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HEAT TOLERANCE AND AGING WITH APPLICATION TO INDUSTRIAL JOBS

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Exercise-heat tolerance has been shown to be reduced in older individuals. Some authors have suggested that aerobically fit older individuals have fewer performance decrements during exercise-heat stress than less fit individuals of the same age. However, none of these studies matched older and younger individuals for any pertinent physiological and/or morphological variables. Recently, experimental results were reported where men differed in age by 25.2 years, but were matched for body weight, surface area, surface area-to-weight ratio, percent body fat and maximal aerobic power. Evidence from this study indicated little impairment of the thermoregulatory system during exercise-heat stress at least through the fifth decade of life for these aerobically trained older men. These findings show the importance of aerobic training and other morphological considerations in selecting older individuals for jobs in hot industrial environments. (AU)

INTRODUCTION

In general, exercise-heat tolerance is thought to be reduced in older individuals (Drinkwater and Horvath, 1979; Wagner et al., 1972). Older men have been reported to have higher heart rates, mean skin and core temperatures, and lower sweat rates compared to younger men during exercise-heat stress both pre- and post-acclimation (Wagner et al., 1972). It has also been shown that older men start to sweat later and/or sweat less during exercise in the heat compared to younger men (Hellon and Lind, 1956). However, active older women had the same sweating capacity and core temperature at sweat onset as younger women while resting in the heat (Drinkwater et al., 1982).

Some authors have suggested that aerobically fit older men had fewer decrements in exercise-heat performance than less fit men of the same age (Robinson et al., 1965). However, this study actually compared the exercise-heat acclimation responses for fit men to the responses of these same individuals some 21 years later. These older men acclimated to exercise in the heat at the same rate and to about the same degree as when they were younger. However, none of the above-mentioned studies matched older and younger individuals for any pertinent physiological and/or morphological variables. It has been suggested by many that body weight, surface area, body fat, and/or maximal aerobic power are closely related to an individual's ability to thermoregulate during exercise in the heat. In addition, the above studies on aging do not answer whether the exercise-heat intolerance observed with aging is due to age per se or related to other factors such as decreased physical activity and lowered maximal aerobic power. Thus, these early studies dealing with aging and exercise-heat tolerance have only descriptively compared various age groups.

Recently, experimental findings were reported from a study where men differed in age by 25.2 years (mean age: 21.2 vs 46.4 yr), but were matched for body weight, surface area, surface area-to-weight ratio, percent body fat, and maximal aerobic power (Pandolf et al., 1988). The greater regular weekly aerobic activity for these older men was associated with their better initial performance during exercise in the heat; however, heat acclimation negated this advantage. Evidence from this study indicated little impairment of the thermoregulatory system at least through the fifth decade of life for these aerobically trained older men. These findings demonstrate the importance of aerobic training and other morphological considerations in selecting older individuals for jobs in hot industrial environments.

EXPERIMENTAL OBSERVATIONS

As depicted in Figure 1, Drinkwater and Horvath (1979) reported that the tolerance time to perform light exercise in dry heat (48°C) was reduced for both young girls and older women. These authors studied 38 non-acclimated females that ranged in age from 12 to 68 years. For the young girls, the reduced tolerance was related to the instability of an immature cardiovascular system. For the older women, exercise-heat intolerance was associated with an inadequate sweating response, cardiovascular instability and a marked decrement in maximal aerobic power.

As shown in Figure 2, Wagner et al. (1972) reported the physiological responses of ten younger (20-29 yr) and seven older (46-67 yr) men to dry heat (49°C) before and after exercise-heat acclimation. Both before and after exercise-heat acclimation, the younger men maintained lower mean skin and rectal temperatures, lower heart rates, and higher evaporation rates than the older men. The younger men also tolerated the exercise-heat stress longer than the older men. These authors suggest that the older men displayed a more limited sensitivity and secretory capacity in their sweating mechanism compared to the younger men which contributed to their inferior temperature regulation.

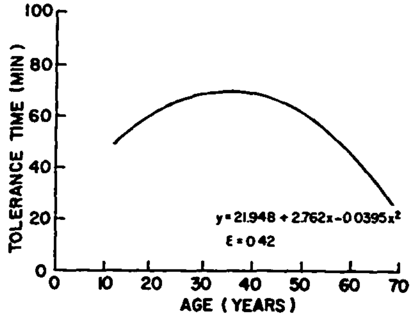

Figure 1. Tolerance time of females to light exercise at 48°C in relation to age (reproduced with permission from Drinkwater and Horvath, 1979).

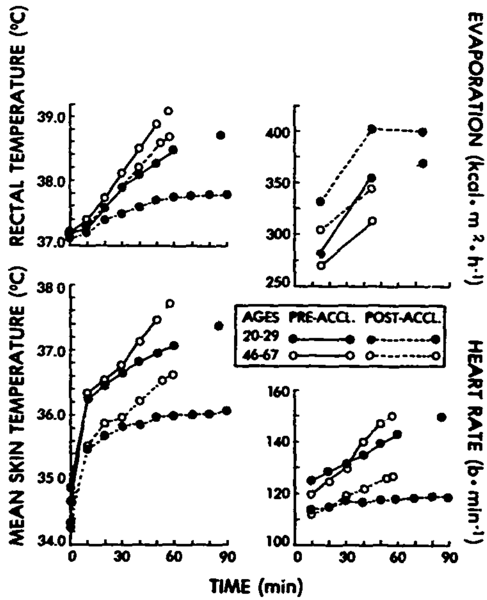

Figure 2. Effects of dry-heat acclimation on physiological responses contrasting young and old men (redrawn from Wagner et al., 1972).

Several authors (Drinkwater and Horvath, 1979; Hellon and Lind, 1956; Lind et al., 1970; Wagner et al., 1972) have suggested that the exercise-heat intolerance observed in older individuals was associated with a deficient sweating mechanism. For instance, Hellon and Lind (1956) compared the onset of sweating for ten younger (18-23 yr) and ten older (44-57 yr) men to passive heating, and reported that sweating onset took twice as long (delayed 15 min) for the older men. During exercise-heat stress, sweating rate has been reported to be lower for older individuals (Drinkwater and Horvath, 1979; Lind et al., 1970; Wagner et al., 1972). Several of these authors (Hellon and Lind, 1956; Wagner et al., 1972) have concluded that the deficient sweating in older

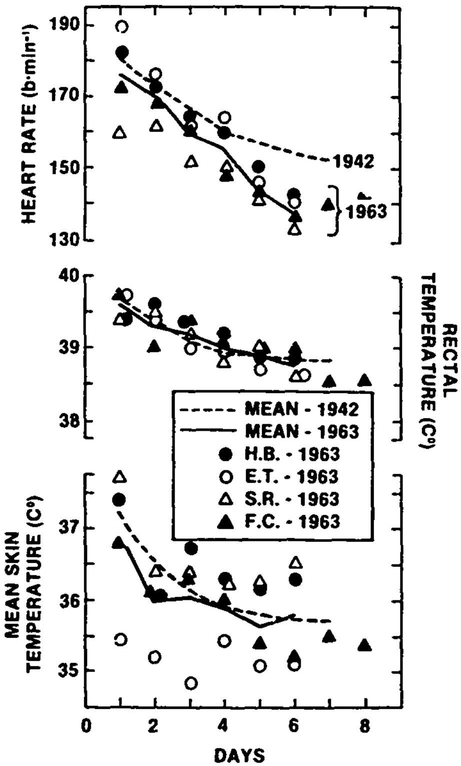

Figure 3. Physiological responses of four men evaluated over eight days of exercise-heat acclimation in 1942 and the responses of these same men evaluated in 1963 (redrawn from Robinson et al., 1965).

individuals was associated with neural degeneration and/or a decline in the functional ability of their sweat glands.

As illustrated in Figure 3, Robinson et al. (1965) compared the exercise-heat acclimation responses (40°C, db; 23.5°C, wb) of four men during 1942 (mean age 31 yr) to the responses of these same individuals some 21 years later. By most of the usual physiological criteria (mean skin and rectal temperatures, and heart rate), these older men showed similar patterns of exercise-heat acclimation and acclimated to about the same extent as when they were younger. The tolerance of these older men on the first day of acclimation was no less compared to their responses 21 years earlier. However, the initial cardiovascular strain observed on the first day of acclimation was greater for the older men in terms of relative cardiac cost given our knowledge concerning the reduction in maximum heart rate with increasing age. Overall, these older men displayed about the same degree of physiological strain during repeated exercise-heat stress as they did 21 years earlier and acclimated about as well. The habitually active lifestyle of these four individuals has been hypothesized to help explain why their thermoregulatory responses were not affected by age.

More recently, Pandolf et al. (1988) compared the thermoregulatory responses during exercise-heat acclimation (49°C, 20% rh) between nine younger (mean age 21.2 yr) and nine older men (mean age 46.4 yr) who were matched ($P>0.05$) for body weight, surface area, surface area-to-weight ratio, percent body fat and maximal aerobic power. Figure 4 compares the performance times between these middle-aged and young men during a comfortable (C) environment day (22°C, 50% rh) and during each of the ten exercise-heat acclimation days. During the first day of exercise-heat acclimation, performance time was 27 min longer for the middle-aged compared to the young

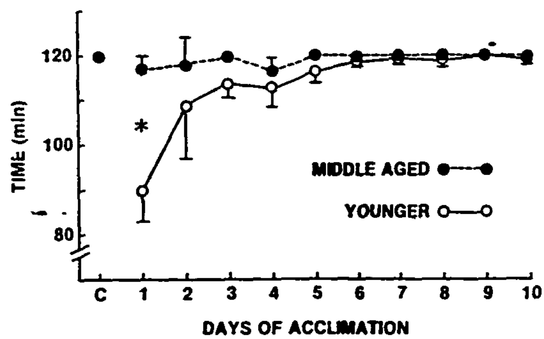

Figure 4. Mean(±SE) performance time of middle-aged and young men during control (C) day and each of 10 exercise-heat acclimation days. * Significant difference ($P<0.05$). All subjects completed 120-min on control day (from Pandolf et al., 1988).

men. However, performance time did not differ between these groups during the remaining days of exercise-heat acclimation.

Figure 5 shows that final rectal temperature, mean skin temperature and heart rate were lower while final total body sweat loss was higher for these middle-aged compared to the young men on the first exercise-heat acclimation day (Pandolf et al., 1988). These thermoregulatory advantages for the middle-aged men persisted for the first few days of exercise-heat acclimation. However, by the end of the acclimation

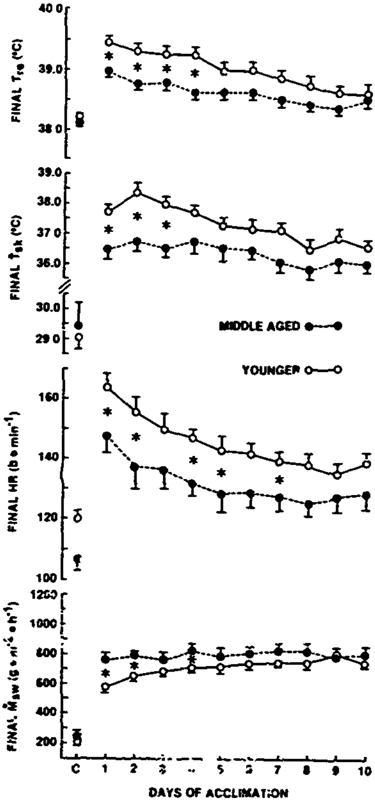

Figure 5. Mean(±SE) final rectal temperature (T_{re}), mean skin temperature ($\bar{T}_{sk}$), heart rate (HR), and total body sweat loss ($\dot{M}_{sw}$) of middle-aged and young men during the control (C) day and each of 10 exercise-heat acclimation days. Asterisk indicates significant ($P<0.05$) difference (from Pandolf et al., 1988).

period, no thermoregulatory differences were observed between these two age groups.

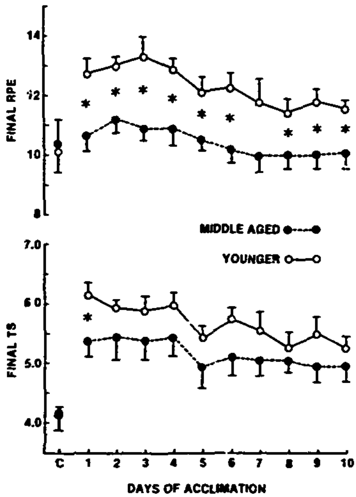

Figure 6. Mean(±SE) final rated perceived exertion (RPE) and thermal sensation (TS) of middle-aged and young men during the control (C) day and each of 10 exercise-heat acclimation days. Asterisk indicates significant (P<0.05) difference (from Pandolf et al., 1988).

Figure 6 illustrates that final rated perceived exertion (RPE) and final thermal sensation (TS) were generally lower for the middle-aged men throughout the ten days of acclimation (Pandolf et al., 1988). Final RPE was significantly lower for the older men on all acclimation days except for day 7 while final TS was significantly lower only on day 1. Pandolf et al. (1988) concluded from this study that there was little impairment of the thermoregulatory system at least through the fifth decade of life for aerobically trained middle-aged men.

CONCLUSIONS

For the general population, exercise-heat intolerance appears to be increased for older compared to younger individuals. However, the greater exercise-heat intolerance observed with aging does not appear to be related to age _per se_, but does seem to be associated with other factors such as decreased physical activity, lowered maximal aerobic power, obesity and certain disease states related to aging.

Researchers generally agree that high aerobic fitness achieved through physical training will reduce the physiological strain associated with exercise in the heat (Armstrong and Pandolf, 1988). The older men studied by Pandolf et al. (1988) averaged nearly 20 miles/week more aerobic activity than their younger counterparts. These authors concluded that the enhanced regular aerobic activity for their relatively lean middle-aged men appeared to have offset any impairment of their thermoregulatory systems.

When considering older individuals for hot industrial jobs, it appears that a history of aerobic training and other morphological considerations such as body fat should be given some consideration in the selection process. If older individuals are aerobically trained and relatively lean in terms of percent body fat, evidence indicates little impairment of their thermoregulatory responses compared to younger individuals at least through the fifth decade of life.

DISCLAIMER AND DISTRIBUTION STATEMENT

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