

THE EFFECT OF TWO CYCLING HELMETS ON THERMOREGULATION AND THERMAL PERCEPTION DURING EXERCISE IN WARM AND HUMID CONDITIONS

D. Jason Gillis, Martin J. Barwood, Geoffrey M. Long & Michael J. Tipton

Department of Sport and Exercise Science University of Portsmouth, England, UK.

Contact person: jason.gillis@port.ac.uk

INTRODUCTION

Aerodynamic cycling helmets are often poorly ventilated. This raises the question of whether the benefit from the improved aerodynamics is offset by the potential detrimental effect on thermoregulation. Few investigations have assessed the thermoregulatory consequence of wearing poorly ventilated aerodynamic cycling helmets versus standard helmets. In 1992, Rodahl *et al.* found head skin temperatures to be significantly higher in participants who cycled indoors whilst wearing a helmet, compared to when not wearing a helmet. More recently, Bruhwiler *et al.* (2006) have suggested that all cycling helmets act as barriers to head cooling, although these conclusions were primarily drawn from data collected using a temperature calibrated manikin head form, equipped with a cycling helmet and placed in a wind chamber.

In contrast to the above, Gisolfi *et al.* (1988) had participants exercise indoors (33°C, 10% RH) for 2 hours at 70% of their VO_{2max} with a fan providing airflow. Participants underwent two conditions: without helmet; or wearing a minimally ventilated helmet. Gisolfi *et al.* found that wearing a helmet did not alter thermal balance. Likewise, Sheffield-Moore *et al.*, (1997) had participants cycle with and without a helmet for 1.5 hours at 60% VO_{2peak} in the heat (35°C, in low [20%] and high [70%] relative humidity) and found no adverse impact on deep body temperature, head skin temperature and sweat rate when a helmet was worn.

Far fewer investigations have considered the effect of a cycling helmet on thermal perception, and those that have offer contradictory findings. For example, Sheffield-Moore *et al.*, (1997) did not observe any increase in heat perception amongst cycling participants who wore helmets, while Gisolfi *et al.* (1988) found that poorly ventilated helmets produce a greater perception of thermal discomfort.

Conclusions surrounding the thermoregulatory and perceptual impact of wearing poorly ventilated cycling helmets remain equivocal, and due in part to poor helmet descriptions, generalizing findings is problematic. Therefore, the primary aim of the present research was to assess the effect of wearing a well-ventilated cycling helmet (Specialized Decibel) versus a less well-ventilated, more aerodynamic helmet (Giro, Advantage) on deep body and skin temperatures and thermal perceptions, in mildly heat stressed humans.

For the purposes of this investigation, only the thermoregulatory impact of wearing the Giro Advantage aerodynamic cycling helmet, versus a standard Specialized Decibel cycling helmet was assessed. The aerodynamic characteristics of the helmets were not measured as this has been done previously. It was hypothesised that no differences in thermoregulation would be observed in participants wearing the two helmets.

METHODS

Physical model

To precisely quantify the difference in cooling rates between each helmet, a physical model was developed. The model was placed in a room (20°C, 40% relative humidity), heated to 37°C and allowed to cool on three separate occasions. First, the physical model cooled in a controlled condition with NO helmet. Secondly, the model cooled with the Specialized, Decibel helmet placed upon it. Thirdly, the model was cooled with the Giro, Advantage cycle helmet placed upon it. Skin thermistors were placed at 5 locations around the model and one location inside of the model.

Human testing

A counter-balanced repeated measure design was employed. Six volunteers were recruited from the University of Portsmouth student and staff population. Participants were healthy, non-heat acclimated males with a mean (sd) age and weight of 24yrs (9.7) and 72.8kg (8.57) respectively. This study received approval from the University of Portsmouth Ethics Committee and all participants provided written informed consent.

Participants visited the Environmental Laboratory on three occasions. On their first day they completed a peak power test. On the second and third day they completed 80 minute trials in the heat (31°C, 70% relative humidity). Over the latter two days, which were separated by 24 hours, each participant wore either the Specialized Decibel Cycling Helmet (December 2006, 54-60cm, medium size. The helmet features a total of 19 ventilation holes and weighs 265g) or the Giro Advantage Cycling Helmet (January 2008, 59-63cm, large size. The helmet features a total of 5 ventilation holes and weighs 466g) (see Figure 1).



Figure 1. Cycling helmets investigated

During each trial participants reported to the laboratory wearing T-shirt, shorts and trainers. Prior to the first trial, participants were asked to perform a peak work (W_{peak}) test on a cycle ergometer to allow experimental workloads to be determined. Percentage (45%) of peak work rate ($W_{45\%}$) values were then determined. During each experimental condition participants were asked to cycle on a stationary bicycle fixed to a Computrainer that provided a quantifiable load (Watts) to the rear wheel. Participants were asked to cycle at $W_{45\%}$ until they either reached a deep body

temperature of 39°C, or until one hour passed. During the 60 minutes of cycling participants were asked to alternate between an aerodynamic cycling position (resting on aero-bars) and a standard cycling position (hands on handle-bars) every 15 minutes (see Figure 2 for experimental timeline).

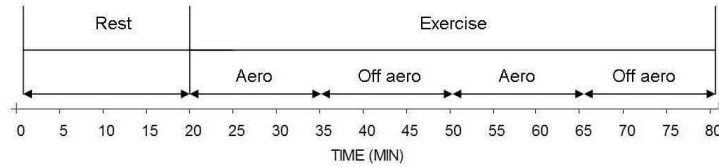


Figure 2. Experimental Timeline

Participants identified their thermal comfort (TC) thermal sensation (TS) and rate of perceived exertion (RPE) using visual analogue scales every 10 minutes. Rectal temperature (T_{re}) was measured using a rectal thermistor inserted 15cm beyond the anal sphincter. Skin temperature (T_{sk}) was measured by fixing thermistors to the left side of the body at the chest (T_{chest}), medial inside forearm ($T_{forearm}$), medial thigh (T_{thigh}) and calf (T_{calf}) (Ramanathan, 1964). Mean skin (MST) (Ramanathan, 1964) and mean body (MBT) (Colin *et al.*, 1971) temperature were also calculated. Heart rate (HR) was measured using a heart rate monitor (Polar, Finland).

The helmet climate (HC) was monitored by placing skin thermistors at the following 4 locations in a hairnet: Forehead ($HC_{forehead}$), Crown (HC_{crown}), Back of head (HC_{back}) and Right temple (HC_{temple}). The hairnet was placed on the participants head, under the helmet.

Normality of the data sets were tested using the Kolmogorov-Smirnov test. Within subject analysis of Time and Condition was undertaken by analysis of variance (ANOVA) using the statistical software package SPSS 15. MST, T_{re} and MBT data were compared at the time points: 25, 30, 35, 40, 45, 50, 60 and 70 minutes. Helmet climate data were compared at time points 10, 20, 25, 30, 35, 40, 45, 50, 60 and 70 minutes. TC/TS and HR data were compared every 10 minutes starting at minute 25 and ending at minute 75. *Post hoc* pair-wise comparisons were used to detect the direction of any significant effects. The alpha level for all statistical tests was set at $P < 0.05$.

RESULTS

Physical model

Figure 3 shows the cooling rates of the physical model whilst under the three different conditions. When the physical model was allowed to cool without a helmet, its cooling rate was the fastest. When the Specialized helmet was worn the cooling rate was slightly slower than when no helmet was worn. When the Giro helmet was worn the cooling rate was the slowest.

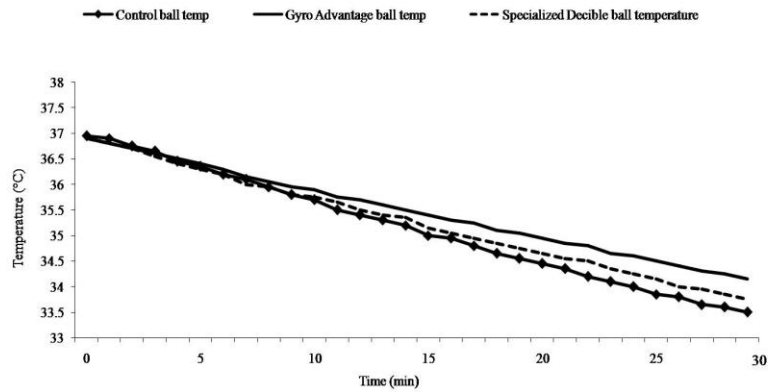


Figure 3. Physical model cooling rates of the two helmets and a control condition.

Human testing

All data sets were normally distributed. The data from one participant was excluded from T_{re} , MST and MBT calculations due to an incomplete dataset. No significant differences ($P < 0.05$) were found between conditions in HR, T_{re} , MST, MBT (Figure 4), helmet climate, TC (Figure 5), or TS (Figure 5).

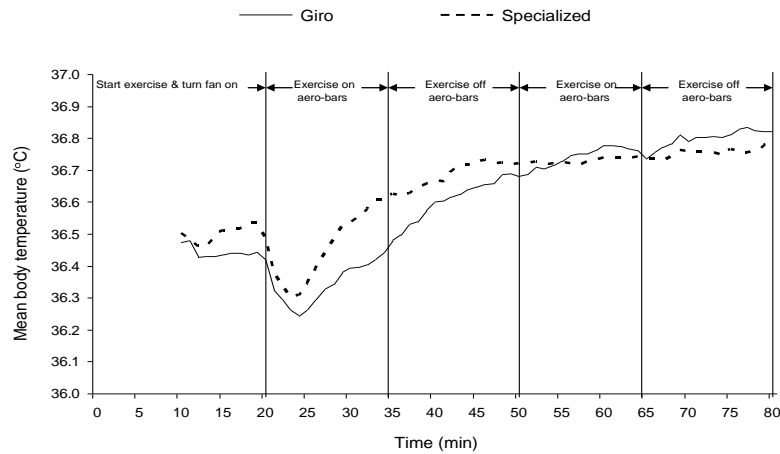


Figure 4. Mean body temperature (°C) with the two helmet conditions (n=5)

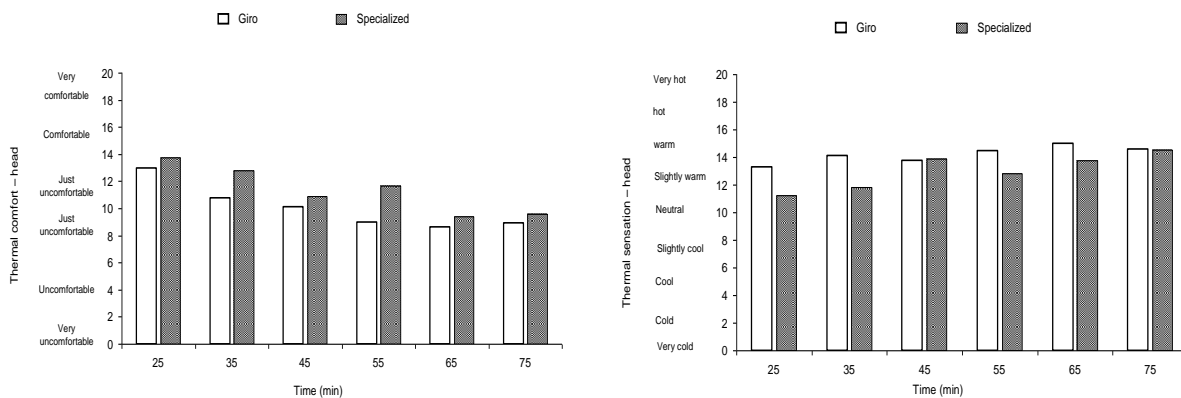


Figure 5. Mean thermal comfort and thermal sensation score between conditions (n=6)

CONCLUSIONS

The major aim of this research was to compare two different cycling helmets (Specialized, Decibel and the Giro, Advantage) in mildly heat stressed humans, in order to identify which enables the greatest cooling and perceptions of thermal comfort/sensation.

Although the Giro helmet presented a slightly greater physical barrier to heat loss in comparisons with the Specialized cycling helmet when physically modelled, this was not reflected in any of the measurements taken in our human tests. That is, the barrier to heat loss represented by the Giro helmet was not large enough to compromise the human thermoregulatory system. Wearing the less well ventilated Giro helmet did not result in deep body, skin and mean body temperatures that were significantly different from those seen when the Specialized helmet was worn. Thermal perceptions also did not differ between conditions.

In the conditions of the present experiment, the hypothesis that the Giro cycling helmet is not significantly different from the Specialized cycling helmet, in terms of body temperature regulation, is supported.

ACKNOWLEDGEMENTS

This work was funded by UKSport

REFERENCES

- Borg GA. (1982) Psychophysical bases of perceived exertion. *Medicine and Science in Sports and Exercise*. 14(5):377-81.
- Bruhwiller PA., Buyan M., Huber R., Bogerd CP., Sznitman J., Graf SF., Rosgen T. (2006). Heat transfer variations of bicycle helmets. *Journal of Sports Science*. 24(9): 999-1011.
- Colin J, Timbal J, Houdas Y, Boutelier C. & Guieu JD. (1971) Computation of mean body temperature from rectal and skin temperatures. *Journal of Applied Physiology*. 31 (3): 484-489.
- Gisolfi, CV., Rohlf DP., Navarude SN., Hayes CL., Sayeed SA. (1988). Effects of wearing a helmet on thermal balance while cycling in the heat. *The Physician and Sportsmedicine*. 16(1):139-46.
- Ramanathan (1964) A new weighting system for mean surface temperature of the human body. *Journal of Applied Physiology*. 19:531-3
- Rodahl K., Bjorklund RA., Kulsrud AH., Kluwer LD., Guthe T. (1992). Effects of protective helmets on body temperature and psychomotor performance. *Proceedings of the fifth international conference on environmental ergonomics*: p.98-99.
- Sheffield-Moore M., Short KR., Kerr CG., Chadwick G., Parcell AC., Bolster DR., Costill DL. (1997). Thermoregulatory response to cycling with and without a helmet. *Medicine and Science in Sports and Exercise*. 29(6): 755-61.