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Forehead, Temple and Wrist Temperature Assessment of Ethnic Groups using Infrared Technology

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ABSTRACT

Non-contact infrared sensors are widely used as a diagnostic tool for elevated body temperature during initial screening for coronaviruses. The aim of this study was to investigate the thermal differences at three anatomical points: temple, forehead, and wrist, in the initial screening for temperature indicative of febrile and non-febrile states in skin pigmentation variations in Black, Half-Black and Caucasian skins, correlated with height and weight variables. Temperatures were obtained by means of an infrared thermometer in 289 volunteers with mean age of 18.30 ± 0.76 , in a controlled environment according to Singapore Standard, SS582 part 1 and 2, normative standard IEC 80601-2-59, with standard technical protocols established by the International Organization for Standardization, ISO / TR 13154. The data were processed in MATLAB® R2021a, and data normality verified by Kolmogorov-Smirnov test, non-parametric data paired between temple / forehead / wrist were compared using the Wilcoxon signed-rank test. The results show different median temperatures in these anatomical regions, 37.2°C at the temple, 36.8°C at the forehead and 36.4°C at the wrist. As the temple region presents a temperature higher than the other investigated regions and, therefore, close to the core temperature, it should be considered for the initial screening of SARS-CoV-2 when using non-contact infrared thermometers. Furthermore, no significant changes were found due to variation in skin tone, height, or weight.

1. INTRODUCTION

Preventive measures for the early detection of people with possible contamination by SARS-CoV-2, in the verification of thermal changes related to febrile symptoms, are being carried out all over the world. Body temperature screening actions aim to reduce the negative impact on health services and limit the spread of the virus on a large scale in society. Therefore, infrared thermometers in conjunction with the acquisition of thermographic images are being used for rapid assessment [1]. In places with large flow of people, such as airports, shopping malls, companies, military organizations, schools and hospital reception areas, the protocol adopted worldwide to carry out a preliminary approach is based on a temperature body check, as infected people may have fever as one of the symptoms of viral contamination. Thermal imaging cameras for medical use are also being adopted at airports [2], as they can

capture reliable values of body temperature on the face up to 1 m away, favoring the possibility of detecting feverish thermal diagnostics, preventing the movement of these passengers in aircraft embarkation and disembarkation spaces and restricting the possibility of transmission.

For an initial assessment of rapid screening, Singapore Standard protocols and technical references, which regulate the parameters of use of medical devices, should be followed. The Standard: SS 582-1: 2020, referring to the specification for thermal imagers for human temperature screening, comprises the necessary requirements for their use and standardizes the thermal screening method [3]. Standard SS 582-2: 2020 presents the specification for thermal imagers for human temperature screening as well as its implementation guidelines [4].

The technical procedures adopted must comply with the IEC 80601-2-59 [5] standard, this normative standard regulates the basic safety and essential performance of thermal cameras, intended for use in

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non-invasive individual screening in closed environments, allowing information from portable infrared sensors to be accurate and reproducible. Thermal data fidelity is based on temperature acquisition in accordance with the standard technical protocols established by the International Organization for Standardization, ISO/TR 13154, for Medical Electrical Equipment, which provides technical operational guidelines for the identification of febrile conditions in the use of rapid screening by means of thermography [6].

However, the human temperature is depending on the body site region, higher temperatures are found in the core, while the skin and the extremities are usually colder [7].

The assessment of body temperature requires knowledge of human physiology, and strict following of the correct data acquisition protocols, as to get the most accurate thermal data. Aspects related to the use of medication can favor thermal changes such as the use of analgesics, corticosteroids and nasal decongestants, the ingestion of beverages containing caffeine (coffee / black tea) or beverages with alcohol content, as they cause vasodilation and, therefore, change the measured temperatures [3, 8, 9]. Dehydration can also cause an increase in body temperature; however, smoking, on the contrary, causes peripheral vasoconstriction and a consequent decrease in the temperature of the extremities, invalidating measurements on the wrist and hands. Psychological aspects such as fear, anxiety and stress can also influence screening for peripheral vascular vasoconstriction and consequent temperature decrease [10]. Other variables can also affect the measured temperature, individual factors such as age, physical activity, temporal variables such as the circadian rhythm, which express different temperatures during the day, the menstrual cycle, or pregnancy [8, 11] can cause an elevated body temperature. In these cases, a reported high temperature with IRT (Infrared Thermography) might be mistaken. The spatial variables such as body volume, skin scars, environmental conditions, data acquisition in a non-controlled temperature environment or outdoor (Sun, wind, etc.) can lead to screening errors [10, 12].

Care should be taken when measuring temperature, with acquisitions in specific regions. The subject must undergo an adaptation period, as the body was under the influence of the outdoor environment temperature. The thermometer must be periodically calibrated by a metrology laboratory (International Temperature Scale 1990 (ITS -90) [13], and it must be positioned perpendicularly to the skin surface.

Environmental conditions must be observed and controlled in the screening room, doors and windows must be closed to avoid drafts that could interfere with the accuracy of the measured temperature. The room temperature must be kept between 21 to 23°C, temperature screening must be away from incident lights on the subject such as lamps or sunlight, and relative humidity maintained between 40 to 75%. The subject should stay far from electrical wires, thus minimizing the interference of infrared energy from external sources, and without metallic objects in the vicinity that could cause reflection to the investigated area [3].

If some of these errors are unavoidable, the standardization of regions is essential in the infrared thermometry exam to reduce systematic errors and make the exam reproducible. The most important aspects regarding temperature acquisition are to be captured perpendicular to the surface of the body, and very close to the skin, usually from 0-80 mm away, as greater inclinations or distances reduce the radiation received by the sensor.

In view of these technical errors, it is observed that the temperature measurements on forehead, wrist and temple are used as reference worldwide in this pandemic period [14].

In many countries, the initial infrared thermometers screening was carried out in the central region of the forehead. However, in the central portion of the skull, no superficial artery passes by. The supratrochlear artery, a terminal branch of the ophthalmic artery, passes in this proximity but deep, through the posterior part of the trochlea of the superior oblique muscle of the eyeball [15]. Its anatomical course is curved, passing through the sides of the glabella, close to the root of the

eyebrows, 1 cm on the side of the central point of the frontal region, as shown in Figure 1 (a). The superficial temporal artery may be the most suitable body region for initial rapid screening on the face. This artery originates from the external carotid artery, his path crosses the posterior root of the Zygomatic process of temporal bone, divided into two branches, one frontal and the other parietal [15], being more apparent in the frontal branch, as shown in Figure 1 (b). Temporal artery temperature is close to rectal temperature and therefore accurately reflects a measure of core body temperature [16, 17].

Thermographic images corroborate the anatomical and physiological information of facial thermal variability and demonstrate the distribution of temperature as a function of its vascularization and according to the path of veins and arteries.

Larger blood vessels have a higher temperature than the small ones, thus the proximity to blood vessels increases local temperature, while terminal portions of vessels with a smaller caliber, such as hands and feet show lower temperature [8, 9].

The temperature scale is mapped by a rainbow color palette, which represents different temperatures. The white color is the highest temperature and the black the coldest one, as shown in the thermographic images Figure 1(b) front view, and Figure 1(d) side view.

The most reliable point would be the trunk, at the upper sternal region - blouse's neckline; however, this region is normally covered by clothing, and thus this site could cause an embarrassment, therefore preventing a quick tracking.

The temperature in the wrist region, tend to show larger variations. It is also usually cooler than the other sites, and more sensitive to environment changes. Additionally, the dorsal portion of the hand and wrist are warmer on the radial side and cooler on the ulnar side [8, 9]. Thus, the quality of the results is somehow dependent on the skill and experience of the health professional [9, 12]. Technical errors are commonly made when positioning the infrared sensor instead of pointing to the region of the styloid process of the radius bone, where the radial artery is more superficial, they point to the vicinity of the ulnar region, not respecting the distance of the sensor, or making oblique readings Figure 2. illustrates the forearm and hand and the path of the radial artery that runs laterally to the wrist, being a palpable artery medially to the styloid process of the radius bone. It is divided into palmar and dorsal carpal branches, which contribute to the formation of carpal arches and the muscle branches, which supply the anterolateral muscles of the flexor and extensor compartments.

The lack of the anatomy and physiology knowledge of the Covid-19 tracking personnel and absence of technical-scientific consensus on the standard measurement site for IR thermometer screening motivate us to study three regions: temple, forehead and wrist, in white, black and brown volunteers. Additionally, it was also evaluated the hypothesis that different skin tones could show changes in thermal reflectance. It was considered that the differences in the constitution of epidermal pigmentation in relation to the main skin chromophores (melanin and hemoglobin) could eventually be an intervening factor in obtaining the thermal values of the initial screening, according to their ethnical characteristics.

2. MATERIALS AND METHODS

2.1. Materials and Methods

2.1.1. Sample

The sample of this study consisted of 289 male soldiers aged between 18 and 20 years old, from different ethnic groups: 170 Caucasian, 20 Black and 99 Half-Black volunteers. Although this group is very specific in age and gender, it has the advantage to be more homogenous, and this way minimize the dispersion.

2.1.2. Material

The data were acquired with a Bioland® model E-127, digital

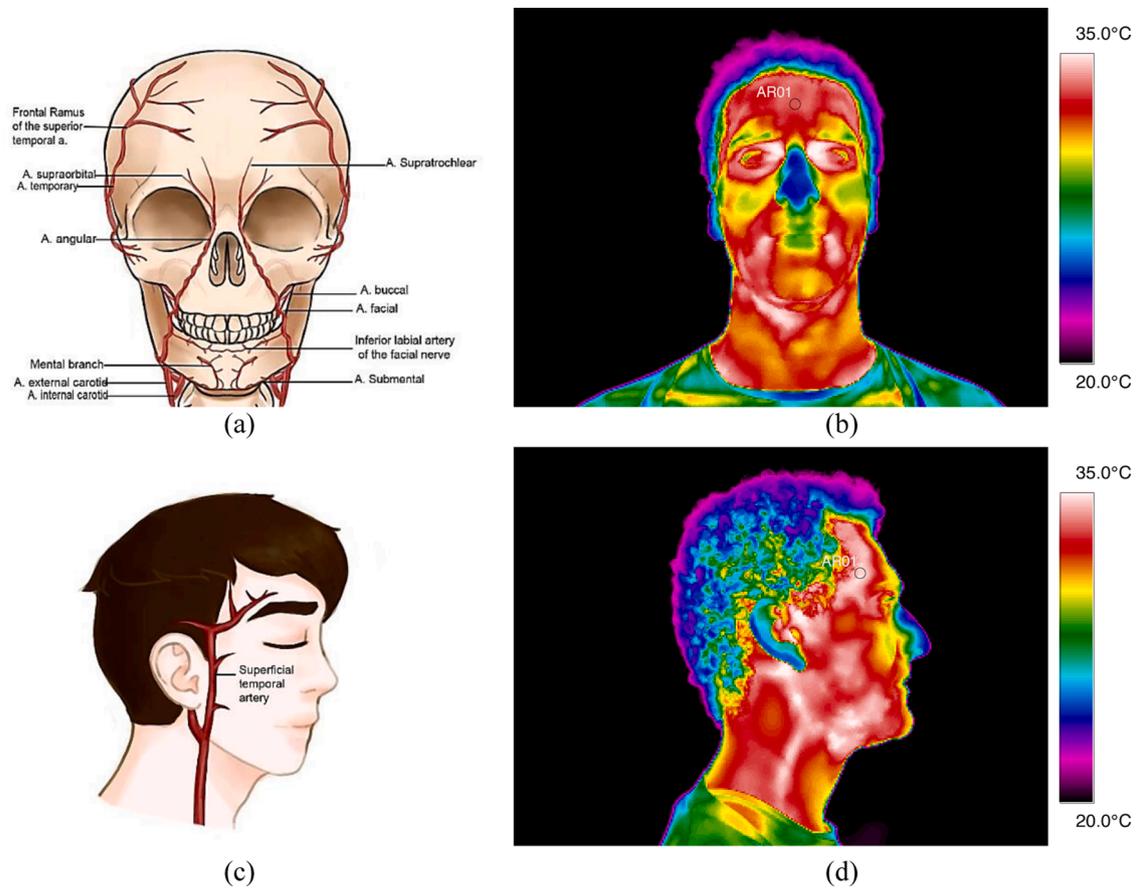


Fig. 1. Facial arteries (a); thermographic image, front view (b), anatomical position of the superficial temporal artery (c); thermographic image, side view (d). The target point is marked as a circumference on images b) and d).

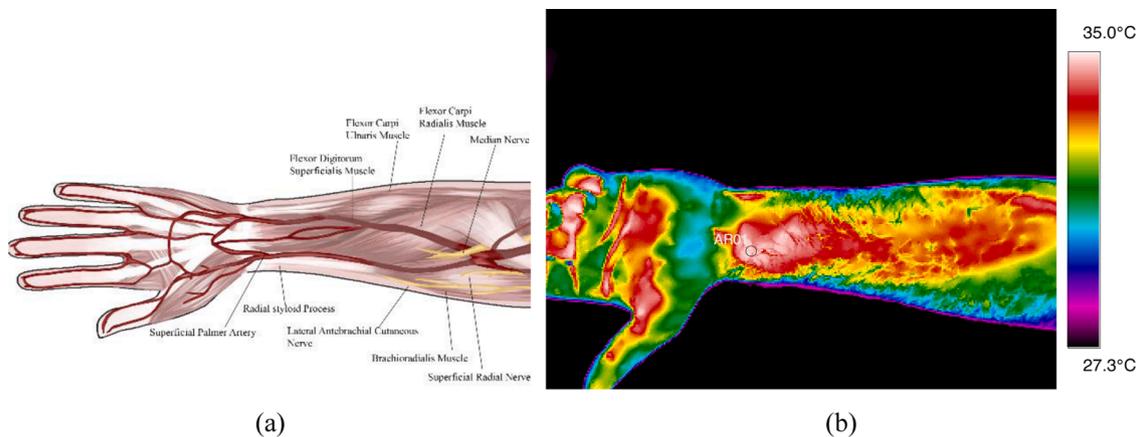


Fig. 2. Schematic targeting point in the wrist region, radial styloid process and the radial artery, palmar ramus (a); thermographic image (b). The target point is marked as a circumference on image b).

temperature clinical infrared thermometer, at three different measurement sites, temple, forehead, and wrist. This thermometer was set to a range of 35.1~39.0°C (uncertainty of $\pm 0.2^\circ\text{C}$, according to the maker), emissivity of 0.98 as define by the standards, distance measurement between 1 and 5 cm, approved by Anvisa, number 1041013.90.03, Inmetro/RBC Traceability Measurement Instruments Calibration (Brazil), international references of 1990 temperature scales (ITS -90) [13].

2.3. Methods

The study followed the ethical recommendations of Brazilian Resolution 466/12 and was approved by the Research Ethics Committee of the Federal Technological University of Paraná - UTFPR number 3014748, and all volunteers were informed about the study, data confidentiality, relevance of the research, and signed an informed consent form. The temperature screening room was maintained at a comfort level of 22°C, and the relative humidity less than 60 %, both assessed by a portable Mimipa® thermohygrometer.

All volunteers were instructed not to eat heavy meals, smoking,

drinking coffee, alcohol, or energetic stimulants for at least two hours prior to data collection [6]. The evaluation room, with a size of 10 m² was previously prepared for the acquisition, keeping the volunteer away from incidence sunlight and air flow, as well as electrical wires, to minimize the interference of infrared radiation from external sources [18]. Likewise, only the researcher and the volunteer remained in the room at the time of temperature measurement, thus minimizing the environment temperature change. The weight and height of the volunteers were also measured to evaluate the body composition. Because the adipose layer is a thermal insulator and interfere in the body thermoregulation, the higher the percentage of subcutaneous fat, the greater the thermal insulation, and thus low heat dissipation to outside. Volunteers considered obese tend to cool slowly when moving from hot to cold environments and, at the same time, tend to have a higher risk of hot thermal stress [19, 20]. However, there is no proven correlation between obesity and body temperature neither a literature consensus; there are authors that favor these findings as mentioned by [21, 22] and others that state an inverse association between temperature and obesity [23].

The volunteers were evaluated in the orthostatic position, without wrist watches and intensive physical activity on the day of the exam was not allowed. Additionally, all the volunteers rest for acclimatization for 15 min before the measurements took place. This study protocol consisted of three consecutively measurements of the temperature in each of the three defined regions, starting with the forehead, in the anterosuperior part of the head, between the eyes and the hair region, maintaining the sensor incidence two centimeters above the eyebrows on the medial portion of the forehead. The second measurement, in the temple region, formed by symmetrical and bilateral bones that constitute a large part of the lateral wall and skull base, maintaining the incidence 5 cm from the upper portion of the zygomatic arch, with the infrared sensor centered on the superficial temporal artery. Third measurement, in the region of the wrist, in the radial artery, located laterally in the region of the forearm and wrist, being visible and equally palpable medially to the styloid process of the radial bone, maintaining the measurement incidence with the sensor positioned in the region of the wrist corresponding to the line tracking of the thumb, according to the positions illustrated in Fig. 3. The three temperature measurements of each region were averaged and processed with MATLAB® R2021a software.

3. RESULTS

The body temperature normality test was performed using the Kolmogorov-Smirnov test on the sample of volunteers with a mean age of 18.30 ± 0.76 years, being the null hypothesis of normality test of body temperature rejected at 5% significance level.

The nonparametric paired data between temple, forehead, and wrist were compared using the Wilcoxon signed rank test, where p value <

0.001 was observed for the three comparisons, so the median hypothesis was rejected. Therefore, the results showed significant thermal differences regarding the body regions, as shown in Fig. 4.

The data are shown by a box diagram (boxplot) where the center of the box represents the median (50th percentile), the limits of the box represent the 25th and 75th percentiles (Q1 and Q3). Whiskers represent the maximum and minimum limits of the data (without inserting the outliers). Data that is above $Q3+3*(Q3-Q1)$, or below $Q1-3*(Q3-Q1)$, that is, three times the interquartile distance, was considered as an outlier, and thus removed. This value would be equivalent to covering more than 99.99% of the area of a normal distribution curve ($\pm 4.7\sigma$), thus ensuring that outliers are in fact anomalous points. The median temperatures were: 37.2°C (temple), 36.8°C (forehead), and 36.4°C (wrist). In addition to the difference between the medians, it is interesting to observe the temperature dispersion is higher in the wrist region, as expected.

In the tested sample, it was not observed a significant correlation between the temperature and the weight or height (Pearson's $\rho < 0.13$). The p -value < 0.3 also indicates the level of confidence as shown in Fig. 5 and Fig. 6.

For comparative analyses of body temperature and ethnicity, the data were separated into groups represented by a boxplot made by the same criteria adopted in the analysis of correlation of intervening variables, using the non-paired and non-parametric statistical test for this analysis. The test adopted for this evaluation was the Mann-Whitney U test or Wilcoxon rank sum test (Mann – Whitney U test or Wilcoxon rank-sum test). The data are no longer matched by groups to be compared, but by differences between individuals, and no longer within individuals.

The results showed a difference between the Caucasians and Half-Black when measure the temple ($p = 0.0357$), however not significant, Fig. 7.

Thus, to highlight the differences between the groups, the temperature was expressed in terms of the percentage difference (percentage error) in relation to the temple temperature (control), calculated by the following equation 1:

$$|\Delta T_{\%}| = \left| \frac{T_i - T_t}{T_t} \right| * 100\% \quad (\text{eq. 1})$$

Being T_t the temperature of the volunteer in the temple and T_i the temperature in another part of the body (forehead or wrist). The average percentage temperature and standard deviation were illustrated in a bar diagram shown in Fig. 8. In addition, Cohen's effect size metric was calculated to bring up the notion of how big the differences are (both globally and in relation to ethnical groups). The temperature differences were computed between temple and wrist, and temple and forehead, respectively.

The temperature difference between temple and wrist is greater than between temple and forehead for the three groups. In addition, the temperature difference between the temple and wrist is slightly greater



Fig. 3. Setup of thermal data acquisition in different body regions: temple (a), forehead (b), wrist (c)

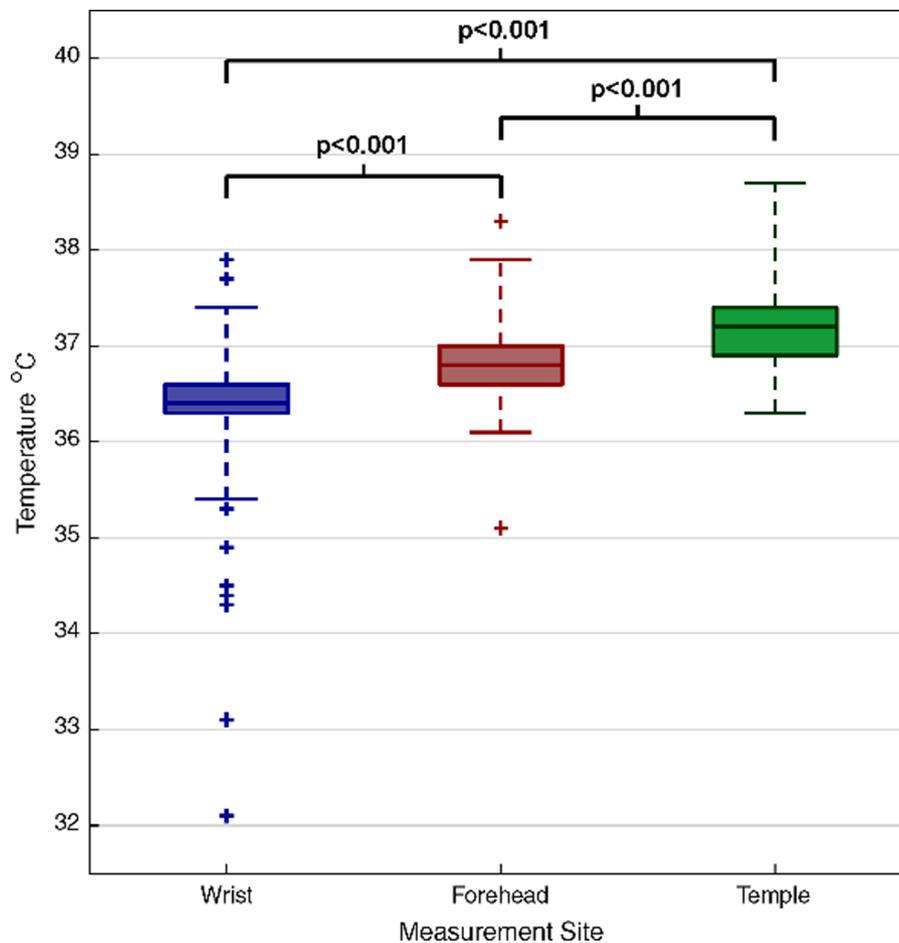


Fig. 4. Body median temperature measurements at the three regions

among Half-Black than for Caucasians.

4. DISCUSSION

Elevated body temperature screening was recommended by health authorities during the period of the SARS-CoV-2 virus pandemic, as a way to quickly detect people with febrile symptoms. Some researchers raised doubts about skin pigmentation influence on the measurements. In the state of the art on differences in emissivity between different skin tones, the reference studies surveyed demonstrated that there is no difference in thermal emissivity between black and white skin, confirmed by the authors [24–26]. According to Fernández Cuevas, 2015 [27], it was suggested that skin pigmentation could cause small variations in skin reflectance [2].

Pertaining to the effect of skin pigmentation, in the hypothesis that different tones influence the thermal readings of temperature tracking, it was observed in the acquisition of the tracking temperatures in 289 investigated volunteers, in the analyzes performed, that the presence of greater or lesser melanin, did not affect thermal emissivity in infrared radiation evaluations. It was found that in the darkest skin tones studied (20 black volunteers and 99 brown volunteers), the results did not show differences in reflectivity, considering that dark skin is more absorptive to temperature and infrared radiation.

In relation to the thermal barrier exerted by the skin, black skin appears to be thicker and have greater intercellular union, being more compact than white ones [28, 29]. In addition to differences in pigmentation, black skin has more active fibroblasts than white skin. Another important factor to be highlighted is that in black skin there is a greater number of blood vessels which, together with the greater activity

of melanocytes, leads to a predisposition to hyperpigmentation [28, 30]. However, the temperature changes would be very tiny, and thus imperceptible.

Despite the epidermal tones, the results presented in this study in 289 volunteers did not show statistically significant differences. The findings corroborate the evidence presented in the studies carried out by the authors Tschachler et al., 2006 [28] and Alchorne et al., 2008 [31], who did not find scientific consensus in the literature regarding the thermal barrier exerted by the skin of different ethnicities.

These results are also validated by the findings of the study by Charlton et al., 2020 [25], which analyzed thermal data from 65 participating volunteers, in the verification of the factor of skin pigmentation affecting the absorption of infrared radiation from visible light, with possible influence on readings temperature tracking thermals, depending on different skin tones.

The results found by the authors, despite the limitation of the analyzes having been carried out in only one volunteer with black skin tone, and eight volunteers with brown skin tone, quantified the skin pigmentation by reflection spectrometry, the findings with equality showed that the pigmentation and skin did not affect the reflectivity in the analysis of thermal images, nor did it show temperature differences on the skin surface, and could be scientifically applied safely for clinical temperature tracking, in areas with high circulation of people.

About the possibility of large body weight being a factor of change in body temperature due to adipose layer resistance to heat dissipation, it was observed that this correlation was not evidenced, in agreement to [23]. In the same way, different heights did not relate with measured temperatures, that is, the body mass index (BMI) does not seem to be an interfering variable in the initial body temperature screening.

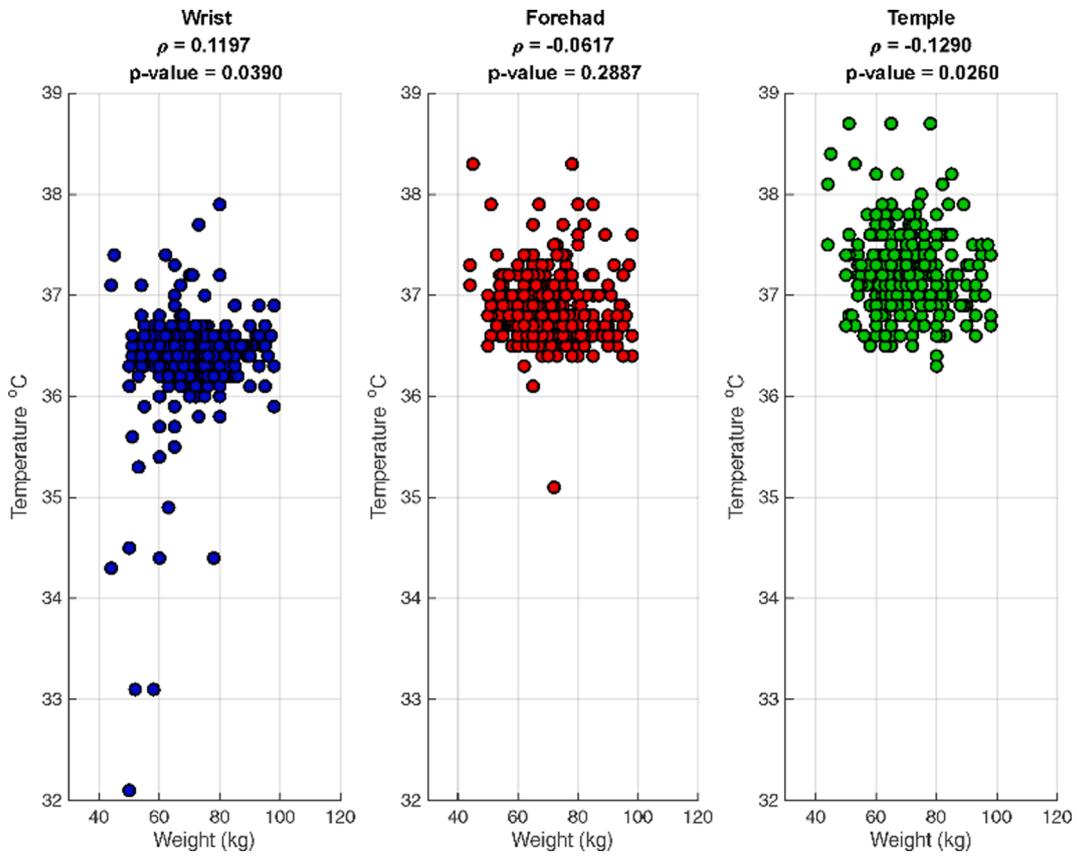


Fig. 5. Average temperature data correlated with body weight data.

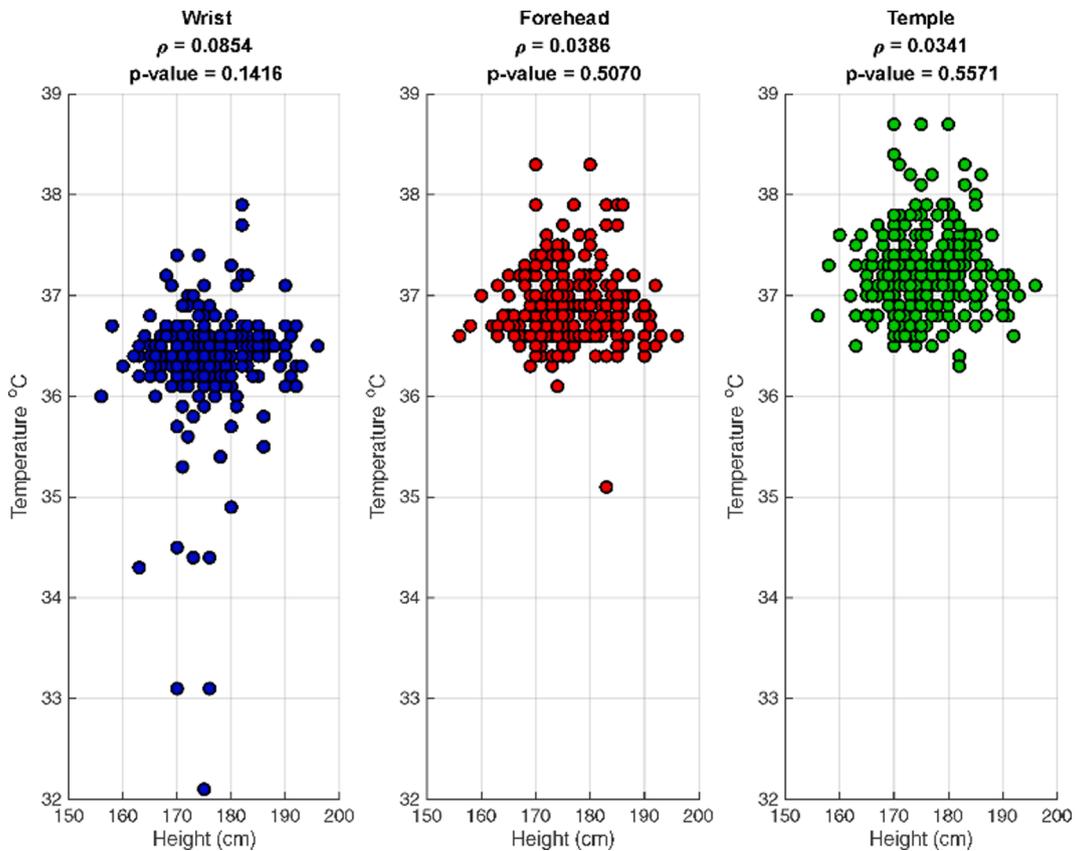


Fig. 6. Average temperature data correlated with height data.

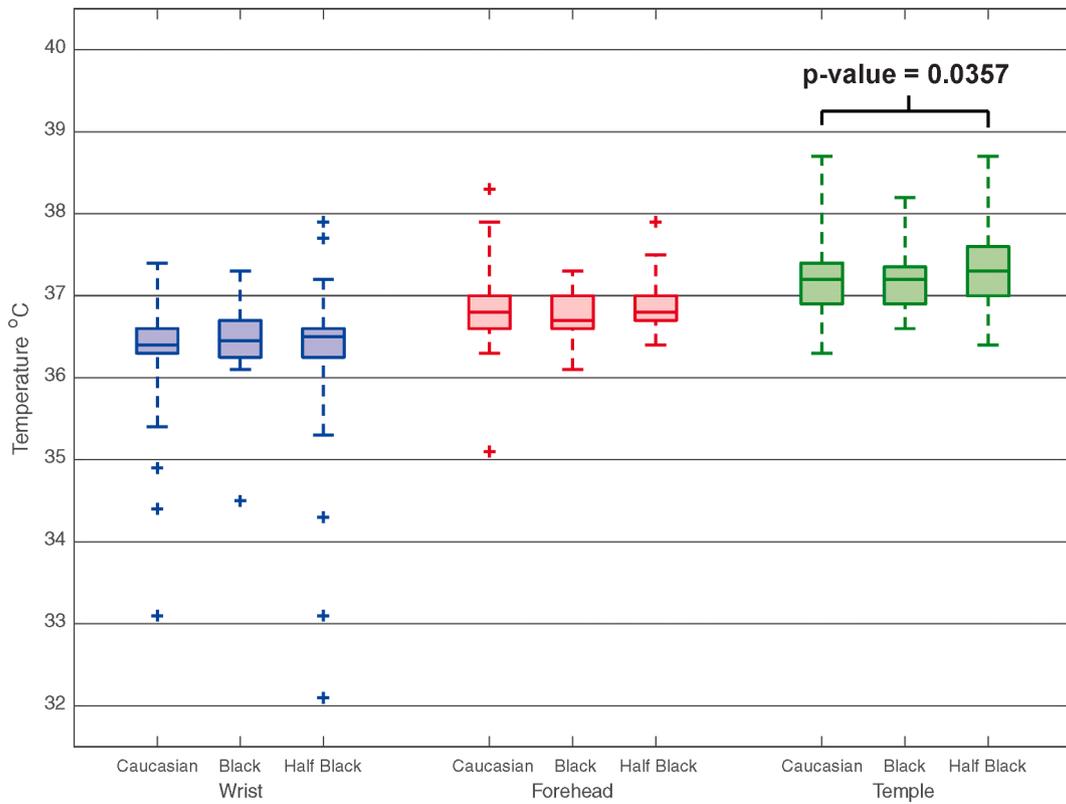


Fig. 7. Temperature data correlated with ethnicity data.

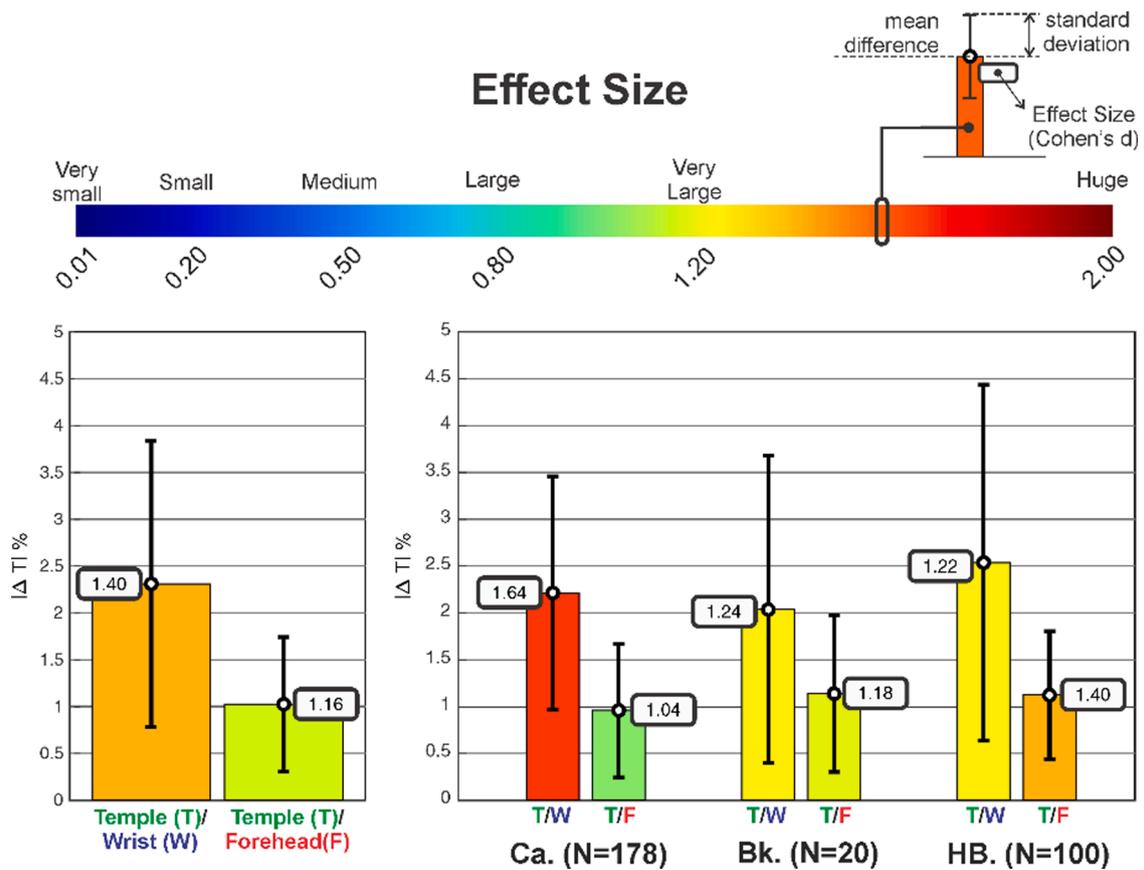


Fig. 8. Effect size data. The left graph includes all volunteers; while in the right is separated by ethnic group, Ca. – Caucasian, Bk. - Black, HB. – Half Black.

The median temperatures found in this work were 36.4°C in the anatomical region of the wrist, 36.8°C in the forehead and 37.2°C in the temple. These results are corroborated by [32] which presents a median temperature of the temple of 37.1±0.65°C. The results show that the temperatures measured are lower in the extremities, thus suggesting that this body region is not adequate as a reliable febrile screening site, which could cause "false negative" diagnoses. Among the measurements in the forehead and temple, they also show a significant difference, being more reliable and reproducible the anatomical region of the temple.

In addition, the cosmetics may also interfere significantly in the measurements. According to [32], febrile state differences of almost 1 to 2°C in body temperature can be masked using common cosmetics that contain solid particles, specially in the forehead region. A facial increase in local temperature (~0.5°C) may also be observed after aesthetic treatment by laser phototherapy to promote blood circulation [33].

The results did not show significant differences between skin tones, but between the usual anatomical temperature tracking points, with emphasis on the superficial temporal artery.

Regarding the measurements of body distances for tracking febrile states, the authors Goh et al., 2021 [34], with the study of the development of a low-cost thermometer, using an arduino, with adjustments for sensor range compensation, it was verified that the authors suggest the center of the forehead for initial screening pattern for thermal changes, suggestive of contamination by COVID-19. However, the distances tested were 2 to 4 cm, one centimeter above the minimum focal length limit allowed by portable infrared sensors for commercial use.

This minimum distance adopted by the authors may show greater inaccuracy in the diagnosis of temperature in the initial screening of febrile states, due to the greater angle of the field of view of the infrared sensor on the skin surface. The spatial resolution of 2 to 4 cm, infers greater dispersion of facial temperature, on the assumption that the targeting of the mapping of thermal focal points was carried out outside the path of the superficial arteries of the forehead or temple.

The farther away from the skin, the less uptake of infrared radiation is emitted by bodies. For definition of the tested protocol, the field of view was established for the thermometer focal point to be completely filled (distance, target set at 1 cm), avoiding temperature measurement outside the anatomical region of interest for the thermal reading.

Portable thermometers differ from thermographic cameras for clinical medical use, where measurements up to 1 m away are possible, due to their greater ability to resolve the images and the consequent assertiveness of the thermal profile measurements of the evaluated body segments.

These variables suggest that they are intervening factors in the reproducibility of the sensor evaluative tests proposed by the authors Goh et al., 2021 [34]. Likewise, they were not explained in the description in the manuscript, as the distances were standardized (screen for delimiting the test distances), to analyze the range of the thermometer and the evaluated volunteers.

The temperature compensation adjustments of infrared thermometers, in relation to angle and distance, suggest adopting the minimum distance allowed between the sensor to minimize this influence on the compensation of the sensor's reach in the thermal measurement in the facial region, where the distances adopted by the authors 2 to 4 cm, denoted a larger field of view, with probable positioning error on the supratrochlear artery in the forehead region and in the right and left superficial artery, in the temporal region, with a probable measurement of facial temperature outside the anatomical reference point.

Another important factor is the number of the sample, which denotes the unfeasible results of being scientifically extrapolated to a larger population.

In the experiment carried out by the authors with only five volunteers, it was observed that at the measurement distances of 2.5 cm, two subjects presented significant differences in thermal values, which can be decisive in an initial thermal screening, with a false positive result, in

places with high circulation of people.

Regarding the distance of 3 cm, there was great variability in the temperature distribution for the left temple, with values ranging from (32°C to 34°C), corroborated with values incompatible with the temperature of the head body segment, according to Haddad et al., 2016 [35]. For greater assertiveness of facial skin temperature measurements, in our work, we tried to adjust the sensor between temperature values from 35°C to 39°C, in the discrimination of febrile and non-febrile states, given the thermal values of reference established by the facial protocol research of Haddad et al., 2016[35].

In the study conducted by Haddad [35], a sample of 161 volunteers was tested using a thermographic camera for clinical use, in the composition of a protocol for interpreting the microcirculatory dynamics of the surface of the facial skin, identifying thermal reference points in the assessment of distribution of heat on the surface of the face by infrared thermography, where the minimum value detected in the temporal region was 35°C and, in the anatomical point of the superficial temporal artery, and in the point of the supratrochlear artery, it was 34.0°C.

The temperature values from 32°C to 34 °, found by the authors Goh et al., 2021 [34] on the surface of the facial skin, express highlighted thermal values for the lower limbs, according to the thermal profile data developed by the authors Morasiewicz et al., 2008 [36] composite by 175 healthy volunteers.

At a distance of 3 cm, the thermal variability presented by the research by Goh and collaborators [34], regarding the discrepancy between the measured temperatures, was shown to be even more evident, denoted in three assessed in the sample, with measurements below 33.0°C.

In the analysis of temperature acquisition at the central point of the forehead, noting that this region does not pass any artery, but 1 cm beside the central point in the supratrochlear artery bifurcation, it was evidently noticed that above 2.5 cm, the sensor's very open field of view demonstrates cooler temperatures. Consequently, inferring strong suggestive indications, that the distance of portable thermometers and the facial region of the evaluated, relevant to the compensation of thermal measurements, must be observed by the evaluators very carefully, in the effective tracking of febrile thermal data, in pandemic periods.

The importance of knowledge of physiology and anatomy for the traceability of febrile and non-febrile states is highlighted. The need for training for temperature acquisition with correct orientation of the infrared sensor perpendicular to the region of interest and the distance sensor-skin during the thermal evaluation and the correct anatomical point for the initial thermal tracking is highlighted. Due to the temperature measurement uncertainty of non-contact IR used as an initial screening, should be referred for a diagnostic confirmation, by means of a clinical contact thermometer; this way reducing the negative impact of "false positive.

4.1. Study Limitations

Despite the important results obtained, the investigation has some limitations as it does not include female volunteers. However, female body temperature can be influenced by the hormonal action, pregnancy and by the circadian cycle [8, 26, 37, 38]. Another limitation is that the group of volunteers was aged 18 to 20 years old, leaving out other population groups. Thus, the results obtained from the temperature medians cannot be extrapolated to other age groups.

5. Conclusion

The established protocol for temperature screening, with the propose of the temple as the most adequate site for facial anatomical thermal reference, was verified in a sample composed by male aged 18 to 20 years old. This specific sample makes the group more homogenous, and the measurements less influenced by cosmetics, hormone cycles and age

factors, as would be with the inclusion of female participants and a wider age. This way, the temperature variations were most probably minimized. However, further studies need to be performed, to confirm the variability of the temperature measured at the temple, wrist and forehead.

Author Contributions

Conceptualization, W.A.D.S.; methodology, W.A.D.S and J.M., formal analysis and validation, D.P.C.; investigation, W.A.D.S. and C.J. A.M.; data curation, D.P.C.; writing–original draft preparation, W.A.D.S and J.M.; writing–review and editing J.M.; J.F.S. and P.N, funding acquisition, supervision and project administration, P.N.

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Ethical Approval

This study met the ethical recommendations of Resolution 466/12 and was approved by the Research Ethics Committee of the Federal Technological University of Paraná - UTFPR - CAEE: 94262718.0.0000.5547, n° 3,014,748, of November 12, 2018. All volunteers were informed about the study, data confidentiality and the importance of the research, then signed an informed consent form.

Conflicts of Interest

The authors declare no conflict of interest.

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