CORRELATION BETWEEN MEASURED SKIN WETTEDNESS AND SUBJECTIVE SENSATIONS OF SKIN WETNESS

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INTRODUCTION

The clothing insulation required to maintain thermal comfort during work in the cold will vary depending on the activity level. The insulation given by the clothing ensemble must be designed for the lowest work intensity and for rest periods when heat production is low. A thick clothing ensemble will reduce the dissipation of heat and water vapour by acting as a diffusion barrier and by absorbing sweat. During periods of high activity, the increased production of body heat and sweat may result in a sweat accumulation on the skin and in the underwear (Bakkevig and Nielsen, 1995). A correlation between skin wettedness and the feeling of discomfort has been claimed (Winslow et al. 1937). However, it is not clear whether we can sense increased levels of skin wettedness. This matter is addressed in this study which evaluates the correlation between measured skin wettedness and subjective sensations of skin wetness.

MATERIALS AND METHODS

Six male subjects, aged 24-29, participated in the experiments. The experiments were conducted in a climatic chamber (T_a = +5°C) and consisted of two bouts of 40 minutes cycle exercise to ensure sweat production followed by 20 minutes rest after each period of exercise. Each subject conducted two tests where the work level in the exercise period was different, one approximated 40% of the subjects' Vo_2 max and the other 60% of Vo_2 max. The experimental procedure with two work levels in the exercise period was chosen to ensure different levels of sweat production. A two layer clothing system was used in which the long-legged/long-sleeved underwear consisted of 80% wool and 20% polypropylene and the outerwear (trousers and jacket) consisted of 100% polypropylene. Relative humidity and temperature were measured at the skin at three locations (chest, back and thigh) during the experiments with the use of humidity sensors from VAISALA HMP 130 Y-series. They were placed between the skin and underwear with the aid of velcro. Local skin wettedness (w) on chest, back and thigh was calculated as

$$w = \frac{Psk - Pa}{Pssk - Pa}$$

where Psk is the water vapour pressure at the skin surface obtained from the humidity sensors, Pssk is the saturated water vapour pressure at the local skin temperature and Pa is the water vapour pressure in the environment (Berglund et al. 1983). General wettedness was calculated from these measurements according to the equation Wgen=(0.175*Chest + 0.175*Back + 0.190*Thigh)/0.54. Subjective ratings on general wetness and on chest, back and thigh were collected according to a discrete number evaluation scale. The subjects were not informed about details in the experiment, like T_a and type of clothing, to ensure that there was no influence on the subjective evaluations.

RESULTS

Using a linear regression analysis, the results showed a correlation between measured skin wettedness and subjective ratings on general skin wetness both during work ($r = 0.73$) and rest ($r = 0.71$). Figure 1 shows the correlation between measured skin wettedness and subjective ratings on general skin wetness during work. However, measured skin wettedness on chest, back and thigh correlated only weakly with subjective ratings of local skin wetness both during work (chest, $r = 0.60$ back, $r = 0.63$ thigh, $r = 0.45$) and rest (chest, $r = 0.67$ back, $r = 0.65$ thigh, $r = 0.72$). The results of the correlation between measured skin wettedness and subjective ratings on skin wetness on the chest during work are shown in Figure 2.

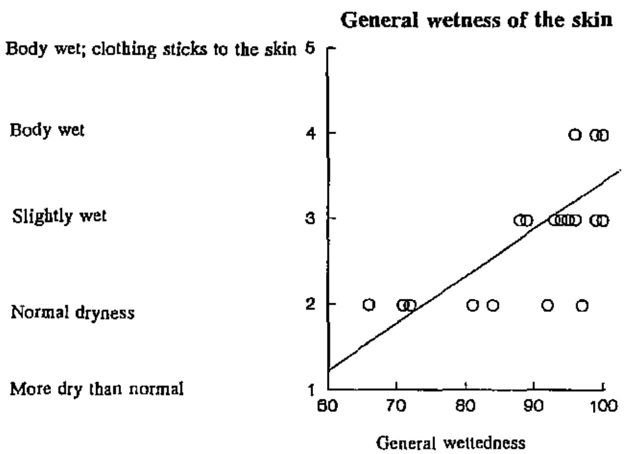

Figure 1 Correlation between general wettedness and subjective evaluation of general wetness during work at T_a=+5°C r=0.73 (n=24).

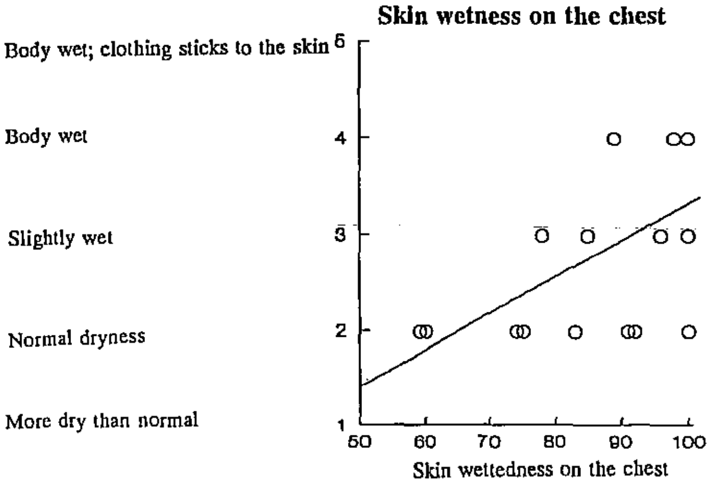

Figure 2 Correlation between measured skin wettedness on the chest and subjective evaluation of skin wetness on the chest during work at T_a=+5°C r=0.60 (n=24).

DISCUSSION

The results, showing a correlation between measured skin wettedness and subjective ratings on general skin wetness, indicate that the test subjects were able to differentiate between different levels of skin wettedness. Whether this ability is a result of a perception of humidity per se or an indirect perception, is not clear. It has been shown (Withers P. C. 1990) that certain terrestrial insects have receptors in the skin that sense the water content of the surrounding air, so-called hygroreceptors. To our knowledge, this has never been found in mammals. The perception of skin wetness could be connected to the evaporative cooling of sweat on the skin. The efficiency of sweating as a cooling mechanism depends on allowing the moisture to evaporate from the skin and diffuse through the clothing to the environment in the form of water vapour. During work in a cold environment, a thick clothing ensemble will reduce the dissipation of heat and water vapour (Meinander, 1985). This will lead to a saturation of the water vapour concentration near the skin resulting in a low evaporation rate. After cessation of work, when heat and sweat production is reduced, the evaporation of accumulated sweat might increase. The rate of sweat evaporation during work might therefore differ, independently of the water vapour concentration and sweat accumulated, from the sweat evaporation during rest. As we found a correlation between measured skin wettedness and subjective ratings on general skin wetness both during work and rest periods, it is likely that other mechanisms than evaporation of sweat are responsible for the ability to differentiate between different levels of skin wettedness. Not surprisingly the results indicate that we are not able to differentiate between different levels of local skin wetness. Most likely, not only local areas but the whole body will be exposed to humidity during natural conditions. Small areas are therefore not thought to give enough relevant information for further processing in the brain. Sensation of local wetness is for instance not as important as the effect from wounds caused by burning. In such situations a selectively sensory input from local areas will be detrimental to survival.

CONCLUSIONS

These experiments show that people may be able to differentiate between different levels of general skin wettedness but not between different levels of local (chest, back and thigh) skin wettedness. However, the mechanism for differentiation is not known.

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