REDUCING HEAT STRAIN WITH ICE-VESTS OR HAND IMMERSION

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INTRODUCTION

Ice-vests are waistcoats that contain packs of frozen gel, which when worn increase heat loss from the body by conduction. Previous studies have demonstrated that ice-vests can reduce heat strain during work in hot environments (1-4). The ice-vests were found to attenuate the rise in rectal temperature during work, but did not cause rectal temperature to fall during subsequent rest periods. An ice-vests therefore may not be the best method of overcoming heat strain when work/rest schedules are employed. Hand immersion in cool water uses the similar principle of convective heat loss utilising the rich perfusion of blood in the hands (particularly via arterio-venous anastomoses). Previous studies have demonstrated that when body temperature is elevated, up to 200 watts of heat can be dissipated by immersing the hands in cold water (5), greater than cooling powers measured for ice-vests (6,7).

This study was undertaken to quantify and compare the cooling benefits of three ice-vests and hand immersion in 20°C water for personnel undergoing work-rest cycles.

METHOD

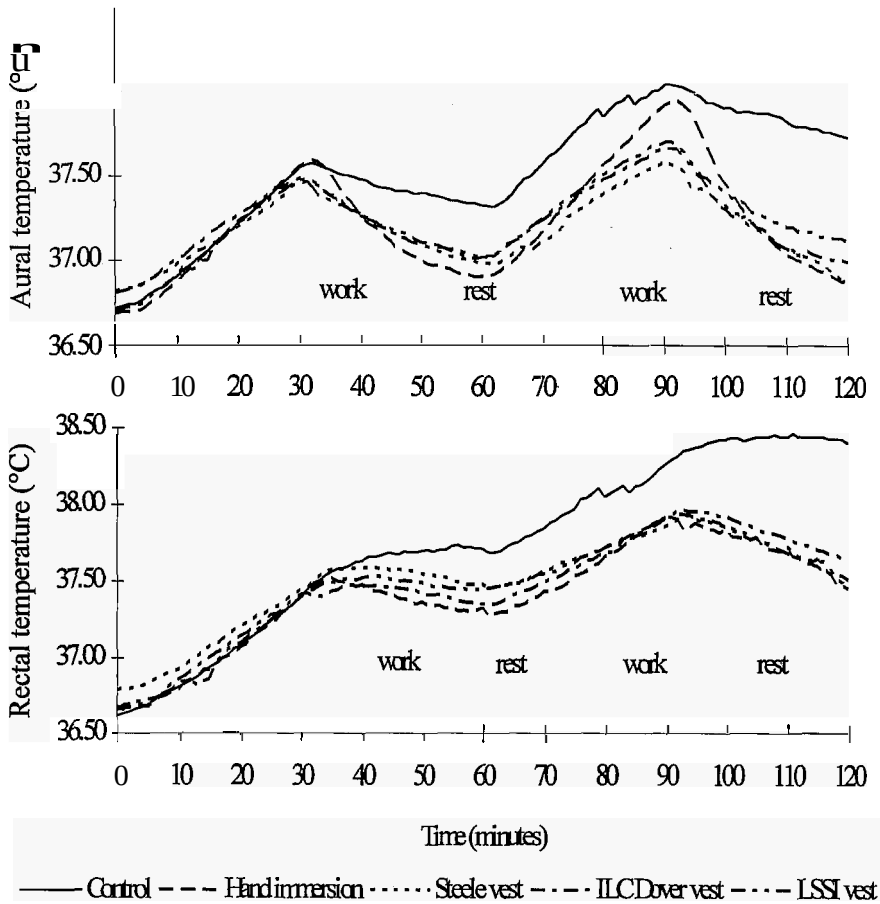
Ten male subjects participated in the study. Subjects exercised, wearing thermally restrictive clothing, in an environmental chamber (40°C *dry* bulb, 29.5°C wet bulb, 50% rh) on five occasions. The exercise consisted of stepping to and from a 22.5 cm box (rate: 12 complete steps per minute) for 30 minutes, followed by 30 minutes of seated rest which was repeated once. There were 5 experimental conditions: control; ice-vest (Steele) (Steele Inc, **USA);** ice-vest (ILC) (Dover Inc, **USA);** ice-vest (LSSI) **(LSSI** Inc, USA), and; hand immersion in 20°C water (Hand). The ice-vests were worn throughout both the work and rest periods, hand immersion was undertaken during rest periods only. **A** balanced randomized order design was used. Aural (T_a), rectal (T_r), and mean skin (T_s) temperatures and heart rate (HR) were monitored continuously and recorded. Water was provided at room temperature to drink *ad libitum.* Sweat production and evaporation rates were calculated from changes in nude and dressed body weights, corrected for water intake. Variables were analysed across conditions using ANOVA.

RESULTS

All subjects completed both work and rest periods in the ice-vest and hand immersion conditions. In the control condition, 4 subjects were stopped during the second work

period: 3 on reaching the T_a limit of 38.5°C; 1 with a HR limit of 210-age. A fifth subject stopped during the second rest period feeling unwell.

Fig 1. Aural and rectal temperatures during work and rest periods



There were no significant differences in T_a, T_r, T_s or HR between conditions at the end of the first work period. At the end of the first rest period T_a and T_r were significantly lower in the hand and ice-vest conditions compared to the control ($P<0.05$). There were no differences in T_s or HR.

At the end of the second work period T_a and T_r were significantly lower in the Steele and ILC conditions compared to the control ($P<0.05$). For the Hand and LSSI conditions only T_r was significantly lower than the control ($P<0.05$). Both T_s and HR

were significantly lower in the ice-vest conditions compared to the control **(PC0.05)** whereas the Hand condition was not significantly different from any other condition.

At the end of the second rest period T_{a}, T_r, T_s and HR were significantly lower in the Hand and ice-vest conditions compared to the Control **(P<0.05).**

There were no significant differences measured between the three different ice-vests at any time point. T_r in the Hand condition was significantly lower than the LSSI at the end of the second rest period (P<0.05).

Significantly more sweat was produced in the control condition than in the 3 ice-vest conditions **(P<0.05).** Sweat production for the Hand condition did not significantly differ from any of the other conditions. Sweat evaporation was similar in all conditions. Water intake was significantly higher in the control condition than the Hand and ILC conditions **(P<0.05)** and slightly higher than in the Steele and LSSI conditions (P<0.1).

CONCLUSIONS

For personnel working in these conditions following a worldrest schedule, any of the ice-vests or hand immersion in 20°C water would provide a significant benefit in the reduction of heat strain.

Until personnel become sufficiently hot the ice-vests did not reduce heat strain. This has been observed previously, in a number of studies where no significant effect on rectal temperatures were seen until 20 to 60 minutes of work had been completed (1-4), probably because of peripheral vasoconstriciton until core temperature rose sufficiently.

Hand immersion also requires peripheral blood flow to be maintained. Since hand immersion was not attempted until body temperature was elevated (at the end of each work period) then this requirement for blood flow was fulfilled during both rest periods. During the second rest period, the reduction in heat strain was greater using hand immersion compared to the ice-vests, albeit from a slightly higher aural temperature.

Sweat evaporation was always limited to a rate of around 350ml/hr because of the clothing. Therefore the lower sweat production rates measured in all but the control condition were an advantage to hydration status without affecting evaporative cooling.

In these conditions, an ice-vest would not provide significant benefit during a single short work period. If work periods were longer or continuous then the ice-vest would significantly reduce heat strain. If a work/rest schedule was used then hand immersion in cool water during rest periods would also significantly reduce heat strain and is a suitable alternative to wearing an ice-vest. Indeed, intermittent cooling during sufficient rest periods has been shown to increase work capacity and reduce heat strain (8).

Aural temperature, is thought to accurately represent brain temperature and responds rapidly to changes (9). Rectal temperature has been considered too slow to reflect rapid changes in body heat storage and has been shown to lag aural temperature (10). This pattern was seen in this study with changes in rectal temperature appearing 'damped' compared to changes in aural temperature although both measures were similar and never in conflict. Measurement of aural temperature illustrates that ice-vests allow greater cooling during rest periods than has been previously demonstrated.

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