Annals Physiol. Anthrop. Vol 5. No. 3 1986

Session VIII
Evaluation of Thermal Characteristics of Clothing
Abstracts 43-47

43 Physiological tests and evaluation models for the optimization of the performance of protective clothing

K.H. Umbach, Bekleidungsphysiologisches Institut **e.V.** Hohenstein, Bonnigheim, Federal Republic of Germany

Clothing in general, but protective clothing in particular, must possess a biophysical function. Thermal insulation and moisture permeability have to be adapted to specific climatic and activity conditions in order to give thermal comfort to the wearer. For the manufacturer of protective clothing it is essential to evaluate the physiological characteristics of his products. Because for the textile and garment industry today time-consuming and expensive wear trials are no longer a suitable means for testing, a system of laboratory measurements has been developed, by which specific quantities of textiles and garments can be determined, which directly show their physiological performance.

In this system with a thermoregulatory model of human skin (**Skin** Model), simulating heat and moisture exchange from the skin, the thermal insulation as well as the moisture permeability of fabrics are measured. These quantities are not only determined under stationary ("normal") wear conditions but also under transient situations, characterized by sweat pulses resulting from strenuous body activity. Thus, a complete set of specific fabric quantities can be measured, which are inserted in predictive formulae, yielding the physiological comfort of fabrics.

However, the wear properties of a clothing ensemble consisting of several garments are not only determined by the fabrics but also by the interspaced air layers' contribution to thermal regulation. Thus, for the evaluation of total clothing ensembles a life-sized movable manikin has been developed. With this manikin the thermal insulation and moisture transport of garments, as they become effective for the wearer, can be measured. Because the manikin can perform body movements, ventilation effects in the microclimate between the garments and their influence on thermal comfort can be evaluated. Thus, the effects of garment patterns on thermoregulation can be made visible.

With the manikin again a set of physiological quantities, now specific for the total clothing system, is resulting, which inserted in a predictive model shows the system's range of utility. This range is limited on the one hand by a minimum ambient temperature, where the wearer performing a certain kind of activity is just not suffering from hypothermia. With this minimum temperature wind-chill effects are also considered. On the other hand, the range of utility is limited by a maximum ambient temperature and air humidity, where hyperthermia is just prevented.

Furthermore, the model can predict thermal comfort of garments under all possible climate and activity conditions. In particular, tolerance times, for which clothing near its very limit of utility can protect its wearer from health damage, can be determined. Thus, this laboratory evaluation of garments has proceeded into a region which would never be covered by wear trials with human subjects.

Due to the broad physiological basis on which this evaluation model has been developed, its predictions are highly consistent with the wear performance of the clothing experienced in actual use by persons. For an example this is demonstrated by a cold-weather protective suit, designed to possess an outstandingly broad range of utility.

Thus, for the manufacturer the physiological apparall and measurements described represent a reliable means to optimize the functionality of his products. They really should be used during the development and design of protective clothing.