time point minus the baseline was used to generate heatmaps, with pheatmap (Raivo Kolde, version 1.0.12, https://cran.r-project.org/web/packages/pheatmap/) installed in R version 3.6.2 (https://www.r-project.org).

When the temperature was <36.0°C, NCIT would display “Low” rather than a specific number, and for this reason all “Low” values were set to “35.9” for further analysis. Given that the accuracy of the thermometer is ±0.2°C, we considered the time-point when temperature reading was no more than 0.2°C lower than baseline the moment when body surface achieved complete rewarming. The mean rewarming time and the upper limit of 95% confidence
interval were calculated. If no obvious pattern was observed, temperature ranges were calculated to indicate the extent of temperature fluctuation.

A total of 30 participants were enrolled, and 29 completed the experiment. 22 were females. The mean age was 26.8 years. The mean values of the difference of 29 matched data were 0 for Standard-Close of the forehead, 0.0690°C for Standard-Far of forehead, 0.0862°C for standard-close of the wrist, and 0.2340°C for standard-far of the wrist. The 95% limits of agreement (LoA) were (-0.1482°C, 0.1482°C), (-0.0706°C, 0.2086°C), (-0.2730°C, 0.1006°C), and (-0.1512°C, 0.2730°C), respectively. The Bland–Altman diagrams [Figure 1A–D] showed only 2, 1, 2, and 1 out of 29 of the dots were outside the 95% LoA. Within the 95% LoA, the maximum differences between each pair were 0.1°C, 0.2°C, 0.2°C, and 0.2°C, respectively. Therefore, temperatures measured with either close or far distances were in acceptable agreement with the standard approach.

The changing pattern of forehead temperature [Supplementary Figure 1A; http://links.lww.com/CM9/A632] was relatively regular. After a 15-min outdoor stay, all forehead measurements fell to a level lower than the baseline. 90% returned to baseline within 9 min. The average rewarming time was 6.2 min (95% CI 5.0–7.5 min). At the end of the study, 21 participants had a forehead temperature similar to the baseline (ie, no greater than 0.2°C from the baseline), while 7 had higher temperatures, with an increase of 0.3°C in 3, 0.4°C in 1, 0.5°C in 1, and 0.6°C in 2 participants, respectively. This might be a manifestation of stress-induced hyperthermia.[4]

In summary, we observed the minimal impact of measuring distance (up to 10 cm) on infrared thermometer readings. Forehead readings were more consistent than wrist readings. We also observed that when participants were subject to exposure to the cold outdoor environment, 9 min was sufficient for rewarming in 90% of them.

Several limitations exist. First, this is a single-institution study with a small sample size, enrolling only healthy young individuals. Second, only one NCIT model was evaluated. Finally, the conclusions may not be applicable to other environmental conditions.

**Conflicts of interest**

None.

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