Passive Microclimate Cooling Prevents Cardiovascular Drift During High Heat Exposure

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INTRODUCTION

Thermal stress and its' compromising effect of the cardiovascular system is a major concern for the US Navy. Navy personnel (engine rooms, galleys, damage control and topside observers) are often tasked to perform their shipboard duties in a thermal environment exceeding 32 degrees C. This study investigated the effects of a passive microclimate cooling system as a countermeasure to prevent or delay the onset of cardiovascular drift during work performed in a high heat environment.

METHOD

The Steele ICE vest, which contains three frozen gel-pack strips (blue ice) across the front and back of the vest, was examined under repeated exposure to a thermal environment consisting of the following mean ambient temperatures (Celsius): globe=45, dry bulb=43, wet bulb=32, and a partial vapor pressure of 31mmHg. Eleven mail engine room personnel volunteered a simulated four hour engine room watch on four consecutive days. Subjects were tested alternately on both vest (ICE) and no vest (NO-ICE) conditions (2 days each condition). Heart rate, rectal and skin temperature were averaged each minute and recorded continuously throughout the experiment using a squirrel data logger. Total body sweat rate was calculated from pre/post body weights and corrected for fluid exchanges. Skin blood flow (TSI laser doppler) and forearm blood flow (Hokansan plethysmograph) measurements were taken at hours 1, 2, and 3 of the heat exposure. Cardiovascular drift was calculated as the difference between the mane 2-hour, 3-hour, and 4-hour heart rate minus the mean 1-hr heart rate.

RESULTS

This study investigated the effects of passive microclimate cooling, specifically the ice vest design (ICE) as a countermeasure to prevent or delay the onset of heat strain during work performed in a high heat environment. Eleven male, US Navy personnel volunteered to perform a simulated 4-hr engine room watch. Testing occurred on 4 consecutive days in alternating ICE and NO-ICE conditions (2 days each condition) with mean ambient temperatures © of DB=43, WB=32, GT=45, WBGT=36 and RH=45%. Heat rate (HR), rectal (Tre) and mean weighted skin (Twsk) temperatures © were recorded continuously throughout the experiment. Total body sweat rate (SWR) was calculated frompre and post body weights and corrected for fluid exchanges (1 hr). A mean skin blood flow (SBF) and forearm blood flow (FBF) value (ml/100g/min) was derived from the average of 3 data points taken during 1-hr, 2-hr, and 3-hr of the experiment. Mean values for the data collected are as follows:

Means	HR(1-hr)	HR(4-hr)*	Twsk*	Tre**	SWR*	SBF	FBF
ICE	84.8	85.1	31.2	37.2	0.22	3.8	3.4
NO-ICE	86.7	97.8	35.9	37.3	0.47	4.2	4.0

*P<.01, **P<.05

A significant (P<.01) cardiovascular drift (i.e. mean HR 4-hr minus mean HR 1-hr)occurred between the ICE +0.3 bpm, and NO-ICE +11.1 bpm, conditions. These data are consistent with the hypothesis that the ice vest reduces peripheral blood pooling, thus increasing central blood volume. It was concluded that passive microclimate cooling maintains cardiovascular stability in the heat by eliminating cardiovascular drift.