EXTREMITY COOLING REDUCES EXERTIONAL HEAT INJURY SEVERITY DURING MILITARY TRAINING

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ABSTRACT

A number of studies have reported the effects of extremity immersion in cool water for accelerating the rate of body cooling after an event or during rest intervals. We have developed an Arm Immersion Cooling System (AICS) as to means to provide cooling in a military training environment; however the effects of systematic application of the AICS on exertional heat injury (EHI) severity are unknown.

PURPOSE: The purpose of this retrospective study was to determine the efficacy of the AICS for reducing the severity of EHI in a military training environment.

METHODS: An Army training school has been using 25 AICS units since August 2010, during the initial high-intensity training phase of the course. Additionally, beginning in 2007 this training school has maintained a database of EHI casualties, which includes data on whether a suspected EHI casualty was transported to the hospital and if so, whether the casualty was hospitalized or not. A case was defined as an individual who was seen by a medic or physician assistant and diagnosed with any form of EHI. As the database only contains de-identified data, medical records were unavailable and hospitalization status was used as a proxy indicator of injury severity.

RESULTS: During the pre-AICS (control) study period, there were 87 EHI cases. Of those, 77 (89%) were evacuated to the hospital and 47 (54% of the total) were hospitalized. In contrast, during the post-AICS implementation (experimental) period, there were 46 EHI cases, 52% of whom were evacuated to the hospital; 15 of these cases (24% of the total) were hospitalized.

CONCLUSIONS: The reduction in hospitalized cases, from 52% to 24% of total EHI cases, strongly suggests a reduction in injury severity due to AICS implementation during military training.

INTRODUCTION

- Numerous commercial and industrial settings, including military operational and training exercises, expose individuals to hot environmental conditions and induce subsequent heat strain
- Extremity immersion in cool/cold water has been examined as an intervention to augment the rate of body core temperature (Tc) cooling during rest periods
- While the literature is generally in agreement that extremity immersion is effective for reducing Tc, data are lacking concerning the impact on cooling on exertional heat injury (EHI) incidence and severity

PURPOSE

The purpose of this retrospective epidemiological study was to quantify the incidence and severity of EHI before and after implementation of a prototype Arm Immersion Cooling System (AICS) during military training

METHODS

- Twenty-five AICS were provided to a military training school in August 2010. School cadre were given guidance regarding implementation during the initial 4-day phase of the course. AICS were made available to students at the conclusion of select high-intensity training exercises and during rest periods
- School classes during the summer months of 2007-09 and early 2010 served as the control (no AICS use) period
- Summer classes from August 2010 through September 2012 served as the experimental (AICS use) period
- EHI data maintained by the installation Operations office were provided after being stripped of individually-identifying information. The data file contained rank, date, training at time of incident and body core temperature data, as well as hospitalization status
- Class size data maintained by the Operations section of the school were provided to the investigators and were utilized to calculate EHI incidence.
- Weather data were downloaded from the National Climatic Data Center, using data from the weather station located at a local Army airfield. The maximum dry-bulb temperature (T_{db}) was obtained for every date that corresponded with the training dates of interest

DATA ANALYSIS

- EHI incidence and severity before and after AICS implementation were analyzed with the chi-square statistic and the rate-ratio was calculated
- Weather data were compared using an independent sample t-test
- For injury severity, ICD-9 diagnostic codes were not available; therefore hospitalization status was used as a proxy indicator of severity, assuming the following:
  - Casualties treated and released at the school aid station were the least severe (i.e. heat exhaustion)
  - Casualties evacuated to the base hospital likely had a more serious EHI
  - Casualties who were admitted had the most severe EHI (heat injury or heat stroke).
- In order to examine the interactive effects of AICS implementation and ambient temperature, logistic regression modeling was conducted

RESULTS

- Incidence was similar before and after implementation of the AICS, 1.24% vs 1.18%, p=0.78
- The maximum T_{db} was higher during the post-AICS implementation period, 31.8±3.4 vs 33.5±2.9°C, p<0.001

Table 1. EHI severity before and after implementation of AICS

	AICS implementation		
	Before	After	Rate Ratio (95% CI)
Did not suffer EHI (N)	6568	3884	n/a
All cases (N)	82	46	0.95 (0.66-1.36)
Treated and released at aid station (N)	10	21	3.55 (1.67-7.55)
Transported to hospital, not admitted (N)	45	16	0.60 (0.34-1.06)
Hospitalized (N)	27	9	0.56 (0.26-1.20)

Table 2. Logistic regression modeling predicted probability of EHI with or without AICS use.

	Mean Temperature	
AICS use	31.8±3.4°C	33.5±2.9°C
No	0.94%	1.70%
Yes	0.49%	0.88%

SUMMARY AND CONCLUSIONS

- Implementation of an AICS did not have an effect on overall EHI incidence
- However, our data support the conclusion that AICS implementation may contribute to reduced EHI severity, as indicated by hospitalization status
- Logistic regression modeling indicates that had the AICS not been available when ambient temperature was higher, EHI incidence may have increased, suggesting that despite the similar overall incidence, AICS implementation successfully contributed to mitigation of EHI risk.

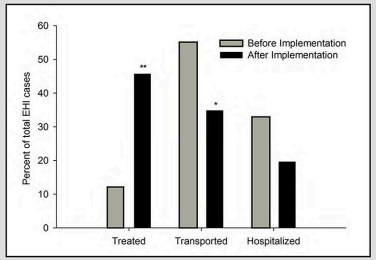

Figure 1. Injury severity before and after AICS implementation, expressed as a percentage of total EHI cases. Treated: casualty was treated and released at the schools aid station. Transported: casualty was transported to the base hospital for treatment but was not admitted. Hospitalized: casualty was admitted to the hospital for treatment. * p<0.05 vs before, ** p<0.01 vs before