Brain thermal kinetics at brain-eyelid thermal tunnels overcoming COVID-19 thermometry limitations for automated asymptomatic infection detection in concert with physical and biological principles

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Abstract

For centuries, temperature measurement deficiencies attributable to biological barriers and low thermo-conductivity (k) have precluded accurate surface-based fever assessment. At this stage of the pandemic, infection detection in children (who due to immature immune system may not effectively respond to vaccines) is critical because children can be readily infected and also become a large mutation reservoir. We reveal hitherto-unrecognized worldwide body temperature measurements (T°), in children and adults, over tissue typified by low-k similar to wood that may reach 6.8°C in thermal variability, hampering thereby COVID-19 control. Brain-eyelid thermal tunnels' (BTT) integration of low-k and high-k regions creating a thermal pathway for undisturbed heat transmission from hypothalamus to high-k skin eliminates current shortcomings and makes the brain indispensable for defeating COVID-19 given that brain thermoregulatory signals are not limited by mutations. Anatomo-histologic, emissive, physiologic, and thermometric bench-to-bedside studies characterized and overcome biophysical limitations of thermometry through high-k eyelid-enabled brain temperature measurements in children and adults. BTT eyelid features fat-free skin (˜900 μm) and unique light emission through a blood/fat configuration in the underlying tunnel. Contrarily, forehead features variable and thick dermis (2000–2500 μm) and variable fat layers (1100–2800 μm) resulting in variable low-k as well as temperatures 1.97 °C lower than BTT temperature (BTT°). Highest emission present in only ˜3.1% of forehead averaged 1.08±0.49 °C (mean±SD) less than BTT° (p=0.008). Environmental and biological impacts during fanning revealed thermal imaging limitations for COVID-19 screening. Comparison of paired measurements for 100 pediatric patients showed that in the children subgroup above 37°C, BTT° exceeded body core temperature (Core°) in 60/72 patients; the average difference in the 72 patients was 0.62±0.7°C ($p<0.001$ by unpaired t-test); and in the subgroup beyond 37.5°C, BTT° exceeded Core°

in 30/32 patients. Delineating hypothalamic activity in children facilitates early infection detection, which is essential because children's immunogenicity prevents effective vaccination and causes accelerated viral evolution. Capturing hypothalamic thermal signals from BTT was further supported by brain thermal kinetics via BTT using wearables during anesthesia, sedation, sleep, brain injury, exercise, and asymptomatic infection, which revealed brain/core discordance and enabled automated noninvasive afebrile infection detection for interrupting asymptomatic human-to-human transmission. BTT-based spot-check thermometry can be harmlessly implemented for children worldwide without undue burden and costs; meanwhile, continuous brain-eyelid T° in concert with biological and physical principles affords a new dimension for combating pandemics. The "detection–vaccination" pair solution presented is required to mitigate COVID-19 from spreading indefinitely through mutations and vaccine evasion while opening a viable path for eradicating COVID-19.

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