

Validity and Reliability of Temperature Sensing Devices During and Following Exercise in the Heat

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ABSTRACT

Background: Exertional heat stroke is a danger for athletes that participate in outdoor and indoor sports and can be fatal if not recognized and treated properly. Oral temperature is commonly used to assess an athlete's temperature during exercise, but previous research suggests it may be an invalid and unreliable measurement of core temperature. A company recently designed a mouth guard prototype that changes color when core temperature reaches a specific threshold.

Purpose: The purpose of this study was to determine the reliability and validity of the color-changing mouth guard when the user reaches a core temperature of 39°C. I hypothesized that the mouth guard would have limited validity and reliability.

Methodology: Thirteen volunteers participated in the study (26 ± 5.3 yrs; 171 ± 8.14 cm; 70.1 ± 11.6 kg; 17.0 ± 4.75% body fat). Participants ingested thermistors 5-6 hours prior to their assigned trial time. When participants arrived, their height, nude body mass, and bioelectrical impedance were measured. They began their trial by sitting in the environmental chamber for 10 minutes. Then, a photo of the mouth guard was taken, and their oral (Welch Allyn SureTemp® Plus) and intestinal temperatures (CorTemp) were measured. Then they began exercise with the goal of reaching >39°C. Every 5 minutes, a photo of the mouth guard was taken, and temperature measurements were recorded. Exercise ceased when the participant wanted to stop, if they reached 40.2°C, or if they showed symptoms of heat exhaustion. After exercise, they sat in the chamber for 5 minutes, outside of the chamber for 5 minutes, and in a cold-water bath at 4.5-10°C for 5 minutes. A photo of the mouth guard and temperature measurements were taken after each of these events. After data collection, oral temperatures were compared to intestinal temperature in order to determine validity and reliability. Water baths were used to confirm that the mouth guards changed color at its reported temperature.

Results: The mouth guard changed color at the correct temperature. Participants exercised for a mean of 47 ± 14 minutes. The participants reached a mean intestinal temperature of 39.08 ± 0.18°C, which was significantly greater than maximal oral temperature (37.33 ± 0.39°C; p<.001). At no point during trials did the mouth guards change color, even though the mean core temperature was above the supposed threshold of the mouth guards.

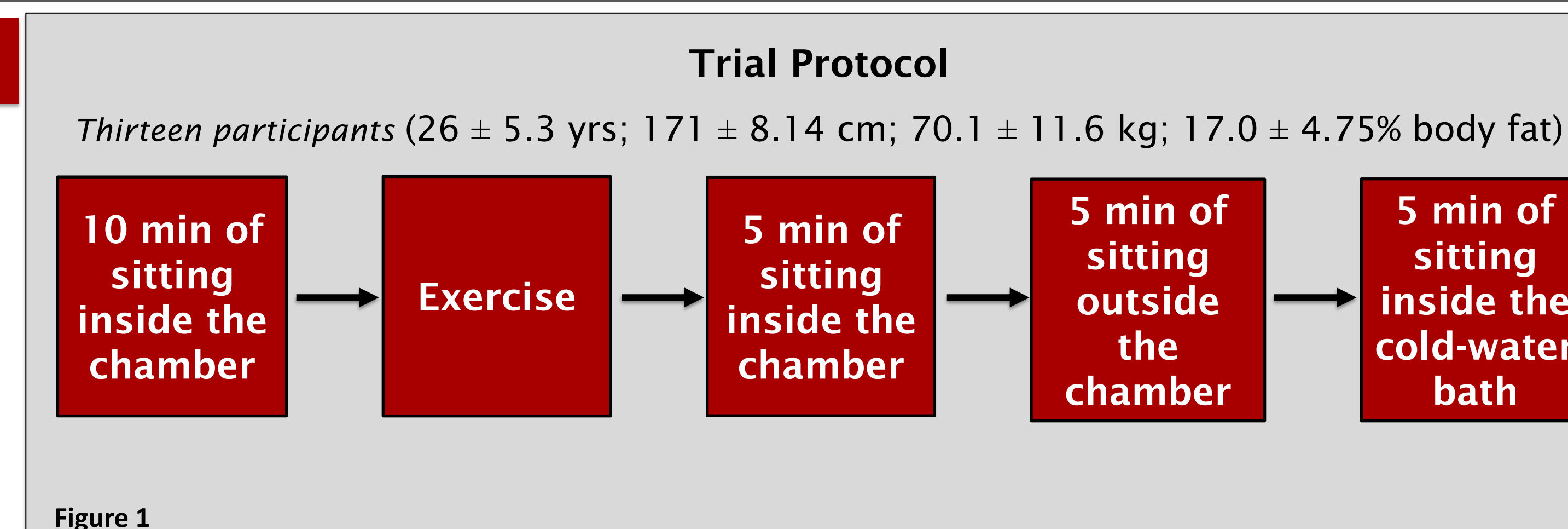
Discussion: The findings of this study support the idea that oral temperature is not a valid or reliable measurement of core body temperature during exercise. It would be unsafe for athletic trainers to use this mouth guard as a diagnostic or preventive tool for heat illnesses.

INTRODUCTION

- Exertional heat stroke (EHS) is an elevated core temperature above 40°C, with central nervous system dysfunction.²
- EHS can affect athletes in all settings and does not always occur in extreme heat.³
- EHS can be fatal so early recognition is important.^{1,4}
- The National Athletic Trainers' Association reports that rectal temperature is the most valid way to assess core body temperature in an athlete that has been exercising.³
- Ingestible thermistors are a valid measurement of core body temperature during exercise.⁶
- Oral temperature has been found to be an invalid and unreliable measurement of core body temperature during exercise.^{5,6}
- A company recently designed a mouth guard prototype that claims to change color when an athlete's core temperature reaches 39°C.

PURPOSE

The purpose of this study was to determine the reliability and validity of the color-changing mouth guard when the user reaches a core temperature of 39°C.



METHODS

- Thirteen healthy participants (26 ± 5.3 yrs; 171 ± 8.14 cm; 70.1 ± 11.6 kg; 17.0 ± 4.75% body fat) each completed one trial of exercise in the environmental chamber with the goal of reaching 39.5°C.
- The environmental chamber was set to 26.7°C and 50% humidity, the room outside of the chamber was 22.2 °C, and the cold-water bath was 4.5-10°C.
- The participants ingested an ingestible thermistor 5-6 hours prior to their assigned trial time.
- Upon arrival, their height, nude body mass, and bioelectrical impedance were measured.
- The participants could not drink any liquids while they were wearing the mouth guard in order to avoid compromising its temperature.
- Researchers ensured that their ingestible thermistor was reading correctly.
- Participants then fit the mouth guard (Figure 2) to each participant by heating it in the microwave for 1 minute and 25 seconds and then instructed them to put it in their mouth and suck in to fit.
- The participants began their trial following the trial protocol (Figure 1).
- After each section of the trial and every 5 minutes during exercise, a photo of the mouth guard was taken, and the participant's oral and intestinal temperatures were recorded.
- Each temperature device recorded 2 separate measurements at each time interval to ensure reliability.
- Exercise was completed when the participant wanted to stop, if their core temperature reached 40°C, or if they showed symptoms of EHS.
- The mouth guard was tested in a water bath to confirm that it changed color at its reported temperature.



Figure 2. On the left is a photo of the mouth guard at room temperature. On the right is a photo of the mouth guard after being heated in boiling water to 39°C.

RESULTS

- The mouth guard changed color at its threshold temperature of 39°C in the water bath.
- The participants exercised for a mean of 47 ± 14 minutes.
- The participants reached a mean intestinal temperature of 39.08 ± 0.18°C, which was significantly greater than the maximal oral temperature of 37.33 ± 0.39°C; p<.001.
- The oral temperatures and intestinal temperatures of the participants throughout the trial are compared in Figure 3.
- Even though the participants' mean core body temperature was above 39°C, none of the mouth guards changed color during any of the trials.

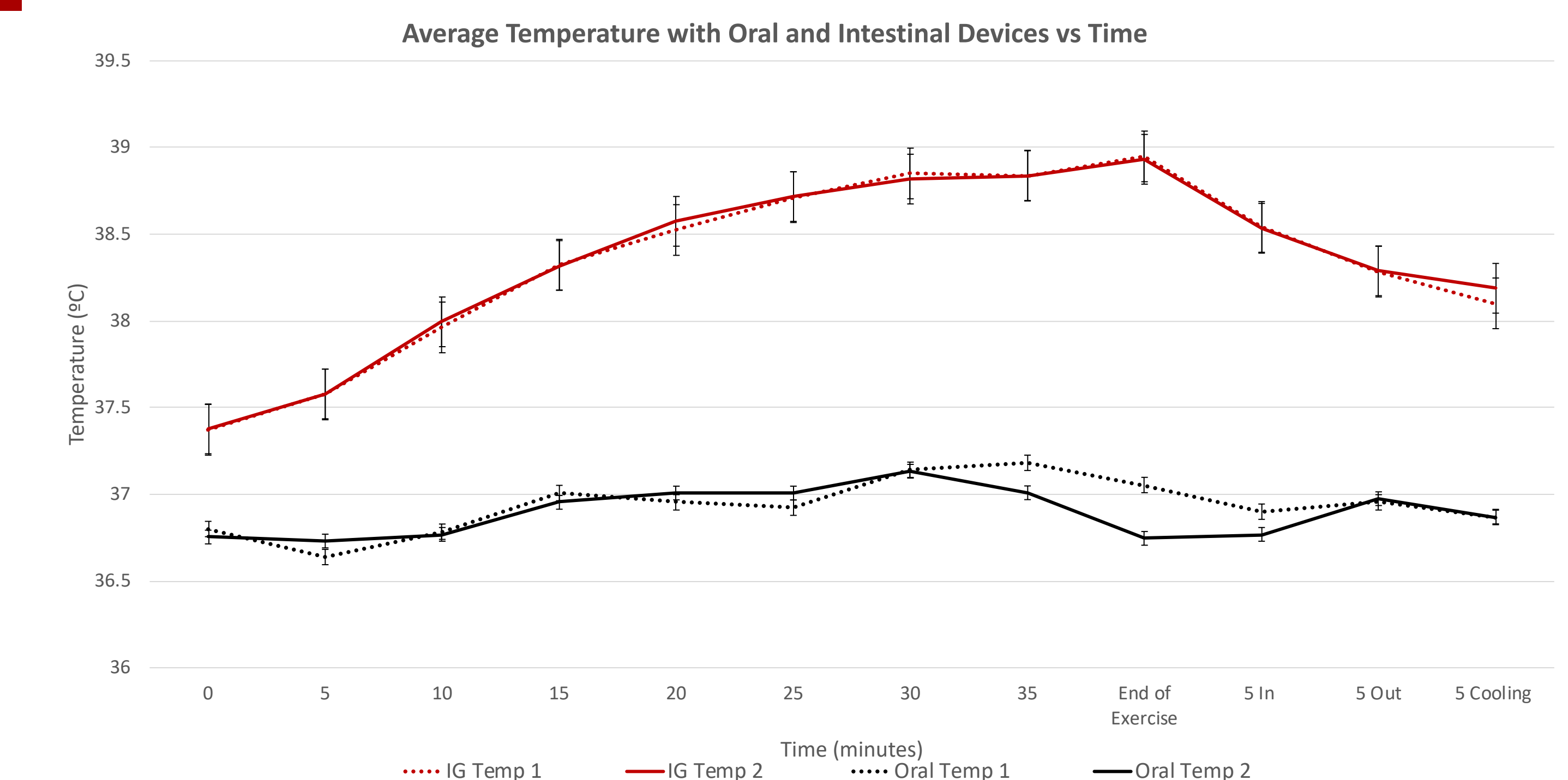


Figure 3. At the peak of average intestinal temperature (IG Temp 1: 38.9°C; IG Temp 2: 38.9°C), average oral temperature experienced a decrease (Oral Temp 1: 37.1°C, Oral Temp 2: 36.7°C).

CONCLUSION

None of the mouth guards changed color throughout any of the trials, further supporting the evidence that oral temperature is not a valid or reliable measurement of one's core body temperature. It would not be safe to use this mouth guard to assess an athlete's core temperature in a clinical setting.

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