Return to school in the COVID-19 era: considerations for temperature measurement

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ABSTRACT

COVID-19 pandemics required a reorganisation of social spaces to prevent the spread of the virus. Due to the common presence of fever in the symptomatic patients, temperature measurement is one of the most common screening protocols. Indeed, regulations in many countries require temperature measurements before entering shops, workplaces, and public buildings. Due to the necessity of providing rapid non-contact and non-invasive protocols to measure body temperature, infra-red thermometry is mostly used. Many countries are now facing the need to organise the return to school and universities in the COVID-19 era, which require solutions to prevent the risk of contagion between students and/or teachers and technical/administrative staff. This paper highlights and discusses some of the strengths and limitations of infra-red cameras, including the site of measurements and the influence of the environment, and recommends to be careful to consider such measurements as a single "safety rule" for a good return to normality.

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KEYWORDS

COVID-19; fever; temperature; infra-red thermal camera; non-contact thermometry

1. Introduction

The infection from the novel SARS-CoV-2 rapidly developed in a global pandemic which resulted in an impressive reorganisation of all social activities, including teaching at all levels, from schools to universities [1,2]. After an initial phase of the pandemic characterised by a lockdown period in many countries [3], a gradual return to normal activities has been regulated by several instructions intended to rapidly recognise potentially infected people and reduce the spread of the virus [4]. Multiorgan symptoms have been associated to COVID-19, mostly fever, cough, myalgia, fatigue [5] and some neurological features such ageusia and anosmia [6,7]. Based on these symptoms, the most common preventive procedure consists in measuring body temperature before entering shops, public offices, or workplaces, including hospitals [8,9]. Currently many countries are discussing and developing the regulations for a safe "return to school", which is expected in the next months. Among the decisions the governments and administrative bodies are considering, measurement of body temperature is one of the strategies suggested to prevent the spread of the virus among students and teachers. This paper aims to discuss some of the limitations some procedures and devices may have in effectively recognise fever symptoms, and how this may apply in teaching contexts such as schools and universities both for students and staff.

2. Strengths and limitations of infra-red thermocameras

Despite optimal temperature measurement to detect fever should be performed using tympanic thermometers (or more invasively, core temperature measurements such as rectal or oesophageal temperature and pulmonary artery catheter) [10–12], due to the need of non-contact and non-invasive measurements, infra-red (IR) thermocameras (often in the shape of "thermometer guns") are among the most widespread devices. Despite some findings encourage remote-sensing IR thermographic camera for screening purposes [13,14], its validity to detect fever is still debated due to the high risk of bias [15–18]. Indeed, some of the limitations are given by (i) the different type of the devices and corresponding accuracy, (ii) the need of an appropriate calibration process, (iii) a proper training of the user, (iv) the distance from the

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measurement site, (v) the environment where the measurement is taken (e.g., atmospheric attenuation, ambient temperature, ambient humidity, etc.), (vi) the different sites of measurement, (vii) the cut-off value to identify fever in the different sites, and (viii) the relationship between surface (skin) temperature and core temperature [16,19–22]. Most of the literature here presented come from studies conducted in paediatric populations, and some caution should be considered when translated to young adults and adults, e.g., university students, teachers, and technical/administrative staff. IR thermometry has been widely used for mass fever screening (e.g., in the airports), with some controversial results [22,23]. Indeed, cutaneous IR thermometry was found identifying hyperpyrexia (oral temperature $\geq$38.0 °C) in 59% of cases, while no hyperpyrexia was predicted 90% of times, therefore leading to false negative results [18]. As mentioned above, bias may come from the type of device and included algorithms; indeed, advanced fever screening system as the Infrared Thermal Detection Systems (ITDS) showed different levels of sensitivity and specificity, with the "Omnisense ITDS" having the best results (sensitivity: 89.7%, specificity: 92%) [24].

The site of measurement may further influence the results. For IR thermometry, the inner canthus of the eye (i.e., the medial and end of the palpebral fissure) has been often suggested as one of the best sites to estimate core temperature [25], although lack of precision may be found both at rest and in particular during/after exercise [26–28]. Forehead surface is the most commonly used site for temperature reading; however, in children and young adults it was characterised by a high false-positive rate of fever screening [29], and thermal screening of facial skin arterial hot spots may not be correlated with tympanic temperature [30]. Additionally, the difference between core and forehead surface temperature may be up to over 1 °C [20], and the environment may significantly influence skin temperature both in the heat [31] and cold [32]. The latter may be of particular relevance in the context of school monitoring. Indeed, most of the students may be exposed to heat or cold prior the measurement, and this may influence the result. In febrile and non-febrile children were necessary at least 10 min to compare forehead skin temperature to the surface temperature of chest: as such, in addition to the aforementioned limitations to the validity of surface temperature, further considerations should account for the "environment" factor, providing the possibility to take measurements only after a proper acclimatisation (i.e., at least 10 min) [32].

3. Special considerations for fever screening and future perspectives

After these technical considerations, a further point of discussion should consider the usefulness of fever detection to prevent COVID-19 spreading [33]. Indeed, even with the most appropriate protocols and devices, fever may not be sufficient to identify virus carriers, as suggested in a recent study showing poor sensitivity for SARS-CoV-2 detection [34]. Because of this limitation and due to the lack of validity of non-contact and IR thermometry for fever detection, novel technology solutions may assist in mass fever screening. A promising tool may be represented by multiple vital signs monitoring cameras able to measure respiration rates, facial skin temperature, and heart rate, which are integrated through an appropriate algorithm to identify the presence of fever. The aforementioned methods based on non-invasive multiple vital signs measurement and predictive models showed high sensitivity and specificity, even higher than those of conventional fever-based screening approaches; therefore a further development and use of these devices should be considered as a valid infection screening tool [35,36].

4. Conclusions

In conclusion, some limitations may be present for mass fever detection during COVID-19 era, that should be taken in account when organising a safe "return to school":

- Non-contact IR thermometry may lack validity for fever screening, due to non-homogenous devices or protocols, the absence of calibration, and poor correlation between surface (skin) temperature and core temperature
- Different factors may influence the reading, such as the distance, the site of measurement, and the environment
- Facial skin, and in particular forehead, may poorly predict core temperature; the inner canthus of the eye is often suggested as the best site on the face, although some conflicting results are present in particular during and after exercise
- When planning surface temperature measurements, enough acclimatisation time should be provided if coming from hot/cold environments

- Provide sufficient training to those who are designated to take the measurements, and strictly adhere to the manufacturer instructions
- Fever is one of the symptoms of COVID-19, and due to the high number of asymptomatic patients or COVID-19 patients without fever, it should not be considered as the only "safety" rule
- Multiple vital signs devices and dedicated algorithms should be further developed and validated with the possibility of measuring different physiological parameters giving a higher infection identification accuracy

Authors' contributions

ABS and MA conceived the study, wrote the draft, and reviewed the final version of the manuscript; PM, GF and AA reviewed the literature and reviewed the final version of the manuscript. All the authors approved the submitted manuscript.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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