INTER-INDIVIDUAL VARIATIONS IN PHYSIOLOGICAL RESPONSE TO EXERCISE WHILE WEARING PROTECTIVE GARMENTS

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INTRODUCTION

Protective garments are often evaluated by measuring variables such as metabolic rate, body temperatures, and hypohydration. Differences between garments are described by central values, mostly the mean and the median, while measures of variation, *e.* g. range and standard deviation, are usually given much less attention other than in tests for statistical significance. However, for prediction of e. g. performance in the field the importance of inter-individual variation is obvious, a fact often considered when describing physical work capacity (1). Thus, it might be of interest to study the magnitude of this variation and whether or not it is affected by factors such as work rate and air temperature. The aim of this paper is therefore to focus on inter-individual variation of variables frequently used as indicators of physiological strain.

METHODS

Data were collected during experiments designed to evaluate different types of protective garments by means of indices of physiological strain e. g. heart rate, metabolic rate, loss of body mass, body temperatures. These experiments were of repeated measurements-design which made it possible to separate the variation between individuals from that between garments, and from the error of the method. Conventional methods for measuring body temperatures, mass loss, and metabolic rate were used. The error of the methods (standard deviation) for single value was: metabolic rate 20 W, body mass loss 85 g, mean skin temperature 0,15 °C . Inter-individual differences are illustrated by the magnitude of overlap (definition see figure 1) e.g. between two garments.

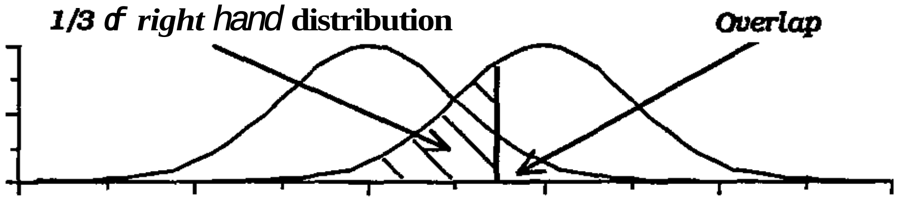

Figure I . Example of distributions of data obtained comparing two different ensembles.

RESULTS

Significant differences between individuals were found in body mass loss, metabolic rate, skin temperatures and hypohydration. Most often these inter-individual differences were greater than differences between treatments *e.* g. different garments. Metabolic rate: The coefficient of variation was independent of clothing and work rate. Skin temperatures: The variation between subjects in mean skin temperature was not influenced by air temperature (6°C compared to 25°C) whereas the inter-individual variation in hand temperature were greater at the lower temperature. No consistent effect of work rate on inter-individual variation was found either in mean skin tempcraturc or in local temperatures. Mass loss: Coefficient of variation was unaffected by work rate (50 W compared to 150 W) and air temperature (6°C compared to 25°C). The coefficient of variation for metabolic rate and mass loss was 7% and 22%, respectively.

Table 1. Magnitude of overlap expressed as the fraction of the distribution with the lower mean value that reaches the level below which the lowest 1/3 of the distribution with the higher mean value is contained (see figure 1).

Variable	Comparison	Fraction (%)
Metabolic rate	Combat uniform vs permeable CW-suit (treadmill walking)	43
Metabolic rate	Without vs with Armored vest (step test)	53
Metabolic rate	Without vs with Armored vest (arm work)	28
Mass loss	Rescue suit (permeable) with vs without charcoal underwear	38
Mass loss	Combat uniform vs permeable CW-suit	10
Mass loss/ body mass	Rescue suit (permeable) with vs without charcoal underwear	43
Mass loss/ body mass	Combat uniform vs permeable CW-suit	5
Mean skin temperature	Combat uniform vs permeable CW-suit	<1
Skin temperature, chest	Impermeable CW-suit, 6 °C vs 25 °C and 50 W vs 150 W	2 resp. 8
Skin temperature, back	Impermeable CW-suit, 6 °C vs 25 "C and 50 W vs 150 W	1 resp 6
Skin temperature, hand	Impermeable CW-suit, 6 °C vs 25 °C and 50 W vs 150 W	1 resp 52
Skin temperature, foot	Impermeable CW-suit, 6 °C vs 25 °C and 50 W vs 150 W	8 resp 31

The overlap was considerable in many situations (table 1), meaning that some people will suffer more in moderately stressful conditions than others do in rather harsh environments, an observation frequently made in the laboratory as well as in the field. Another implication is that e.g. a mean value for the water requirement is likely to be a rather poor predictor of the individual need for water replenishment. Hence, using mean values to prescribe water intake can lead to hypohydration for a number of people. On the other hand, mean values may serve well in predicting the amount of water needed to supply a group of people.

For metabolic rate during exercise theinter-individual variation was much less than for mass loss which would act to make the overlap smaller for metabolic rate than for mass loss. However, the increments of metabolic rate induced by wearing an armored vest or a CW-suit was rather modest (20 to 60 W), thus increasing the overlap. Another implication is that the mean value is a better predictor of individual values for metabolic rate than for water requirements.

Mean skin temperature displayed little overlap, a trend similar to that of chest and back temperature. Hand and foot temperature showed a greater inter-individual variation, and overlapped more, than did trunk temperature, indicating that recommendations for suitable hand- and footwear based on e.g. their thermal insulation will leave many wearer unsatisfied.

CONCLUSIONS

The inter-individual variation in response to exercise is often quite large and some people will experience more strain in moderately stressful situations than others do during harsh conditions. This variation complicates predictions of individual requirements. The usefulness of data on e.g. thermal insulation will be much less for predicting individual responses than for estimating the mean response of groups of people.

REFEENCE

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