ASSESSMENT IN HUMANS OF HEAT EXCHANGE AT SPECIFIC BODY AREAS USING A MULTI-COMPARTMENT LIQUID COOLING/WARMING GARMENT

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Assessment of maximal heat exchange between different body areas and the environment is important for the purpose of designing more effective protective clothing systems against extreme ambient temperatures. For this purpose, we developed a multi-compartment liquid cooling/warming garment (LCWG) with the capability to impose simultaneously different temperature regimes in various compartments. Six healthy men ages 25-35 served as subjects in these studies. The experimental design consisted of sequentially cooling (8°C) and warming (45°C) selected body zones via LCWG inlet water temperature while maintaining the remainder of the garment's body zones at 33°C. The same zones also were studied at more moderate LCWG water temperatures (15°C, 28°C and 38°C) as reference points for establishing relationships between LCWG surface temperature and capability of body heat exchange. The quantity of heat exchange with the LCWG from highest to lowest was sleeveless shirt, shorts, sleeves, and hood, likely related to differences in the size of the anatomical areas covered by the various compartments and thus involved in the heat exchange process. The hands under gloves cooled to 8°C released approximately 1.0kcal/min and under heating to 45°C absorbed approximately 0.7-0.9kcal/min, which was less than for the zones mentioned above. For the different regions of the upper extremities, the order of effectiveness of heat exchange was forearms, shoulders, and hands. However, considering heat transfer from the LCWG in relation to tubing length, these results confirm our prior research demonstrating that the hands have a high capability to transfer heat in and out of the body. The finding of individual variability in quantity of heat exchange from different body regions and different temperature conditions on the skin surface suggests that advanced protective garments for extreme environments including outer space can be enhanced by obtaining individual thermal profiles and incorporating these data in garment design. This should help provide a safer, more economical, comfortable, and effective garment for physical performance in harsh environments.

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