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Heat transfer characteristics of rowing headgear with radiant heat flow

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The head is one of the strongest sensors determining human thermal comfort. For this reason several thermal manikin studies have been conducted in reducing heat stress on the head. These studies focused on optimizing convective and/or evaporative heat loss. Radiant heat flow, though often mentioned as a potential factor, has been studied relatively little. Considering that radiant heat flow easily delivers 25 W to the head alone during the summer in temperate climates, this suggests that large differences among different headgear (types) could exist. Shielding solar heat flow while maintaining heat loss close to optimal favors comfort perception and might reduce heat strain. These considerations motivated the development of a prototype rowing headgear (PRH) (Bogerd et al., 2005). The goal of this study is to compare that PRH with other widely-used sports headgear in a non-sweating condition on i) net heat transfer, ii) radiant heat flow, and iii) convective heat flow.

The following headgear were studied: i) the PRH, ii) a white cotton cap (CW) and iii) a black cotton cap (CB). The experiment was carried out for different radiant arrangements: i) without radiation (NoRad), ii) with 18.7 W radiant heat flow from directly above (90) and iii) with 9.6 W radiant heat flow from an angle of 65° (65). Wind, ambient temperature and humidity were kept constant at 4 $m \cdot s^{-1}$, 22 °C and 50%. The measurements were then repeated for arrangements NoRad and 90 with headgear PRH, CW and CB in combination with a wig.

All headgear reduced the radiant heat flow: ~80% for the caps and 95% for the PRH. Furthermore, the radiant heat flow contributed maximally for 13% to the net heat transfer indicating that convective heat flow is a more important heat transfer parameter under the tested condition. The PRH reduced convective heat flow only minimally and was therefore the only headgear outperforming the nude head in a radiant environment. The extra heat transfer obtained with the PRH in the most optimal condition and compared with the nude head is 12 W. It is known from studies with artificial cooling that a cooling power as low as 12 W results in a reduction of heat strain for pilots carrying out a flight simulator in a warm environment (Williams & Shitzer, 1974). However, it is unknown if the PRH results in a reduction of heat strain for athletes. Wearing a wig greatly reduces convective heat flow but shows similar qualitative results. The PRH is shown to be more effective in reducing heat stress of the head compared to traditional rowing headgear under the tested conditions.

Bogerd CP, Heus R & Willems JWM (2005). A sun shading headgear used by a Dutch Olympic sculler: A comparative study. Proceedings of ICEE, Ystad, Sweden, 22-26 May: 396-399.

Williams BA & Shitzer A (1974). Modular liquid-cooled helmet liner for thermal comfort. Aerospace Med., 45, 1030-1036.