THE EFFECTS OF MICROCLIMATE COOLING ON CARDIOVASCULAR STRAIN DURING WORK IN THE HEAT

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INTRODUCTION

U.S. Navy personnel working in high heat shipboard environments must adhere to a set of guidelines called the Physiological Heat Exposure Limit (PHEL) Curves. The six curves (PHEL-I to PHEL-VI) identify maximum safe exposure limits, i.e. watchstation time, based on a combined thermal environment and time weighted (Tw) metabolic work rate. The Tw metabolic work rates range from light activity (PHEL-I = 164 watts) to strenuous activity (PHEL-VI = 271 watts). Previous laboratory and field investigations by the U.S. Naval Health Research Center (NHRC) (1,2) and the U.S. Navy Clothing and Textile Research Facility (NCTRF) (3) identified the effectiveness of a passive microclimate cooling system (ice vest model) for combating thermal strain. Currently both laboratories are collaborating by conducting a series of similar but separate data collections at each laboratory which will result in the development of ice vest safe exposure limits or tolerance times (i.e. ice vest PHEL curves). The first paper on this topic presented preliminary results of heart rate, skin and core temperature, and tolerance time data collected on 14 subjects at the NCTRF laboratory (Pimental, et al.). This paper presents some preliminary results on several additional cardiovascular variables that were only measured during the data collection at the NHRC laboratory.

METHODS

Upon the completion of an 8-day heat acclimation protocol, eight U.S. Navy engineroom personnel underwent six simulated engineroom watches (EW) in an environmental chamber located at NHRC, San Diego, CA. Two duplicate EW tests, with and without a passive ice vest (ICE), were performed in three thermal conditions: EW1=44°C, 49%RH; EW2=51°C, 33%RH; EW3=57°C, 25%RH. The EW protocol, equivalent to a PHEL-III Tw metabolic rate (208 watts), consisted of a 20-min treadmill walk (4.8km/hr, 3%grade or 411 watts) and 40-min of seated rest each hour to a maximum of 6-hours or volitional withdrawal. Cardiac output, determined by a CO_2 rebreathing technique and measured approximately midway through each treadmill walk, provided stroke volume (SV) and heart rate (HR) information. Blood samples, collected after 20-min of seated rest, were obtained prior to entering and exiting the heat chamber and examined for changes in plasma volume, aldosterone, cortisol, electrolyte and glucose levels. A repeated measures MANOVA was used for statistical analysis of the data.

RESULTS & DISCUSSION

Group means for all environments and ice vest conditions are presented in Table 1. Ice vest tolerance time, as reported in the preceding paper at this meeting (Pimental, et al.), was twice that in the non-ice vest condition. Plasma volume (PV) changes (%) adjusted for exposure time (pre-post/test time=% change per hour) and HR drift (last exercise HR - first exercise HR) in the EW1 and EW2 environments, SV drift (last exercise SV - first exercise SV) in the EW1 environment and cortisol changes (last sample - first sample) in the EW2 environment were

TABLE 1.

	EW1		EW2		EW3	
	No-ICE	ICE	No-ICE	ICE	No-ICE	ICE
Adjusted PV changes (%/hr)	-2.9	-0.1*	-3.5	-0.7*	-4.0	-2.4
HR Drift (bpm)	39	17*	39	20*	44	30
SV Drift (ml/beat)	-34	-19*	-37	-25	-28	-23
Aldosterone change (pg/ml)	384	163	415	277	374	502
Cortisol change (μg/dl)	5.0	2.6	6.4	1.5*	7.1	5.0

* = $p \leq .05$

significantly lower in the ICE condition ($p<.05$). The trend for lower (though not significant) ICE condition values was also observed for EW2 SV drift and EW3 adjusted PV, HR drift and SV drift. Additionally, the lower ICE cortisol values would suggest some reduction of the hormonal response to both the physiological and environmental stress imposed. Aldosterone changes were reduced in the EW1 and EW2 ICE conditions but not statistically different from the No-ICE results. Serum electrolyte and glucose changes were unremarkable across all environments and conditions.

CONCLUSIONS

Results from this study comparing physiological responses with and without an ice vest show an overall trend of reduced thermal strain during exposure to high heat and moderate work rate with ice vest usage. The ice vest was most effective in conserving plasma volume loss, and reducing heart rate and stroke volume drift in the EW1 and EW2 environments (except for EW2 stroke volume drift). These findings, combined with an increased tolerance time, indicate that the ice vest was effective in reducing cardiovascular strain. These data will be used in the development of appropriate ice vest PHEL curves for the U.S. Navy.

REFERENCES

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