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Malcolm B. Doupe
University of Manitoba

Glen P. Kenny
University of Ottawa

Matthew D. White
University of Ottawa

Gordon D. Giesbrecht
University of Manitoba

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

BY

MALCOLM B. DOUPE, INSTRUCTOR II

UNIVERSITY OF MANITOBA

DR. GLEN P. KENNY, ASSISTANT PROFESSOR

UNIVERSITY OF OTTAWA

DR. MATTHEW D. WHITE, NATIONAL INSTITUTE OF NUTRITION, POST DOCTORAL FELLOW

UNIVERSITY OF OTTAWA

AND

DR. GORDON G. GIESBRECHT, ASSOCIATE PROFESSOR

LABORATORY FOR EXERCISE AND ENVIRONMENTAL MEDICINE
HEALTH, LEISURE AND HUMAN PERFORMANCE RESEARCH INSTITUTE
UNIVERSITY OF MANITOBA
WINNIPEG MANITOBA, CANADA R3R 2N2

ABSTRACT

Resort operators often do not allow children to use hot tubs/whirlpools because of the general belief that children cannot tolerate even a short exposure to warm water (40°C). This belief is based on body size characteristics and under developed thermoregulatory responses of children. Therefore, we measured anthropometric, thermoregulatory, and immersion time required to increase core temperature at 38.5°C, on 14 female subjects (7-23 years). All subjects tolerated 10 minutes of immersion safely, but indicated they would have voluntarily exited the water earlier. Warming rates were somewhat related to body type, but did not depend on age. Healthy female children (>7 years) could therefore safely tolerate 5 to 10 minutes of warm water immersion with adult supervision.

INTRODUCTION

Public facilities often forbid the use of hot tubs or whirlpool baths by children (sometimes to ages as high as 16 yrs.). These restrictions can be frustrating for parents who may wish to share and enjoy

these leisurely activities with their children. However, these policies are usually implemented for protection against litigation because it is generally believed that children cannot tolerate even a short exposure to warm water (40°C).

There is some physiological basis for this belief because of children's small body size and inability to regulate body temperature effectively (i.e. by sweating). Despite these factors and some empirical evidence, physiological responses of children immersed in warm water have not been scientifically determined or compared to those of adults. Therefore 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 increase in body temperature and the sweating response for children, adolescents and adults; and 3) establish the relationship between rate of increase in body temperature and the sweating responses to age and body size. This information could assist a resort operator in determining safe policies regarding the use of hot tubs/whirlpool baths by children and adolescents.

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. Anthropometric variables such as body weight, height, surface area, and percent body fat (3) were determined. We monitored body core temperature (via a thermocouple inserted into the ear to read tympanic membrane temperature), heart rate, and forehead sweat rate during immersion in 40°C water until body core temperature increased from 37°C to 38.5°C. Rates of body core temperature increase, core temperature thresholds for sweating as well as maximal sweating responses were each correlated against age and anthropometric variables.

RESULTS

Immersion times (to body core temperature of 38.5°C) ranged from 10 to 31 min. (mean$\pm$SD) (children - 18.1$\pm$5.3 min.; adolescents - 19.8$\pm$8.0 min.; and adults - 20.7$\pm$4.4 min.) (see Fig. 1). All subjects tolerated at least a short period (10 min.) of warm water immersion well. One child experienced a brief fainting episode soon after exiting the warm bath (this condition was immediately relieved by laying the subject down). However, she had been immersed for 23 min. before reaching the exit criterion core temperature of 38.5°C. She later returned to the lab and underwent a 10 min. immersion in water of the same temperature without incident. 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 1.8 to 8.2 °C/h (children - 3.9$\pm$1.3°C/h; adolescents - 4.5$\pm$1.9 °C/h; and adults - 4.9$\pm$0.9 °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 = .13, $p<0.05$). 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 body core temperatures ranging from 36.7 to 38.1°C (children - 37.5±.3 °C; adolescents - 37.5±.4 °C; and adults - 37.1±.2 °C) (see Fig. 2). Maximal sweat rates ranged from 160 to 719 g/m²/h (children - 369.1±118.3 g/m²/h; adolescents - 484.4±138 g/m²/h; and adults - 584±93.4 g/m²/h). There were weak but significant correlations between age and core temperature sweating threshold (r^2 = .34, $p<0.05$) and maximal observed sweat rate (r^2 = .47, $p<0.05$). There were no significant correlations between any of the anthropometric variables and either core temperature sweating threshold or the maximal observed sweat rate.

DISCUSSION AND CONCLUSIONS

There is some physiological basis for the belief that children cannot tolerate warm conditions as some thermoregulatory mechanisms are not fully developed in the child. However these limitations may not be a major concern during immersion in warm water. First, preadolescent children (younger than 11 yrs.) have a decreased capacity for sweating, in comparison to adults (6). This should have little effect on body core warming during whole body immersion since evaporative heat loss can only occur from skin areas exposed to the air and would therefore be minimal. Second children tend to have a higher surface area-to-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) (1).

We found that children safely tolerated at least 10 min. of warm water immersion. The sweating response was active in children although this process is unlikely to remove much heat during immersion. In conclusion we feel that this data may provide valuable insights for the resort operator. Our study indicates that healthy children (>7 yrs.) can safely tolerate 5-10 min.. of warm water immersion. There seems to be a built in safety factor because children would likely exit warm water before reaching dangerously high core temperatures. Under close parental supervision, this activity can be a safe enjoyable family experience.

ACKNOWLEDGMENT

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REFERENCES

1. D. M. Autsin and M. W. Lansing, Body Size and Heat Tolerance: A Computer Simulation, Human Biology, Vol. 58, pp. 153-169, 1986.

2. B. L. Drinkwater, J. E. Denton, J. L. Crist, and S. M. Horvath, Response of Prepubertal Girls and College Women to Work in the Heat, Journal of Applied Physiology: Respiration Environmental and Exercise Physiology, Vol. 43, pp. 1046-1053, 1977.

3. J. V. G. A. Durnin and J. Womersley, Body Fat Assessed from Total Body Density and its Estimation from Skinfold Thickness: Measurements on 481 Men and Women Aged 16-72 Years, British Journal of Nutrition, Vol. 32, pp. 77-97, 1974.

4. F. P. Ellis, A. N. Exton-Smith, K. G. Foster, and J. S. Weiner, Eccrine Sweating and Mortality During Heat Waves in Very Young and Very Old Persons, Isreali Journal of Medical Science, Vol. 12, pp. 815-817, 1976.

5. E. M. Haymes, E. R. Buskirk, J. L. Hodgson, H. M. Lundegren, and W. C. Nicholas, Heat Tolerance of Exercising Lean and Heavy Prepubertal Girls, Journal of Applied Physiology, Vol. 36, pp. 566-571, 1974.

6. J. A. Wagner, S. Robinson, S. P. Tzankoff, and P. R. Marina, Heat Tolerance and Acclimatization to Work in the Heat in Relation to Age, Journal of Applied Physiology, Vol. 33, pp. 616-622, 1972.

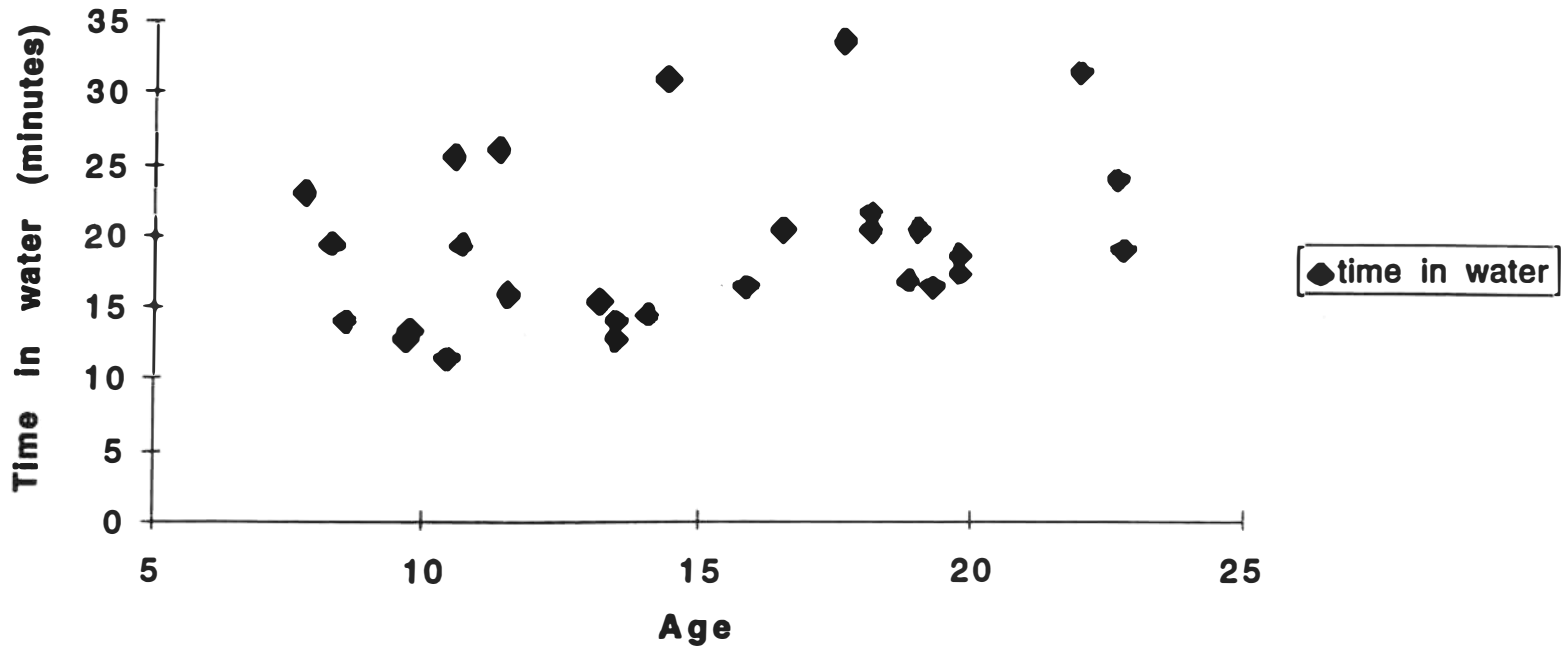

Figure 1. Total immersion time in water (minutes) with age (years)

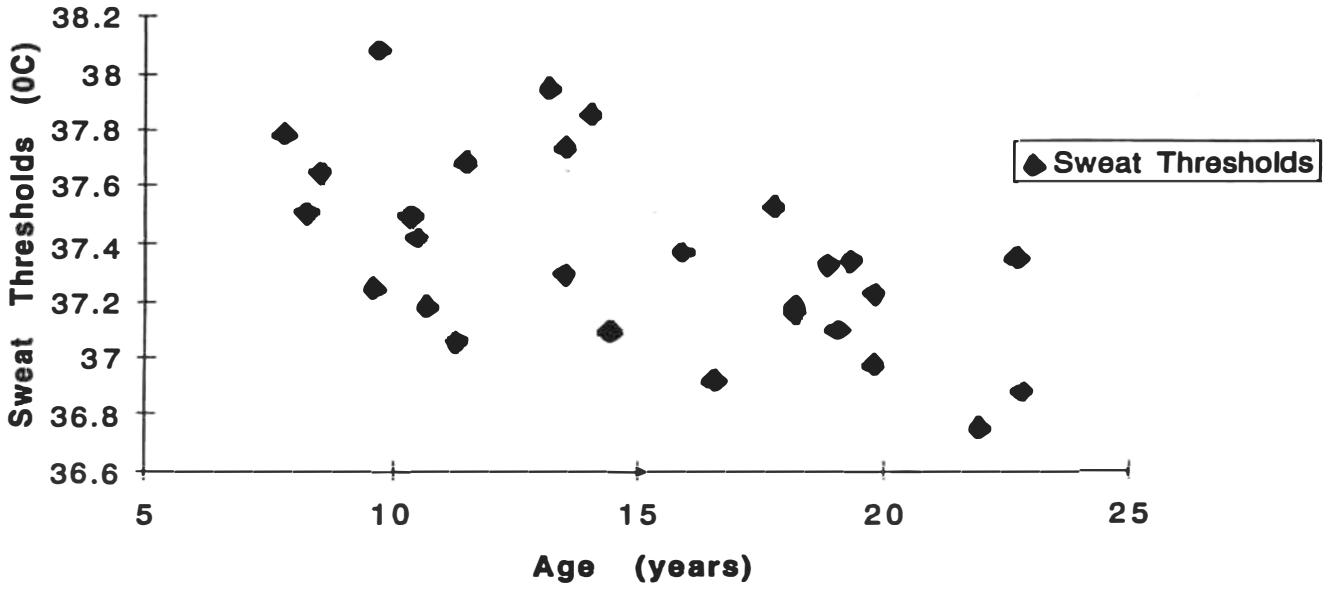

Figure 2: Sweating thresholds (^{0}C) with age (years).

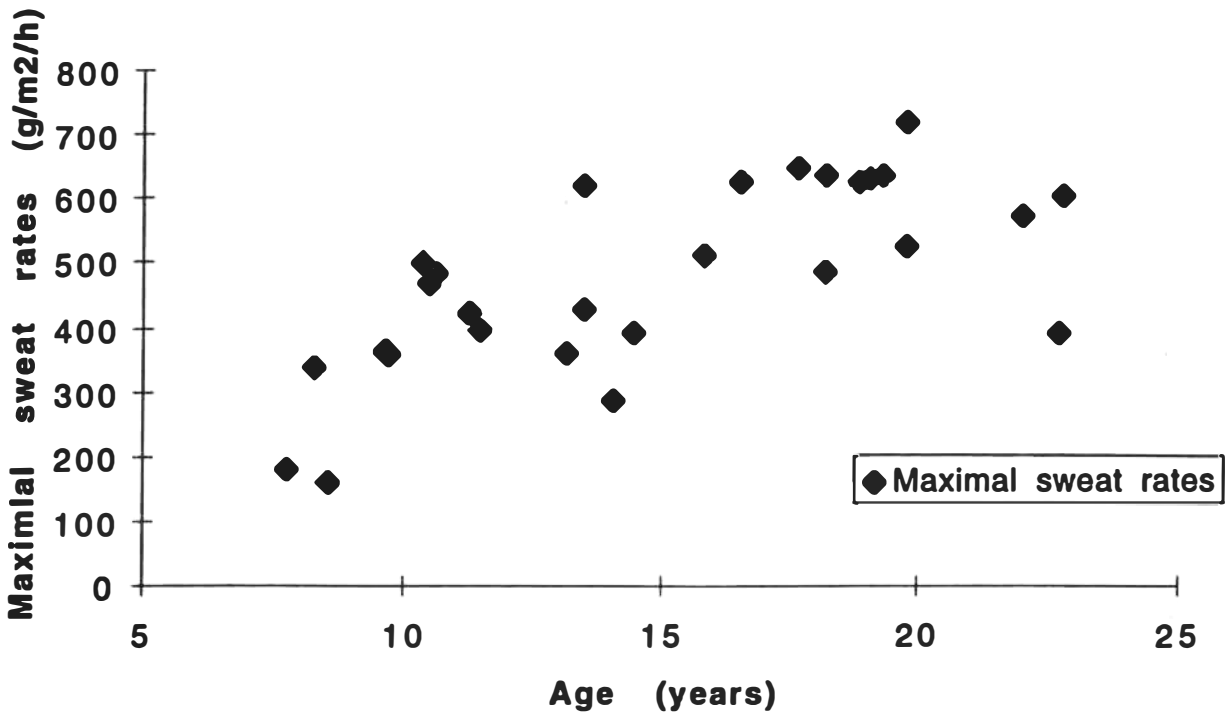

Figure 3: Maximal sweat rates ($g/m^2/h$) with age (years).