THERMOREGULATION AND RATE OF BODY WARMING DURING WARM WATER (40°C) IMMERSION IN FEMALE CHILDREN AND ADULTS.

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INTRODUCTION

Public facilities generally forbid the use of hot tubs or whirlpool baths by children (sometimes to ages as high as 16 yrs), because of the general understanding that the core temperature of a child increases much faster than that of an adult. It is therefore believed that children cannot tolerate even a short exposure to warm water (40°C), while adults can safely tolerate a longer exposure to these conditions. There is some physiological basis for this belief as some thermoregulatory mechanisms are not fully developed in the child. First, preadolescent children (younger than 11 yrs) have a decreased capacity for sweating, in comparison to adults (Wagner et al. 1972). This should have little effect on core warming during whole body immersion however, as evaporative heat loss would be minimal. Second, children tend to have a higher surface area:body mass ratio than adults. This characteristic actually provides an advantage for heat loss to the child (especially in water) at lower temperatures, but not during exposure to higher temperatures (i.e. 40°C water) (Autsin and Lansing 1986). Finally, it has been demonstrated that children and young adolescents have a shorter exercise tolerance time in the heat than young adults (Drinkwater et al. 1974, Wagner et al. 1972) and children are also more prone than adults to heat illness during climatic heat waves (Ellis et al. 1976).

Despite these physiological factors and empirical evidence, core warming rates and sweating responses of children immersed in warm water have not been determined or compared to those of adults. Our purpose was to: 1) determine if children could tolerate even a short exposure to moderately warm (40°C) water; 2) quantify the rate of core temperature increase and the sweating response for female children, adolescents and adults under these conditions; and 3) establish the relationship between rate of core temperature increase and sweating responses to age and body physique.

METHODS

With faculty ethics approval, 14 females (8 children aged 7-11 yrs; 3 adolescents aged 12-17 yrs and 3 adults aged 19-23 yrs) were studied. Body mass, stature, surface area, and percent body fat (Durnin and Womersley 1974) were determined. We monitored core temperature (via indwelling aural canal thermocouple) (T_{ac}), heart rate, and forehead sweat rate (ventilated capsule) during immersion in 40°C water until T_{ac} increased to 38.5°C. Rates of core temperature increase, core temperature thresholds for sweating as well as maximal sweating responses were each correlated against age and anthopometric variables.

RESULTS

Immersion times (to T_{ac} of 38.5°C) ranged from 10 to 31 min (mean±SD) (children - 18.2±6.0 min; adolescents - 21.5±8.3 min; and adults - 22.5±6.4 min). All subjects tolerated at least a short period (10 min) of warm water immersion well. One child experienced a brief syncopal episode soon after exiting the warm bath (this orthostatic intolerance was immediately reversed by laying the subject down). However, she had been immersed for 23 min before reaching the exit criterion T_{ac} of 38.5°C. She later returned to the lab and underwent a 10 min immersion (in water of the same temperature) without further complication. All subjects indicated that they would have voluntarily exited the warm water before reaching the core temperature exit criteria if they were not participating in the study.

Rates of core temperature increase ranged from 3.4 to 7.9 °C/h (children - 5.5±1.4 °C/h; adolescents - 4.7±0.8 °C/h; and adults - 4.9±1.8 °C/h). There was no correlation between age and either immersion time or warming rate. There was a weak but significant inverse relationship between % body fat and warming rate(r^2 = .33, $p<0.05$). However, this relationship was not necessarily independent of other anthropometric parameters due to a high degree of multicolinearity between many anthropometric variables. There was no significant correlation between % body fat and immersion time.

Sweating responses were initiated at T_{ac}'s ranging from 36.7 to 37.9 °C (children - 37.5±.3 "C; adolescents - 37.7±.4 "C; and adults - 37.0±.3 °C). Maximal sweat rates ranged from 157 to 775 g/m^2/h (children - 355.9±122.7 g/m^2/h; adolescents - 351.7±57.0 g/m^2/h; and adults - 617±144.7 g/m^2/h). There were weak but significant correlations between age and T_{ac} sweating threshold (r2 = .32, $p<0.05$) and maximal observed sweat rate (r2 = .49, $p<0.05$). There was no significant correlation bewtween any of the anthropometric variables and either T_{ac} sweating threshold or the maximal observed sweat rate.

CONCLUSIONS

The sweating response was active in children and they tolerated at least 10 min of warm water immersion. We were not able to demonstrate a significant relationship between age and rate of core temperature increase. Other variables may determine the rate **of** core temperature increase under these circumstances. Although our analysis indicated that % body fat was an important anthropometric parameter to consider when determining rate of core temperature increase, further study of more subjects is required in order to develop and validate a complete formula for accurate prediction of rate of core temperature increase in warm water.

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