

result of increasing vapour pressure already in a moderate warm environment with a light work rate. Further elevation was seen in humid heat, especially with a moderate work rate. The heat strain due to clothing did not increase linearly with the insulation in clo-unit; instead the increase was exponential.

The results indicate that it is not possible to consider clothing independently of other heat stress factors. The physiological effects of a specific set of clothing are always dependent on the combinations of the thermal parameters and the activity level.

8 Cardiac output of children during submaximal exercise under different ambient temperatures

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The present study measured cardiac output (\dot{Q}) in children during exercise at different ambient temperatures in order to investigate the effects of ambient temperature on this parameter. The values obtained were compared with the same measure in adults to clarify any differing characteristic features of \dot{Q} in children.

Ten boys and nine girls, aged 10-11 years old, participated in the present experiment. All studies were carried out in a climatic chamber kept at 20, 30, and 40°C, with a relative humidity of 50%. Subjects exercised on a Monark bicycle ergometer for 8 minutes, each at loads of 300 and 450 kg.m.min⁻¹. Oxygen uptake ($\dot{V}O_2$) and carbon dioxide elimination ($\dot{V}CO_2$) were determined by the Douglas bag method during 5-7 minutes of exercise. At the same time, heart rate (HR) was counted from a bipolar chest lead ECG. \dot{Q} was estimated by the CO_2 rebreathing method during the last seconds of an exercise period. The fraction of CO_2 was measured by a rapid infrared CO_2 meter (Godart Capnograph). The experiment was undertaken during fall and winter for boys, and during summer and fall for girls.

For a given $\dot{V}O_2$, stroke volume (SV) tended to be reduced and HR increased in a 40°C environment in both sexes. Accordingly, \dot{Q} at 40°C was maintained at a level similar to that in cooler conditions. A lower HR and a higher SV at a given $\dot{V}O_2$ in boys was found to be similar to that in girls. The values of \dot{Q} in relation to $\dot{V}O_2$ in the children studied were compared with those in children and adults who had been previously studied. The children in the present study were found to have a \dot{Q} response corresponding to those of children of similar age already reported in the literature and to have a lower \dot{Q} compared with most adults.

9 Aerodynamic and thermoregulatory characteristics of running apparel

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The aerodynamic drag associated with three types of commercially available running apparel (SS: nylon singlet and shorts; L: lycra/nylon bodysuit and RS: nylon rainsuit) and two bodysuits of newly developed stretchable, water vapour permeable fabrics (T and K) was measured in a wind tunnel on a human mannequin at four velocities (4.7, 7.1, 8.8 and 9.7 m.sec⁻¹). Commercially available running apparel provided consistently higher drag than the T and K bodysuits. Under all conditions the high sheen and tight fit of the K fabric allowed drag reductions of between 17.5 and 7.4% at running speeds. At sprint speeds a hood over the hair was responsible for 6 of the 7.4% reduction in drag noted with the K suit. It is estimated that reductions in drag of this size provide real time savings of between 1.05% in the marathon to 2.75% in the 100m dash. A field trial of the K suit with 16 male subjects (mean age: 22 yr) revealed a significant ($p < .025$) decrease in 100m running time amounting to a time saving of 1.17% at a velocity of 7.43 m.sec⁻¹. The thermoregulatory properties of the SS, L and K suits and a suit of stretchable, membrane porous fabric (B) were investigated at

environmental temperatures of 0° and 25°C subsequent to the aerodynamic study. Six male, middle distance runners performed 30 minute runs on a treadmill at a pace requiring approximately 75% of maximum oxygen uptake against a fan generated wind of 4.2 m.sec⁻¹. Oxygen uptake kinetics, heart rate, sweating rate, core and skin temperature and perceived exertion were recorded. At 25°C, the K suit retained 23.5 and the B suit 9.1 times as much sweat as SS apparel ($p < .05$). Both suits were intolerable to running beyond 22 and 25 minutes, respectively ($p < .05$) at the designated speed. At 0°C, subject tolerance for all apparels exceeded the criterion time. In the cool (0°C) condition the comparatively high air permeability of the L suit resulted in a significantly lower core temperature increase ($p < .05$), compared with the other apparels. Even in cool conditions, the K suit retained significantly more sweat than the other apparels ($p < .05$) however subjects favoured the K suit over the B suit due to its lighter weight and greater stretchability. This research suggests that aerodynamic clothing may impact significantly upon running performance. In order to maintain efficient thermoregulation during extended wear in the hotter environment, future running suits should be developed from stretchable materials which have better vapour permeability.

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10 The effects of local cooling on physiological responses and thermal comfort in resting man

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11 The measurement of clothing air exchange and its role in clothing design

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Since the development of the trace gas technique for investigating the air exchange of the micro-environment of fishermen's clothing in the late 1960's, the technique has been used by a number of research groups. The designs and fabrics of a wide range of garments from ladies' skirts to survival clothing have been assessed using the technique. Sleeping bags have also been investigated using the method. The work on clothing using a trace gas will be reviewed and the technical aspects of the technique and investigative procedures discussed and assessed.

The basic principle of the technique and the equipment required is simple but the research worker has to ask how accurately it indicates micro-environment air exchange and how much the investigator can learn about garment fabrics and designs. The physiological significance of air exchange rates will be assessed and the methods of improving their value in this respect by measuring the micro-environment volume reviewed and discussed.