Developing a Wearable Device to Deliver Preferential Cooling to the Brain

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Introduction

Therapeutic hypothermia is a promising neuroprotective strategy following cardiac arrest, stroke, and epilepsy, as it can reduce ischemic brain damage and limit irreversible neuronal necrosis. However, current cooling methods often rely on whole-body hypothermia or bulky devices, which may cause complications such as shivering and poor portability.

Clinical studies have reported improved neurological outcomes and reduced mortality with controlled hypothermia treatment. By lowering brain temperature, hypothermia decreases cerebral metabolic demand, oxygen consumption, and inflammation, thereby protecting against ischemic injury.

This project developed a localized, portable wearable cooling device through computational modeling, complementary physical prototyping.

Design Concept

A wearable prototype consisting of 4 Peltier modules, heat sinks, trigger boards, silicon pads, and power banks was assembled. The Peltiers provide localized cooling, while the silicone pads and heat sinks were used to dissipate heat and improve efficiency.

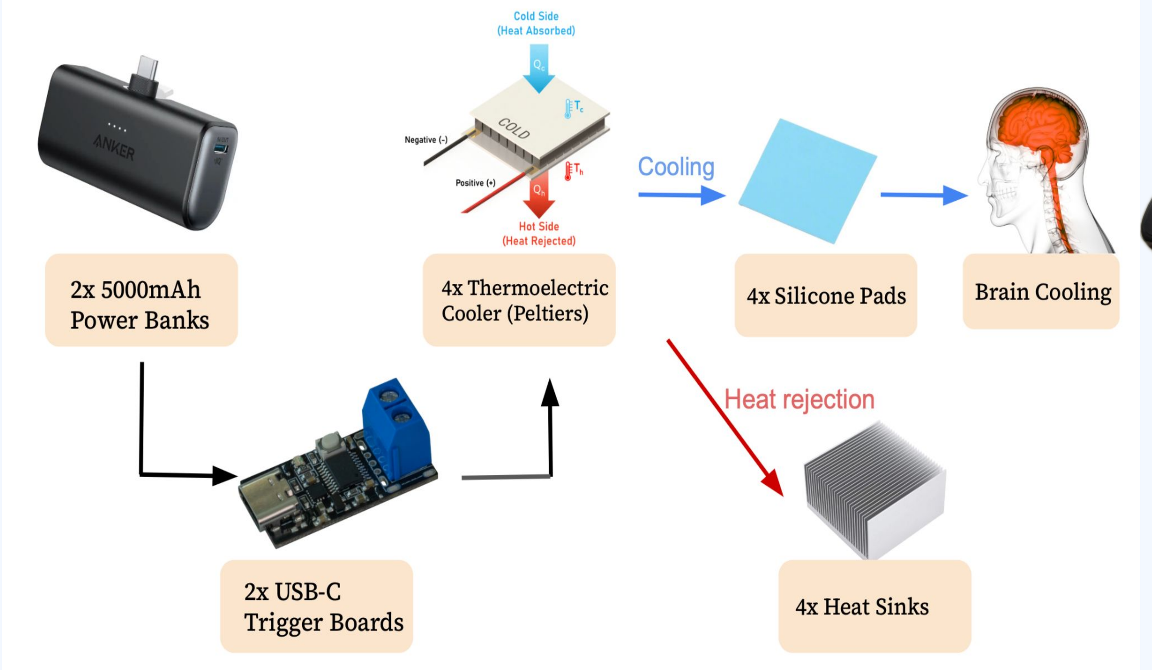

Figure 1: Brain Cooling Experimental Test System Schematic

Figure 1a: Envisioned Use

A CAD model of the brain was developed with several 6 mm internal flow channels to approximate simplified cerebral perfusion and allow circulation of temperature-controlled fluid during testing. Figure 3b was fabricated using a Formlabs resin printer with Elastic 50A material, selected for its mechanical properties that resemble biological tissue

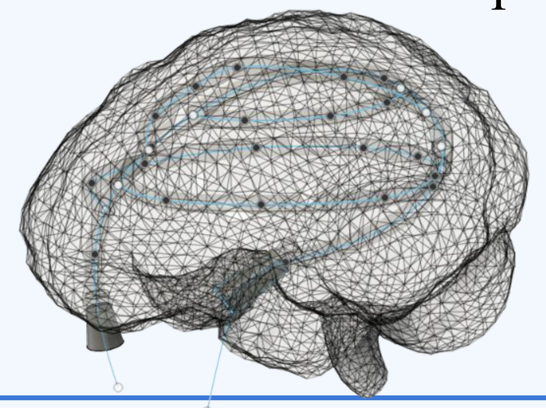

Figure 2: CAD model of brain + flow channels

Physical Prototyping

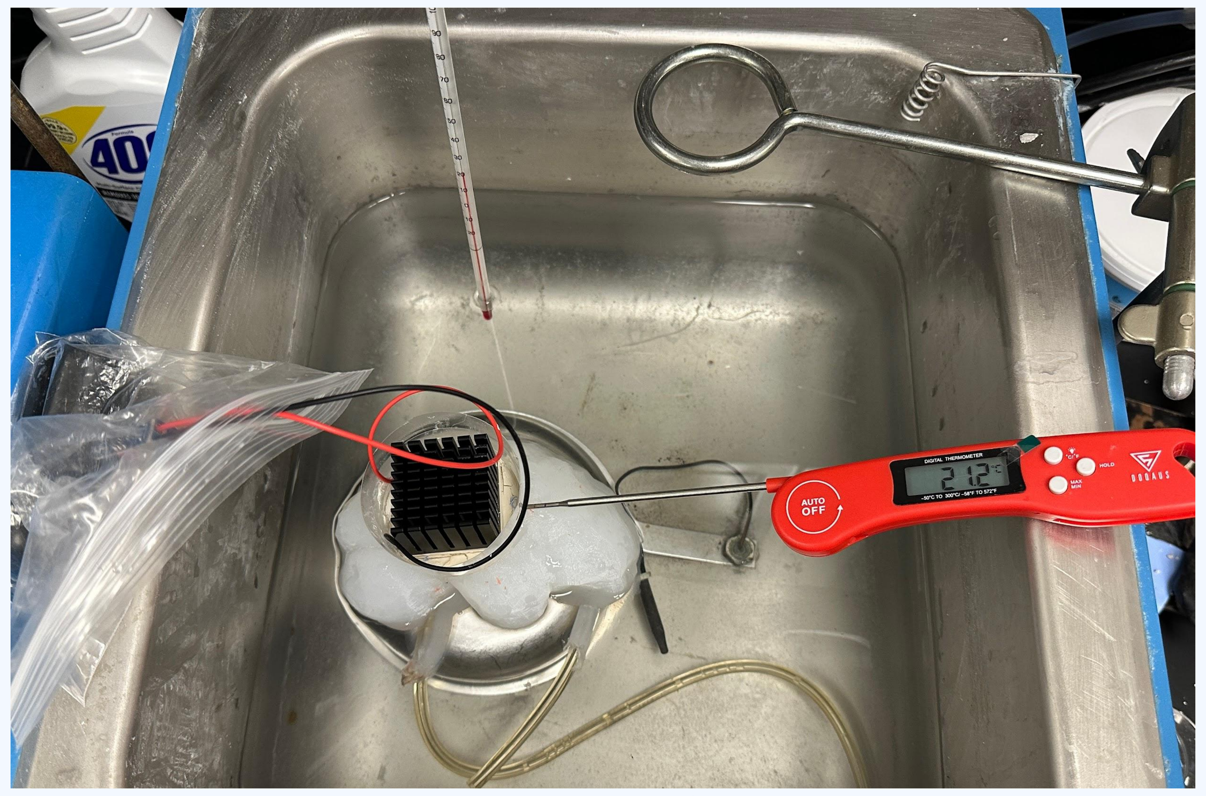

Figure 2: Experimental Test System

Figure 3a: Brain v1 for experimental testing

Figure 3b: Brain v2 for experimental testing

For testing, a thermoelectric peltier module was applied to the surface of the brain model. Circulating water at 37 °C was pumped through to mimic cerebral perfusion. and temperature changes were measured to evaluate cooling performance and thermal penetration.

Results

Physical testing was conducted under various conditions, including fan-assisted heat sink and a heated water reservoir. Across trials, the maximum temperature reduction was 15 °C at the brain's surface.

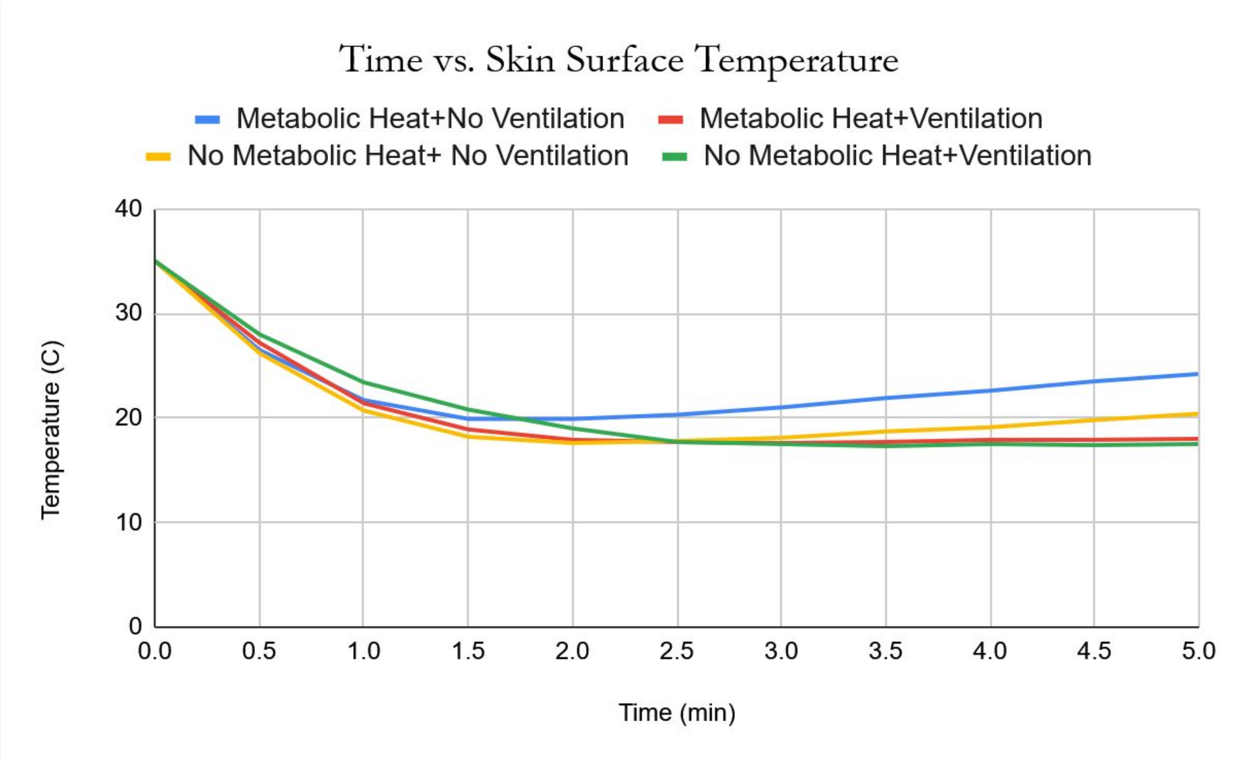

Figure 4: Change in skin surface temperature over time.

Results

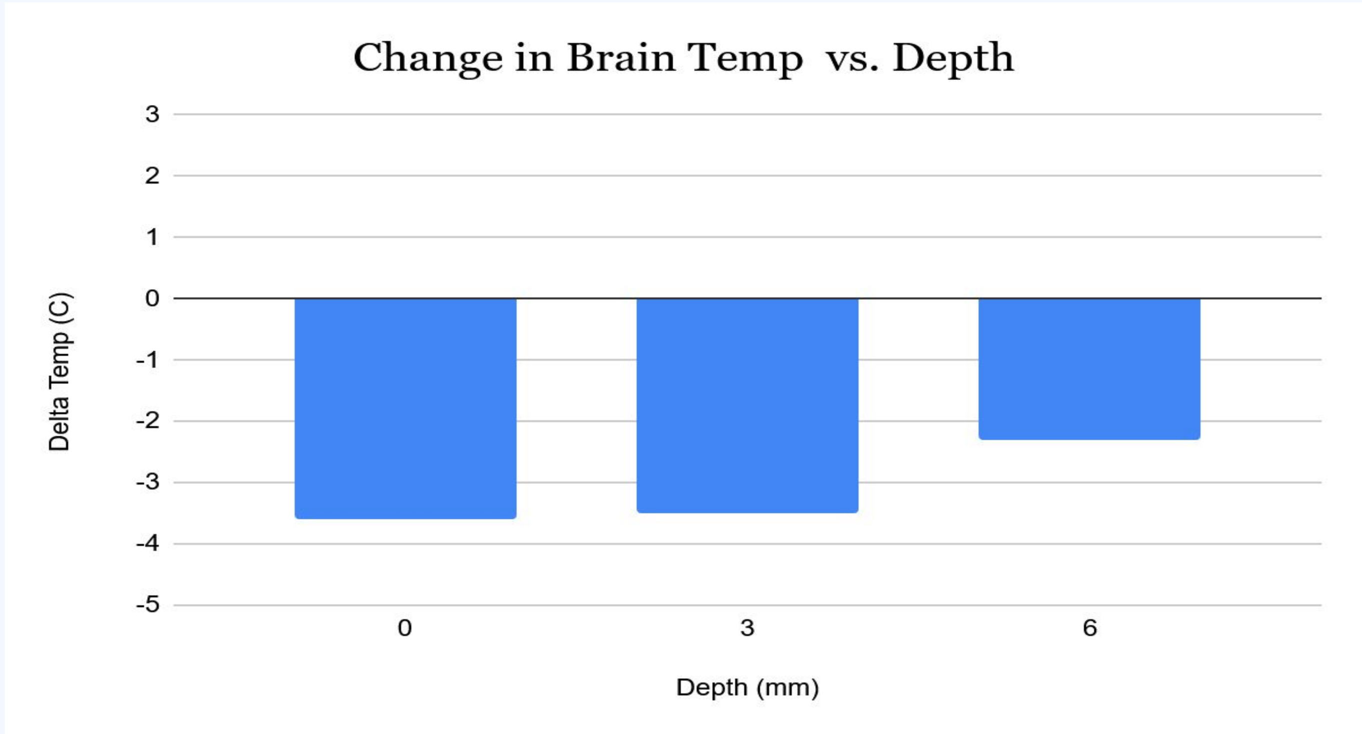

Figure 5: Change in temperature at various depths.

Conclusions and Future Directions

The key results collected from computational modeling and physical experiment demonstrated the device was capable of achieving sustained 2-3 °C. cooling in the cortical gray matter region of the brain.

A current limitation of this design is that the cooling area is restricted by the fixed placement and surface area of the Peltier modules. Future improvements may include a system with repositionable cooling elements to target patient-specific regions, or distribute full-head cooling to increase coverage. Such advancements could improve treatment flexibility, personalization, and overall device effectiveness.

Acknowledgements

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