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Thermoregulatory and non-thermoregulatory factors in humans during exercise and rest: influences on thermoeffector function

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THERMOREGULATORY AND NON-THERMOREGULATORY FACTORS IN HUMANS DURING EXERCISE AND REST: INFLUENCES ON THERMOEFFECTOR FUNCTION

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CERTIFICATION

I, Christopher James Gordon, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Health Sciences, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Christopher Gordon
24th February 2010

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ABSTRACT

The primary control of thermoeffector responses arises from the integration of core and skin thermoafferent signals. However, other thermal pathways, not ascribed to the known core and skin regions, may also contribute to sweating. In addition, the influence of several non-thermal factors on human thermoregulation remain to be elucidated.

A series of four human experiments were conducted to investigate the role of thermal and non-thermal factors on thermoeffector responses during exercise and resting conditions. Two studies were conducted with subjects exercising in a thermoneutral environment (air temperature 25 C, relative humidity 50%). Bilateral venous occlusion of the legs was implemented to retard venous return and increase local muscle temperature, whilst delaying changes in core temperature. The second study examined the effect of venous occlusion on sudomotor responses during a sinusoidal forcing function. Exercise sine waves uncouple body temperatures and allows differentiation of phase delays between thermoafferents and thermoeffectors. The third and fourth studies involved resting subjects exposed to mildly hyperthermic conditions (air temperature 36 C, relative humidity 60% and water-perfusion suit 36 C). The third study used posture and venous occlusion of the legs to displace central blood volume unloading baroreceptors. In the final study, subjects performed isometric handgrip and knee extension exercise over a range of absolute and relative intensities. This permitted examination of muscle mass differences and exercise intensity on thermoeffector responses.

Five key observations arose from these studies. First, venous occlusive exercise delays the increase in core temperature without delaying increases in sweating (219.6 versus 63.6 s; $P<0.05$). Thus, the feedback during sweating may have arisen from sites other than the body core, with the active muscle being the most likely site. This provides circumstantial evidence for the possible existence of intramuscular thermoreceptors. Second, sweating was not different between upright-seated and supine postures during venous occlusion (0.108 versus 0.109 $mg \cdot cm^{-2} \cdot min^{-1}$; $P<0.05$), suggesting that

baroreceptor unloading does not modulate sudomotor function. Third, venous occlusion alone, irrespective of posture, attenuates sweating at sites distal to the level of occlusion, while simultaneously enhancing sweating at sites proximal to occlusion. Fourth, sweat rate was found to be proportional to exercise intensity (handgrip: $r=0.79$, knee extension: $r=0.85$; both $P<0.05$), irrespective of muscle mass. Fifth, the size of the muscle mass recruited during isometric exercise was not significantly related to the sweating response ($P>0.05$). It appears that feedforward activation was the primary non-thermal driver of sweating, as body temperatures did not change during the exercise bout. Collectively, these findings suggest that thermal afferents, other than the known core and cutaneous sites, may contribute to sweating during dynamic exercise, and non-thermal sweating appears to be influenced by exercise intensity and the magnitude of the thermal load. However, the exact role and integration of thermal and non-thermal afferents is yet to be elucidated.