

USE OF A HEAT TOLERANCE TEST TO EVALUATE RETURN TO DUTY STATUS IN US NAVY AND MARINE CORPS PERSONNEL

Jay H. Heaney, Jesse L. Hascall, Janine M. Wong, Evan C. Johnson, Paul W. Miller

Naval Health Research Center, San Diego, CA

Contact person: jay.heaney@med.navy.mil

INTRODUCTION

Within operational and training scenarios, military personnel are constantly exposed to extreme environments that put them at risk for a heat illness. The severity of heat illnesses range from mild heat cramping, heat syncope, and heat exhaustion to life threatening exertional heat stroke. Comprehensive medical/safety programs and procedures have been established to prevent and reduce the severity of heat illnesses. However, despite these efforts heat illness is still prevalent and there are typically several heat related deaths each year that occur within the military population (Scoville, et al, 2001). Although heat illness can lead to permanent injury most military personnel experience a normal recovery and resume their operational specialty or continue with their training soon after their incident. The question of when and how to best return to a normal physically demanding routine is less certain (Armstrong, et al, 2007). Complicating the return to duty/training issue is whether experiencing any heat illness results in an increased future risk (Epstein, 1990). Across the services there is a great deal of variation in the approach to evaluating the heat injured service member and the time course for returning to duty can vary from a few days to weeks to several months (O'Connor, et al, 2007).

The heat tolerance test (HTT) is one protocol that has been developed by researchers with the Israeli Defense Force for return to duty following heat illness. The HTT has been used to evaluate whether personnel who have experienced a severe heat injury, (i.e., heat stroke) still have the capacity to effectively thermoregulate body temperature (Moran, et al, 2007). The purpose of this HTT is to expose an individual to a thermal and physical stress with the intent of eliciting a physiological response that will assist with determining if the individual is able to effectively thermoregulate (Text Book of Military Medicine). The Naval Health Research Center (NHRC), San Diego, CA, has adopted the use of a modified version of the Israeli HTT. The individuals who perform the HTT at NHRC have all experienced a prior heat illness and have been prevented from resuming their normal duties. This paper will provide information on a series of HTTs conducted by NHRC on US Navy and Marine Corps personnel who have experienced a heat injury.

METHODS

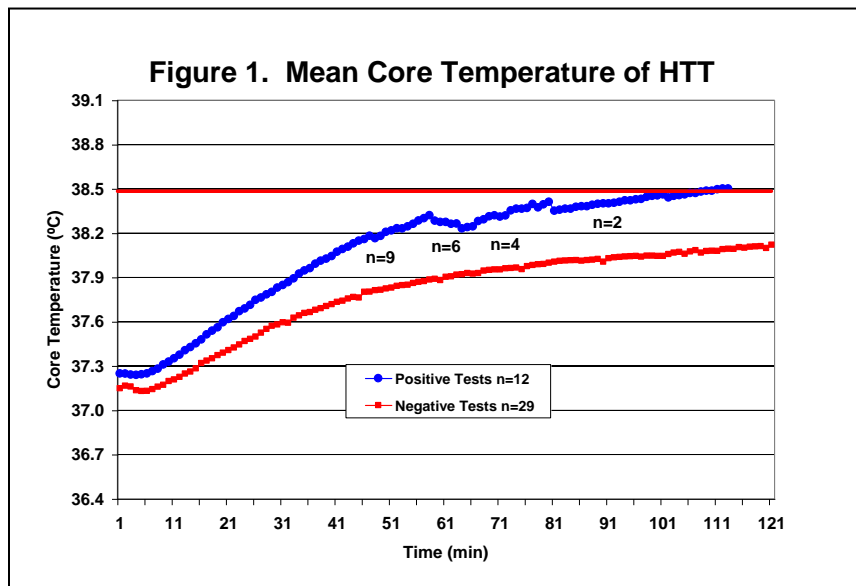
A total of 36 patients were referred for heat tolerance testing by their Command Clinicians. The HTT was typically performed 6-8 weeks post their heat injury once all blood chemistry values

had returned to normal levels and the patients were symptom free. During the recovery period the patients gradually progressed from performing light to moderate intensity exercise. The HTT protocol performed at NHRC consists of 2 hr of treadmill walking at 3.3 mph and 4% grade in an environment of 104°F ambient temperature and 40% relative humidity. Rectal temperature and heart rate and skin temperature at four locations (shoulder, chest, thigh and calf) were measured each minute. Patients were dressed in PT shorts and PT shoes were allowed to consume water ad lib during the HTT. Sweat rate was calculated from pre/post body weight changes corrected for fluid exchanges. Completing the 2-hr test with an ending core temperature < 38.5°C and a heart rate <150 was classified as a negative HTT indicating that the patient had an appropriate physiological response to the thermal and physical stresses of the HTT.

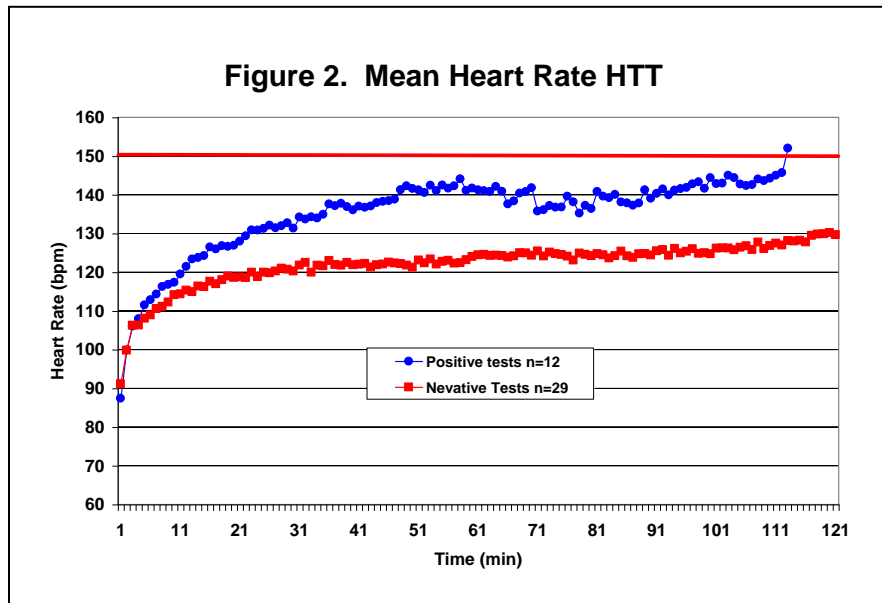
RESULTS

A total of 41 HTTs were conducted on 36 patients, with 5 patients performing a second test. The patients had the following physical characteristics (mean ± stdev): Age = 25 ± 3 yrs; Height = 177.8 ± 7.6 cm; Weight = 83 ± 17.4 kg. Of the 41 HTTs conducted, there were 29 negative trials with the patients completing the 2-hr thermal challenge ending with a final mean core temperature of 38.0 ± 0.5°C, heart rate of 128 ± 14, mean skin temperature of 36.6 ± 0.4°C, and a sweat rate of 1.27 ± .32 L/hr. In comparison there were 12 positive trials with most patients only able to complete 70-80 mins of the thermal challenge and had an final mean end of test core temperature of 38.5 ± 0.2°C, heart rate of 140 ± 19, mean skin temperature of 36.5 ± 0.6°C, and a sweat rate of 1.34 ± 0.39 L/hr.

Figure 1 displays the mean core temperature response for the negative (passing, n=29) and positive (failed, n=12) HTTs. The graph depicts a sharp rise in core temperature response for the patients unable to meet the thermal challenge of the HTT as half of the failure group individually reached the limit of 38.5°C approximately 50-60 minutes into the test. Conversely the core



temperature response for the patients passing the test demonstrated a slower rise in temperature with a gradual levelling off. This clearly demonstrates the ability of the patients who passed the HTT to effectively thermoregulate. The plateau of the core temperature curve reveals that the patients dissipated enough metabolic heat to stabilize their core temperature while in an environment that challenged their thermoregulatory system. Mean Heart rate response is displayed in Figure 2. Although there is clearly a 15-20 bpm difference between the patients who passed the HTT and those who failed, the mean heart rate response for both groups was below the failure threshold value (150 bpm). In almost all cases failed HTTs were due to the core temperature response elevating above the 38.5°C cut-off and not the heart rate response.



In the rare instances patients that failed the HTT protocol a few were recommended by their command to perform a second trial after allowing a longer recovery time interval. Figure 3 shows the initial positive HTT of one patient followed by second, successful, negative trial 26 months later. Upon experiencing the initial heat injury and the subsequent positive HTT, the patient was prevented from continuing participation in a specialized training program and sent back to standard work in the fleet. However after achieving a negative test result in the later trial the patient was permitted to resume the specialized training program.

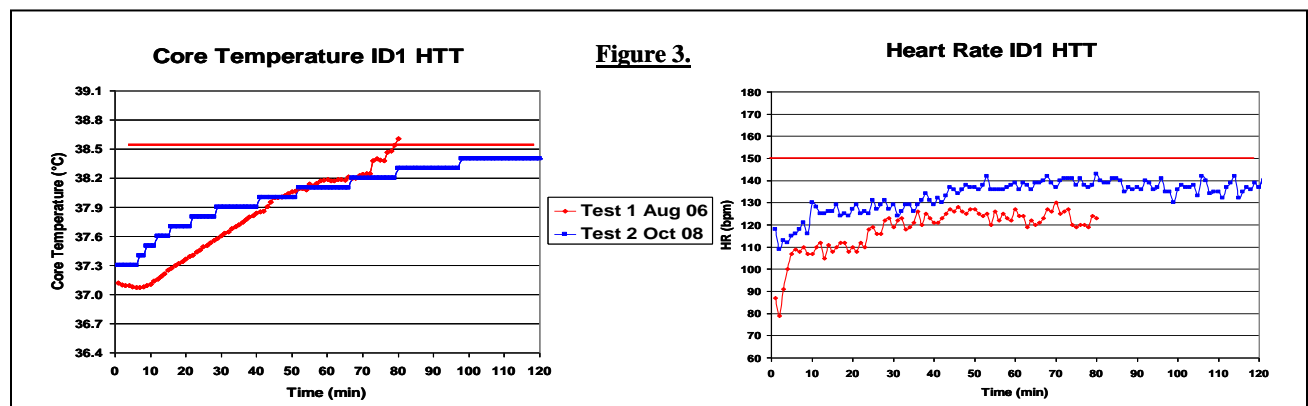
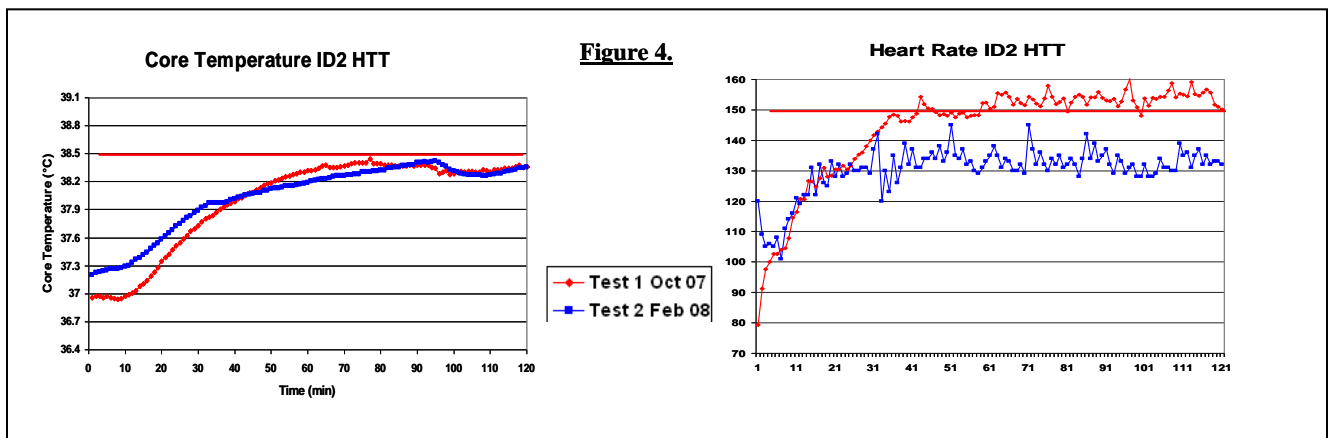
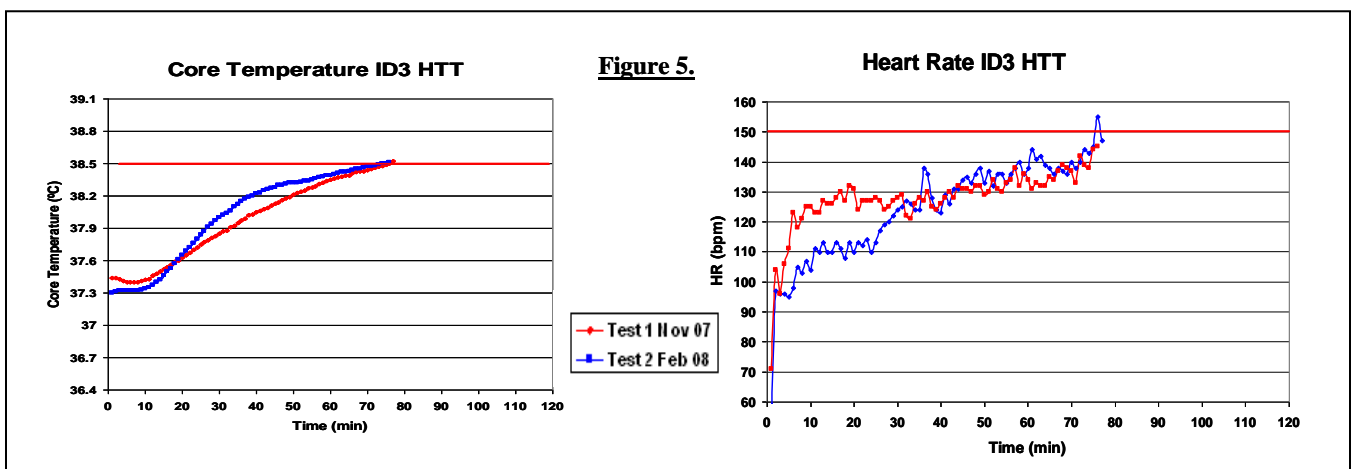


Figure 4 displays the only HTT failure based on heart rate. After this incidence of exertional heat stroke the patient was instructed to not exercise until the HTT evaluation had been performed. The elevated heart rate response to the physical demand may demonstrate the cardiovascular detraining effect of no aerobic training prior to performing the HTT. Core temperature response, though slightly higher than the mean for those passing the HTT, was under the cut-off limit in both trials. The patient was instructed to begin a regular exercise regime and the 20 bpm lower HR response in the second trial may be reflective of improved cardiovascular fitness.



Following a failed HTT a few patients were referred to perform a second HTT in hopes of re-entering a training program or potentially enrolling into a different program. A passed (negative) HTT was required to move forward for these patients. Figure 5 displays repeat HTT results for one patient conducted 3 months apart with an almost identical core temperature and heart rate response. Despite an additional 12 week recovery and a return to physical training during this recovery, the patient was unable meet the thermal challenge of the HTT.



The HTT outcomes for these patients, who were all classified as experiencing exertional heat stroke, demonstrate a variety of interesting responses. First, there appears to be a typical core temperature response for patients who have effectively recovered from their heat injury and clearly demonstrate an ability to dissipate both the metabolic heat created while exercising in the challenging environment of the HTT. Second, patients who fail the test typically have a sharp rise in core temperature indicating an inability to effectively dissipate the heat storage due to the HTT. Third, the recovery process from a heat injury varies. Among the 36 patients, 29 were able to pass their first attempt at the HTT 6 to 8 weeks after their heat illness, a few were only able to pass a repeat HTT several months to 2 years after their initial failed HTT, and a few patients have been unable to pass a second or in some cases a third HTT. Therefore, there is strong evidence that the HTT does have a level of sensitivity and can discriminate among patients who can effectively thermoregulate body temperature and those who cannot. All 29 patients who had a negative HTT were immediately returned to full active duty status and/or allowed to resume their specialized training. Although repeated heat exposure and multi-week acclimation protocols would provide more information and a better thermal profile the logistics, including, patient availability, chamber availability, support staff, and cost make that option less feasible. These results suggest that the use of a Heat Tolerance Test can provide valuable information to clinicians when evaluating the return to duty status of personnel who have experienced a heat injury.

REFERENCES

1. Scoville SL, Gardner JW, Potter RN. Traumatic deaths during U.S. Armed Forces basic training, 1977-2001. *Am J Prev Med.* 2004;26:194-204.
2. Armstrong LE, Lopez RM. Return to exercise training after heat exhaustion. *J Sport Rehabil.* 2007;16:182-189.
3. Epstein Y. Heat intolerance: predisposing factor or residual injury? *Med Sci Sport Exerc.* 1990;22:29-35.
4. O'Connor FG, Williams AD, Blivin S, Heled Y, Deuster P, Flinn SD. Guidelines for return to duty (play) after heat illness: a military perspective. *J Sport Rehabil.* 2007;16:227-237.
5. Moran DS, Heled Y, Still L, Laor A, Shapiro Y. Assessment of heat tolerance for post exertional heat stroke individuals. *Med Sci Minot.* 2007;10:CR1-6.
6. Medical Aspects of Harsh Environments. / Borden Institute. Specialty Editors, Pandolf, KB, Burr, RE.P. Textbooks of Military Medicine.