HEAT STRAIN AND EFFECT OF PASSIVE MICROCLIMATE COOLING

Guy R. Banta and Ralph Burr
Naval Health Research Center
San Diego, California

INTRODUCTION

Throughout the years numerous studies have addressed the effects of high heat on human performance in *military* working environments: aviation (1,2), land-based operations (3,4), and wearing chemical defense ensemble (5,6). Most recently, concerns have been expressed by Fleet Commanders for U. S. Navy personnel conducting shipboard operations in the Persian Gulf. The Navy's presence in the Gulf has involved a variety of ship types; many of them World War II model, steam and diesel powered vessels. Aboard these ships a number of job are tasks exposed to high heat without the benefit of work space cooling. One in particular is the Engine/Fire Room watch stander. During a previous study in the Persian Gulf, shipboard engine room temperatures had been recorded in the range of 32°C to 71°C (7). Because of operational necessity, workers in this type of environment may also be required to work many hours and repeated shifts during the day. Unlike industry, the Navy's working environment is not always able to be readily changed by appropriate engineering methods such as, provision of air conditioning or structural isolation. However, Navy guidelines for watch standing stay times (8) and/or provision of individual protective countermeasures have been implemented *to* assist maintenance of safety, performance, and health. The most recent countermeasure has been the introduction of a microclimate cooling system (passive ice vest) (9). The passive ice vest, called the Steele Vest, manufactured by Steele Incorporated, is made of cotton canvas, and contains six frozen thennostrips sewn in horizontally thinsulate insulated pockets, three m front and three in back. The vest is recommended to be worn over a T-shirt and working shirt *to* prevent excessive skin chilling and reddening by direct contact.

METHOD

In order to confirm the effectiveness of the ice vest to retard the physiological strain commonly associated with high heat environments, a field study was conducted during shipboard operations in the Persian Gulf during the summer of 1989 (June-August). Sixteen Engine/Fire Room (ER/FR) personnel (x age = 26.0 +/- 7.3 years) serving on two U. S. Navy ships (one *steam* and one diesel-powered) volunteered *to* participate. Subjects were evaluated in a with and without cooling vest condition during separate four-hour ER/FR watch periods. Data collection watch periods were restricted to one watch per day, and in order to reduce circadian influences, were at the same time each day. All subjects had been aboard their ship, and had stood similar watch periods for more than two weeks; therefore, were considered to have acquired heat acclimatization. During watch, the frozen thennostrips were replaced at two hours in order to maintain the vests cooling effect. The metabolic workload of the ER/FR job task was determined by investigator observation to be light and most likely not exceeding 200-250 watts. Performance measures taken included levels of anxiety and fatigue (measnred by questionnaire), heart rate (HR), rectal temperature (Tre), mean weighted *skin* temperature (Twsk), dehydration, and grip strength.

RESULTS

Ambient conditions within the ER/FR during this study were: Mean Dry Bulb temperature = 39.7°C, range = 34.2 to 42.7°C; Mean Relative Humidity = 56.4%. range = 50.0 to 67.5%; Mean Partial Vapor Pressure (PVP) = 30.5 mmHg, range = 26.0 to 37.0 mmHg. Anxiety increased during the watch period for subjects without an ice vest and decreased with an ice vest, although these changes were not statistically significant. During the watch, fatigue increased for subjects when not wearing an ice vest, $t = 2.75$, $p = .015$. Over time on watch, HR increased in relation to heatload. After two hours, subjects wearing an ice vest began *to* demonstrate a reduced cardiac strain response so by hour four of the watch, mean HR was 97 bpm without an ice vest and 84 bpm with. PVP proved to have the highest correlation with HR response. At PVP > 29 mmHg mean HR was significantly reduced in the vest condition, $F = 10.11$, $p = .034$. Twsk was reduced, $F = 38.3$, $p = .003$, however, Tre did not significantly change during the watch or between vest/no vest conditions. Dehydration as measured by urine specific gravity, osmolarity, and reduced sodium excretion demonstrated opposite effects following watch in the vest condition. Hematocrit did not markedly change between pre *to* post watch in either vest condition, yet grip strength, as a measure of total body strength, decreased significantly in the no vest condition, $p > .05$.

CONCLUSIONS

Due to the nature of today's U. S. Navy shipboard working environment and climate regions of operations, the safety, health, and job performance of the ship's crew may be compromised. Current operational guidelines describing *authorized* stay times in high heat working environments would seem to he appropriate to protect the individual for a given watch period. However, when these guidelines cannot be adhered to due to operational reality, e.g., General Quarters, mechanical breakdown, reduced manning, emergency response, etc., supplemental countermeasures must be utilized. Additionally, when individuals are required to work in conditions of high heat and humidity without protection over repeated periods of time, concerns include questions about chronic (long term) health effect. Provision of a supporting countermeasure such as a passive cooling vest may retard or prevent such adverse effects.

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