Proceedings of 3rd International Conference
on *Environmental Ergonomics*
8—12 August 1988 *Helsinki.* Finland
eds R Ilmarinen and **A Påsche, p 68**

PREDICTION OF FOOT TEMPERATURE AND FOOT COMFORT

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To improve thermal comfort in combat boots in the cold, the sole insulation was increased, with an option to wear gaiters. The boot is designed to be all season military footwear, and should offer acceptable comfort during summer conditions. To investigate the feasibility of the design seven experiments were conducted with four subjects over a temperature range from -15°C to 30°C. including effects of sole and gaiter insulation, upper and lower body exercise, skin and core temperature, water vapour permeability of the gaiter, floor conductivity and cold acclimatization. The subjects were instructed to maintain predefined levels of core and skin temperature by adjustment of workload and clothing respectively. To this purpose they could monitor their own core temperature. Among the measured variables were foot and toe temperatures, foot relative humidity, weight change of socks and boots, thermal sensation and wetness sensation votes.

The results show that both sole insulation and gaiters improve foot comfort in the cold, but the thicker soles cause more discomfort in the heat. At 30°C the sweat accumulation increases to over 10 g/h of sweat per foot during moderate work. This will cause discomfort with virtually any kind of boot within a day. In the cold semipermeable gaiters give slightly less sweat accumulation than impermeable gaiters.

Lower body exercise produced a significant but only .5°C increase in foot temperature compared to upper body exercise. Effects of floor conductivity and cold acclimatization were not found. Comfort votes correlate well with foot temperature in the cold, but in the heat humidity becomes a factor as well. Wetness sensation depends largely on the wetness of the sole of the sock. Comfort votes are modified by psychological factors like previous experiences and time interval during comparisons of boots.

A mathematical model was designed to explain the results. The model is based on the heat balance of the foot, which is the result of heat loss through the boots and heat gain by the blood flow. The blood flow is controlled by the core and mean skin temperature, as well *as* the foot temperature itself, resulting in a positive feedback control system. Typically the foot tends to be either warm or cold. The key factor in foot temperature is the core temperature. Subjects show individual variability but this can be accounted for with a single parameter. With the model over 90% of the experimental variance is explained. Sweat producrion is similarly controlled as blood flow, but the effect of core temperature is even stronger.