INDIVIDUAL CHARACTERISTICS AND RESPONSE TO HEAT STRESS

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INTRODUCTION

The purpose of this paper is to provide an overview of those individual characteristics which have the ability to, or have been purported to, influence physiological responses to heat stress. This overview is based on studies which are, for the most part, cross-sectional in design and singular in focus. As used here, "individual characteristics" refer to physical or physiological traits which are not readily modifiable within a relatively short time frame. Therefore, such factors as heat acclimation and hydration state are not included. Those individual characteristics covered are gender, age (including menopausal status), race, body size and composition, and VO_2max.

Furthermore, there is a propensity to use the general (but typically ill-defined) term "heat tolerance" in the vast body of literature which relates to individual characteristics and heat stress. In the interest of clarifying the often contradictory findings in this area, the present paper divides the vague notion of "heat tolerance" into 2 distinct levels of response Variables – body core temperature responses and heat loss effector responses (sweating, skin vasodilatation, etc.). It is important to note that these 2 related response outcomes are often not directly linked, e.g. a lower sweating rate does not necessarily result in a higher body core temperature.

GENDER

While most of our knowledge of human responses to heat stress is derived from studies involving primarily male subjects, many studies have compared the responses of men and women during heat stress. Early studies which concluded that women were less heat tolerant than men routinely failed to account for intergender population differences in body size, fitness, acclimation state, etc. When subjects are matched for such traits, (a) there are no clear gender differences in heat tolerance or body temperature responses to heat stress, and (b) few differences remain with regard to heat loss responses. Women exhibit, on average, lower maximal sweating rates than men of equal fitness and acclimation. This appears to be the result of a more efficient hidromeiotic mechanism. This difference in sweating response may provide a slight advantage in humid heat and a slight disadvantage in dry heat; however, on a practical basis, the effects are small. Likewise, menstrual cycle phase effects are minimal and usually disappear as work begins or heat stress becomes more severe (1).

AGE

Even when homogeneous samples of older individuals are compared with young subjects of the same gender, VO_2max, acclimation and hydration state, and body size and adiposity, age-related differences in heat loss responses exist. Skin blood flow at a given core temperature is lower in working older individuals and maximal functional vasodilatation is likewise diminished (2). Sweat gland function is similarly diminished, although whether this difference is manifested as a lower sweating rate during work/heat stress seems to be environment-dependent (3,4). These age-related differences in effector responses do not translate into higher core temperatures or shortened exposures, provided that older individuals (through age 70) maintain a high VO_2max and remain relatively disease-free.

There may be changes in heat loss responses associated specifically with menopause (i.e. loss of cyclic ovarian hormonal fluctuation) in older women. Recent evidence shows that estrogen replacement therapy may reduce thermoregulatory and cardiovascular strain in middle-aged women (5).

RACE

Comparisons of racial populations in the literature are almost ubiquitously confounded by such factors as length of residence, acclimatization, body size, etc. A recent review of studies conducted in the U.S. and Africa (6) concluded that in hot humid conditions, blacks (a) waste less sweat and (b) experience less cardiovascular strain than whites during similar work tasks. On a practical basis, these differences are minimal.

BODY SIZE

Body size and composition determine (a) the SA:mass ratio and (b) blood volume (BV), which in turn effect the biophysics of heat transfer within the body and exchange with the environment. Physiological effects are determined, both in direction and magnitude, by the environment (as shown in the table below) and activity (i.e. weight-bearing or not) under consideration.

size	SA:mass	Evaporative cooling	BV	warm/dry	warm/humid
small	high	higher	lower	advantage	
large	low	lower	higher		advantage

Obesity alters heat loss responses independent of body size and the effects are greatest with weight-bearing activities.

VO_2max

With careful scrutiny, cross-sectional and longitudinal studies concur that the most reliable predictor of individual responses to heat stress is VO_2max. Again, the literature in this area must be interpreted carefully for (a) the interactive effects of physical training and heat acclimation, (b) the choice of work intensities based on absolute vs relative work intensities. The paper presented by Havenith at this conference (7) provides clear evidence of the importance of VO_2max as an individual predictor of heat strain using an atypical experimental approach.

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