The relevance of age for work in a warm humid climate

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Abstract
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. Recent research has questioned the causal relation between age and heat tolerance in the light of changes in physical fitness and anthropometry with age. the present study was designed to single out the effects of age, build and fitness on heat tolerance. For this purpose, 60 healthy subjects in the age range of 18 to 73 years old (+ 10 per decade) of various fitness levels (VO2max) worked at a fixed load in a warm, humid (35°C, 80% rh) environment. Multiple regression analysis of the heat strain parameters body core temperature and heart rate showed that the effect of age was not significant, and that commonly observed "age" effects will actually be caused by differences in physical fitness and anthropometric measures in the tested population.

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. For this purpose, a test group was selected in which no correlation was present between the subjects fitness level and their age, but in which large variations of both parameters within groups were present.

Methods

A group of 73 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 first 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 dependence on individual characteristics by multiple regression analyses, using the statistical package SYSTAT (Wilkinson, 1990).

Results and discussion

The physical characteristics of the subject groups are presented in Table I. All but three subjects were able to finish the ninety minutes heat exposure. Fourteen subjects were excluded from the data set as their data would cause the correlation between $O_{2\,max}$ and age to become significant.

Table I: Physical characteristics of the subjects (n=56).

	mean	sd	minimum	maximum
age (years)	44.4	14.8	20	73
$Vo_{2\,max}$ ($l{\cdot}min^{-1}$)	3.03	0.65	1.86	4.44
fat (%)	21.9	6.3	9.9	40.4
weight (kg)	72.5	12.1	49.8	104.6
height (cm)	173.9	7.5	157.1	192.0
bsa (m^2)	1.87	0.17	1.52	2.26
surf/mass ($m^2{\cdot}kg^{-1}$)	0.26	0.002	0.021	0.031

In the final data set, no correlation between fitness (O_{2max}), age and body fat content was present. Thus the requirement for the use of regression analysis of independence of the individual parameters was met. This is illustrated in Figure 1.

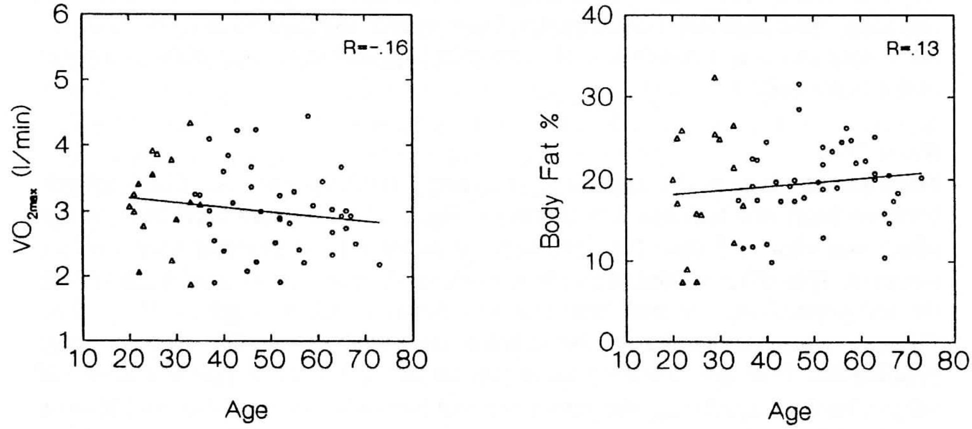

Figure 1, the relation between fitness and body fat content and age. Each data point represents one subject.

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 O_{2max} (Lxmin^{-1}), as O_{2max} per kg body weight, or with work load expressed as percentage of maximal oxygen uptake. No significant effect of age on heat storage and rectal temperature was observed, as illustrated in Figure 2. After correction of rectal temperature and body heat storage data for the physical fitness effect, neither age nor body composition appeared to have a significant influence.

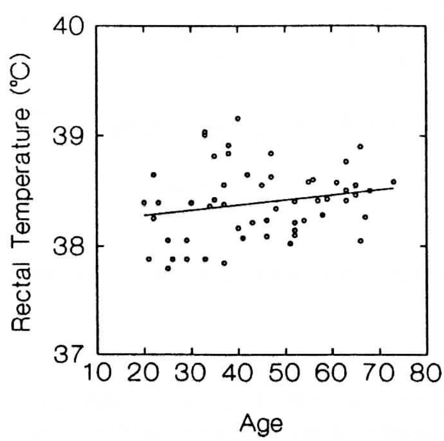

Figure 2, the relation between rectal temperature at the end of the heat exposure and the age of the subjects

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. No direct relation between heart rate and age was observed (Fig. 3). For absolute heart rate, an age effect was observed once the data were corrected for the physical fitness effect, however. 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 literature for large populations. This age effect on heart rate means that when a young and an old subject have an equal O_{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.

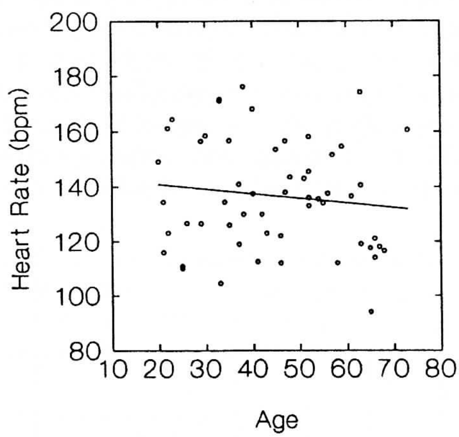

Figure 3, the relation between heart rate at the end of the heat exposure and the subjects age

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 O_{2max}. The reduction in individual absolute maximal heart rate with age results in lower heart rates for equal work loads in older subjects.

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