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NOTES

Thirst and Work Capacity of Older People in a Hot Environment

Anna Marszałek

Department of Ergonomics,
Central Institute for Labour Protection, Warsaw, Poland

In a hot environment, especially during exercise, the main role of thermoregulative mechanisms is to dissipate excessive heat from the body. The most effective way of heat dissipation is sweat production and its evaporation off skin surface. Intense sweating results in a considerable loss of water and electrolytes. There are some results that indicate lower thirst of older men than young ones in response to a hot environment and osmotic stimuli. Our studies conducted in men of different ages exposed to a hot environment indicated that there were no significant differences in rectal temperature *(T_{re})* or heat storage *(S)* among groups at rest. Lower T_{re} and lower *S* in older men with higher physical capacity for their age than in young ones with average physical capacity was shown. However, in all the experiments significantly lower thirst in older men than in the young was indicated. Special attention should be paid to fluid replacement among workers in a hot environment because of lower thirst and lower hydration of older men. These individuals may be exposed to dehydration risk during prolonged exercise, despite the possibility to tolerate heat strain as well as young ones. Further studies are necessary because of some diversity in the meaning of the results.

thirst thermal strain older people

1. INTRODUCTION

Some studies suggested that middle-aged (45–64 years) men and women tolerate work less well in a hot environment and their acclimation to heat causes higher physiological strain than young individuals (Hellon & Lind, 1958; Lind, Humphreys, Collins, Foster, & Sweetland, 1970). It

Correspondence and requests for reprints should be sent to, Anna Marszałek, Central Institute for Labour Protection, ul. Czerniakowska 16, 00-701 Warszawa, Poland. E-mail: < anmar@ciop.pl >.

is difficult to state to what extent these differences are related to factors accompanying an ageing of humans including an increase in the prevalence of chronic diseases, increased use of prescription medications, socioeconomic factors, decreased physical activity or lower physical performance (Kenney & Havenith, 1993; Pandolf, 1997).

Newer studies indicate that work tolerance and physiological responses during acclimation in a hot environment in trained middle-aged individuals are the same or even better than in young ones (Armstrong & Kenney 1993; Pandolf et al., 1988). Other studies conducted at workstations in women of different ages suggested lower heat strain of experienced older women than of young ones. Lower changes in adrenaline and creatinine levels in older women compared to young ones were shown (Markiewicz & Konarska, 1971) and lower physiological responses such as heart rate, cardiac output, and mean skin temperature during work in the heat of older women than of young ones (Puchalska & Kozłowski, 1969).

Work performance in a hot environment requires blood flow from the heart (cardiac output) for nutrition of the working muscles and heat transfer to the skin. During work of a high intensity, heat dissipation may not be sufficient and core temperature will rise (Nielsen, 1986). Lack of fluid replacement during physical activity in a hot environment will also cause core temperature to rise. In this case the water source for sweat production will decrease and the body's ability to cool will be limited (Nielsen, 1986). During highly intensive work in a hot environment workers can produce almost 5 kg of sweat during a working day. Fluid replacement is always lower than the amount of sweat secreted and in this case it is equal to 3.5-4.2 L of drunk fluids (Spioch, 1997).

Homeostatic mechanisms ensure stability of the environment inside the human body. The water and electrolyte balance of fluids in extra- and intravascular space is precisely regulated by neural, behavioral, and hormonal homeostaic mechanisms. Vasopressin has a central role in the control of body water (Stout, Kenny, & Baylis, 1999).

Recent studies suggest that middle-aged women and men and older people (over 64 years) are more susceptible to greater heat strain and physiologically significant levels of dehydration (over 2% of body mass) than younger ones (Pandolf, 1997). These observations may be explained by results of some authors about lower perception of thirst in older age (Mack et al., 1994; Philips et al., 1984; Stout et al., 1999). Therefore fluid levels are not sufficiently replaced for proper body hydration. It is known that dehydration causes a decrease of the sweating rate and consequently the possibility to dissipate excessive heat from human body by the most effective way also decreases. This situation results in a reduction of themoregulatory efficiency, which leads to attenuation of work ability in a hot environment. Also in the recovery period after work in heat middle-aged individuals do not replace fluid deficiency to an adequate extent because of their lower thirst compared to young ones (Philips, Bretherton, Johnston, & Gray, 1991). Dehydration effects may therefore be much larger in older men and make fluid replacement difficult because of lower thirst and changes in the renal function (Kenney, 1997).

The aim of the study was to compare subjective ratings of thirst in men of different ages in a hot environment without and with heat radiation and then without and with radiation protective clothing.

2. METHODS

Studies were conducted at rest (24 participants) and during exercise (20 participants) in a hot environment without and with heat radiation and then without and with protective clothing at maximal thermal load determined by hygienic standards of about 29 °C WBGT and about 26 °C WBGT at rest and during exercise, respectively. The participants were divided into three age groups: young (Y, 20-29 years), middle-aged (M-A, 41-55 years) and older (O, 58-64 years).

The rest study lasted 1 hr and the age groups were matched on the basis of the participants' activity level in leisure time. In the exercise study, groups Y and M-A represented average whereas the participants in the O group had high maximal oxygen uptake (VO_{2max}) for the respective age groups. In the study, participants exercised for 30 min on a cycloergometer at 40% VO_{2max}.

In experiments without protective clothing participants wore only shorts, socks and tennis shoes (0.09 clo) whereas in experiments with protective clothing garments included cotton long-sleeve and long-leg underwear, a three-part aluminized protecting set (jacket, trousers, gloves), socks, and leather shoes (1.17 clo).

During the experiments, rectal and skin temperatures were registered, heat storage was calculated, and the subjective ratings of thirst were collected. These ratings were based on a four-point scale questionnaire.

To assess intergroup differences in physiological responses to heat exposures Student's *t* test was used. Subjective ratings were analysed using the ranked sign test.

3. RESULTS AND DISSCUSION

During 1-hr passive heating there were no significant differences in t_{re}, $\bar{t}_{sk}$, and S in young and older men matched on the basis of their physical activity (Table 1). However in response to 30-min exercise at moderate intensity and at similar relative physical load in a hot environment, lower t_{re} increase and lower S in the older group with higher physical capacity for their age than in the young group with average physical capacity were indicated (Table 2).

TABLE 1. Physiological Responses of Men of Different Ages at the End of a 60-min Rest in the Heat Without (R1) and with (R2) Infrared Radiation

		Physiological Indices, $\bar{x} \pm SD$		
Experiment	Group	Δt_{re} (C)	$\bar{t}_{sk}$ (C)	S(W · m^{-2})
R1	Y	0.00 ± 0.00	35.8 ± 0.3	10.25 ± 6.65
	M-A	0.14 ± 0.01	36.3 ± 0.4	17.76 ± 9.39
	O	0.20 ± 0.02	36.1 ± 0.4	17.97 ± 7.60
R2	Y	0.14 ± 0.01	36.0 ± 0.2	18.48 ± 6.40
	M-A	0.19 ± 0.02	35.8 ± 0.2	17.78 ± 4.56
	O	0.27 ± 0.02	36.1 ± 0.4	19.49 ± 7.28

Notes. Δt_{re}—rectal temperature increase, $\bar{t}_{sk}$—mean weighted skin temperature, S—heat storage; Y—young group, M-A—middle-aged group, O—older group.

TABLE 2. Physiological Responses of Men of Different Ages at the End of a 30-min Rest in the Heat Without (E1) and with (E2) Infrared Radiation

		Physiological Indices, $\bar{x} \pm SD$		
Experiment	Group	Δt_{re} (C)	$\bar{t}_{sk}$ (C)	S(W · m^{-2})
E1	Y	0.53 ± 0.04	35.1 ± 0.3	51.7 ± 10.4
	M-A	0.58 ± 0.05	35.3 ± 0.4	62.3 ± 11.4
	O	0.38 ± 0.07*	35.1 ± 0.7	41.1 ± 11.1*
E2	Y	0.52 ± 0.05	35.7 ± 0.3	68.2 ± 9.9
	M-A	0.55 ± 0.06	35.9 ± 0.4	73.2 ± 7.8
	O	0.42 ± 0.08*	35.4 ± 0.5	52.1 ± 17.8*

Notes. Δt_{re}—rectal temperature increase, $\bar{t}_{sk}$—mean weighted skin temperature, S—heat storage; Y—young group, M-A—middle-aged group, O—older group; *—$p < .05$ compared to group M-A.

In all conducted experiments including experiments with protective clothing protecting against radiant heat, significantly lower thirst in older men than in young ones was observed (Table 3 and 4). Thus, prolonged exposure of older men to a hot environment may carry a potential risk factor of dehydration, especially that their sweating rate may be similar to young men's, which was the case in our experiments.

TABLE 3. Subjective Ratings of Thirst (range 1–4) of Men of Different Ages at Rest in the Heat Without (R1) and With (R2) Infrared Radiation.

		Perceived thirst, $\bar{x} \pm SD$		
Experiment	Group	0	30 min	60 min
R1	Y	1.4 ± 0.5	2.0 ± 0.7	2.7 ± 0.9
	M-A	1.2 ± 0.4	1.9 ± 0.6	2.4 ± 0.7
	O	1.2 ± 0.4	1.2 ± 0.4*	1.5 ± 0.5*
R2	Y	1.3 ± 0.7	2.1 ± 0.8	2.8 ± 1.0
	M-A	1.0 ± 0.0	2.1 ± 0.8	2.6 ± 0.7
	O	1.3 ± 0.5	1.5 ± 0.5*	2.0 ± 0.9*

Notes. Y—young group, M-A—middle-aged group, O—older group; *—$p < .05$ compared to Y.

TABLE 4. Subjective Ratings of Thirst (range 1–4) of Men of Different Ages During Exercise in the Heat Without (E1) and with (E2) Infrared Radiation

		Perceived thirst, $\bar{x} \pm SD$	
Experiment	Group	0	30 min
E1	Y	1.25 ± 0.43	2.50 ± 0.50
	M-A	1.33 ± 0.47	2.33 ± 0.75
	O	1.00 ± 0.00	1.67 ± 0.75*
E2	Y	1.38 ± 0.48	2.75 ± 0.83
	M-A	1.50 ± 0.50	2.67 ± 0.75
	O	1.17 ± 0.37	1.83 ± 0.69*

Notes. Y—young group, M-A—middle-aged group, O—older group; *—$p < .05$ compared to Y.

A number of authors indicated significantly lower thirst in older individuals compared to young ones (Mack et al., 1994; Philips et al., 1984; Philips et al., 1991; Stout et al., 1999). Philips et al. (1991) indicated that older men (65-78 years) drank less during a 30-min rehydration period than younger men after 120-min hypertonic and isotonic saline infusion. These authors concluded that the reduced thirst in those older men was primarily related to a lower sensitivity to hypertonicity; those individuals also showed trends towards an increased thirst threshold compared with younger men. Mack et al. (1994) obtained similar results in studies where lower rehydration in older men (69 ± 2 years), which followed 105 min of work (60% HR_{max}) in heat (36 °C, <30% relative humidity) was observed. Lower thirst in older men results in plasma volume decrease and then in lower skin blood flow (Fortney, Wenger, Bove, & Nadel, 1984).

Sawka and Pandolf (1990) indicated that during work in a hot environment thermoregulation responses are influenced by the following factors: acclimation status, physical capacity, and hydration level of the human body. It was shown that dehydration causes a decrease of work performance in the heat and an increase of physiological heat strain. Dehydration is thought to be the most common cause of fluid and electrolyte imbalance in the elderly (Philips et al., 1984). The authors indicated that after 24 hrs of water deprivation, elderly men (67-75 years) displayed larger increases in plasma osmolality, sodium concentration, and vasopressin levels, but their urinary osmolality was decreased and they showed reduced thirst and consumed less water than younger men. The authors explained the thirst deficit by the central nervous system disorder or hypothalamic disturbance in the elderly. An alternative mechanism hypothesised by the authors involves reduced physiological sensitivity of the thirst mechanism to osmotic or volume stimuli.

There are few studies suggesting that thirst in the elderly is similar to younger, healthy individuals' thirst (Davies, O'Neill, McLean, Catania, & Bennett, 1995; Stachenfeld, Mack, Takamata, DiPietro, & Nadel, 1996). Differences in hydration status during measurements could be a possible reason of the diversity in the meaning of the results (Stout et al., 1999).

Summing up, it should be emphasised that in a hot environment, especially during exercise, the main role of thermoregulative mechanisms is to dissipate excessive heat from the body. The most effective way of heat dissipation is sweat production and its evaporation off skin surface. Intense sweating results in a considerable loss of water and electrolytes. Special attention should be paid to fluid replacement among workers in a hot environment because of lower thirst and lower hydration of older men. These individuals may be exposed to dehydration risk during prolonged exercise, despite the possibility to tolerate heat strain as well as young ones. Further studies are necessary because of some diversity in the meaning of the results.

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