THE EFFECTS OF AGE AND FITNESS ON HEART RATE AND BODY HEAT STORAGE DURING WORK IN A WARM, HUMID CLIMATE

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INTRODUCTION

The relation between ageing and the reaction to heat stress has become an important issue in research in the last decades. Increasing life expectancy has resulted in an increase in the number of older people participating in the work force and in growing numbers of retirees. Epidemiologically, it has been shown that these older people are more susceptible to heat stress than their younger fellow citizens, resulting in a larger mortality and morbidity rate in the older groups. Research has attempted to investigate the causes for this deterioration in heat tolerance. Early studies showed increased strain in response to heat in older people, but later these results were questioned because the studied groups differed in physical fitness. Other researchers tried to compensate for the confounding fitness factor by matching young and older subjects for their fitness level. This approach has resulted in sometimes equal responsiveness to heat stress (Kenney, 1990), sometimes higher strain (Kenney, 1988) and sometimes even a lower strain in response to heat stress (Pandolf, 1988) in older subjects. Matching older and younger groups exactly for all their characteristics except age was never completely achieved in the mentioned studies though. Also the relevance of observed age related differences in heat stress response in matched groups received little attention. Therefore, the present study was designed to study the relevance (if present) of age related differences in heat stress response in relation to physical fitness related differences.

METHODS

A group of **46** subjects with a wide range of activity patterns and age were asked to participate in the experiment. All subjects were medically screened and gave their informed consent. Physical fitness was determined by measuring maximal oxygen uptake on a treadmill, using a modified Balke protocol. Body composition was measured by skinfold measurement and under water weighing. After the subjects characteristics were defined, they performed a heat stress test. The heat stress test consisted of a 90 minute exposure to a warm humid climate (35°C, 80% rh), in which they Erst rested for **30** minutes and subsequently cycled on a reclining bicycle ergometer at an external work load of 60 Watts for the remaining 60 minutes. Data on heart rate, rectal temperature, average skin temperature, weight loss, blood pressure and forearm blood flow were collected throughout the experiment. The exposure was terminated when subjects reached a heart rate above 90% of their personal maximum, or when rectal temperature increased above **39°C.**

Final rectal temperature, heat storage and heart rate data were analyzed for their dependance on individual characteristics by multiple regression analyses, using the statistical package SYSTAT.

RESULTS

The test population ranged in age between 34 and **73** years, with approximately 10 subjects per decade. Their fitness value, expressed as maximal oxygen uptake level ranged from **24.3** to **56.6** $ml \cdot kg^{-1}\ min^{-1}$. The average physical fitness for each age group was similar over all four decades (40 $ml \cdot kg^{-1}$ mid).

No correlation was present between the subjects fitness level and their age. All but *two* subjects were able to finish the ninety minutes heat exposure.

Final rectal temperature and body heat storage at the end of the heat exposure correlated significantly ($P < .01$) with the subjects' physical fitness level expressed as absolute Vo_{2max} ($L \cdot min^{-1}$), as Vo_{2max} per kg body weight, or with work load expressed as percentage of maximal oxygen uptake, but not with age. After correction of rectal temperature and body beat storage data for the physical fitness effect, neither age nor body composition appeared to have a significant influence.

Both heart rate at the end of the heat exposure and heart rate relative to the individual's maximum correlated significantly with fitness as well ($P<.05$). Again no singular correlation was present with age. However, once heart rate data were corrected for the physical fitness effect, the residual variance in the absolute heart rate data were significantly correlated with age ($P<.05$), but relative heart rate was not.

The approach in the present study is quite different from most recent research related to age effects on heat exposure. Firstly, instead of taking only two age groups, a continuous age range was studied. Secondly, instead of concentrating on an exact match between young and old subjects, an attempt was made to do a cross-sectional study over age groups with the restriction that the average values for the different age groups' physical characteristics should not differ. However, a wide range of each individual characteristic should be present in the data set. In the present study subjects from different age groups had very similar average Vo_{2max}, body fat content, body surface area data, but indeed had large variations within age groups.

A prerequisite of the type of analysis used (multiple regression) is that the parameters which are used to explain the dependent variable are truly independent of each other. Although age and physical fitness show an epidemiological correlation when tested on the whole population, there was no such correlation present in the sample population in this experiment. Thus the assumption of independence was met.

Body Core Temperature and Heat Storage

No significant effect of age on heat storage and rectal temperature was observed. The question whether the effect of age, observed in other studies is relevant compared to the effect of physical fitness is thereby answered in a negative sense. Though a small age effect may exist, as observed in literature (Pandolf, 1988, Kenney, 1988), this is only measurable when groups are matched precisely with respect to their physical characteristics. Once natural variation in physical fitness is introduced in the test population, the age effect appears to be negligible, compared to the fitness effect.

Heart Rate

Similar reasoning can be applied to the results for heart rate. For absolute heart rate, an age effect was observed once the data were corrected for the physical fitness effect. This effect is caused by the age-related decrease in maximal heart rate. In the test population, maximal heart rate was shown to relate to age as: $HR_{max}=218-.72*age$, which is similar to the relation described in the literahue for large populations. This age effect on heart rate means that when a young and an old subject have an equal Vo_{2max}, the young one will have a higher heart rate for the same workload. When heart rate is expressed as percentage of maximal heart rate, no age effect is present however. Thus, though the older has a lower absolute heart rate compared to his younger, equally fit colleague, the physical strain is equivalent.

CONCLUSION

No relevant age effect on heat stress response in body core temperature and heart rate (expressed as percentage of maximal heart rate) is present when comparing age groups with equal average Vo_{2max}. The reduction in individual absolute maximal heart rate with age results in lower heart rates for equal work loads in older subjects.

REFERENCES

1. Kenney W.L., Tankersley C.G., Newswanger D.L., Puhl S.M., Turner N.L. (1990) Age and hypohydration independently influence the peripheral vascular response to heat stress. J. Appl. Physiol., Vol. 68, no. 5, Pages: 1902-1908.

2. Kenney W.L. (1988) Control of heat induced cutaneous vasodilation in relation to age. *Eur. J.* Appl. *Physiol.*, Vol. 57, no. 1, Pages: 120-125.

3. Pandolf K.B., Cadarette B.S., Sawka M.N., Francesconi R.P., Gonzalez R.R. (1988) Thermoregulatory responses of middle-aged and young men during dry-heat acclimation. Journal of Applied *Physiology*, Vol. 65, no. 1, Pages: 65-71.