Seasonal Trends for Environmental Illness Incidence in the U.S. Army

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ABSTRACT

Introduction:

The incidence of and risk factors for exertional heat illness (EHI) and cold weather injury (CWI) in the U.S. Army have been well documented. The "heat season", when the risk of EHI is highest and application of risk mitigation procedures is mandatory, has been arbitrarily defined as May 1 through September 30, while the "cold season" is understood to occur from October 1 to April 30 each year. The proportions of EHI and CWI that occur outside of the traditional heat and cold seasons are unknown. Additionally, it is unknown if either of the seasonal definitions are appropriate. The primary purpose of this study was to determine the proportion of EHI and of CWI that occur within the commonly accepted seasonal definitions. We also report the location-specific variability, seasonal definitions, and the demographic characteristics of the populations.

Methods:

The U.S. Army installations with the highest frequency of EHI and of CWI from 2008 to 2013 were identified and used for analysis. In total there were 15 installations included in the study, with five installations used for analysis in both the EHI and CWI projects. In- and out-patient EHI and CWI data (ICD-9-CM codes 992.0 to 992.9 and ICD codes 991.0 to 991.9, respectively) were obtained from the Defense Medical Surveillance System. Installation-specific denominator data were obtained from the Defense Manpower Data Center, and incidence rates were calculated by week, for each installation. Segmental (piecewise) regression analysis was used to determine the start and end of the heat and cold seasons.

Results:

Our analysis indicates that the heat season starts around April 22 and ends around September 9. The cold season starts on October 3 and ends on March 24. The majority ($n = 6{,}445$, 82.3%) of EHIs were diagnosed during the "heat season" of May 1 to September 30, while 10.3% occurred before the heat season started (January1 to April 30) and 7.3% occurred after the heat season ended (October 1 to December 31). Similar to EHI, 90.5% of all CWIs occurred within the traditionally defined cold season, while 5.7% occurred before and 3.8% occurred after the cold season. The locations with the greatest EHI frequency were Ft Bragg ($n = 2{,}129$), Ft Benning ($n = 1{,}560$), and Ft Jackson ($n = 1{,}538$). The bases with the largest proportion of CWI in this sample were Ft Bragg (17.8%), Ft Wainwright (17.2%), and Ft Jackson (12.7%). There were considerable inter-installation differences for the start and end dates of the respective seasons.

Conclusions:

The present study indicates that the traditional heat season definition should be revised to begin ~3 weeks earlier than the current date of May 1; our data indicate that the current cold season definition is appropriate. Inter-installation variability in the start of the cold season was much larger than that for the heat season. Exertional heat illnesses are a year-round problem, with ~17% of all cases occurring during non-summer months, when environmental heat strain and vigilance are lower. This suggests that EHI mitigation policies and procedures require greater year-round emphasis, particularly at certain locations.

INTRODUCTION

Environmental injuries such as exertional heat illnesses (EHIs) and cold weather injuries (CWIs) present a significant risk to service members.[1,2] Exertional heat illnesses signify a variety of conditions ranging in severity from minor heat cramps and heat exhaustion to more severe illnesses, including exertional heat stroke, which can have fatal repercussions. There is sufficient documentation of incidence, severity, risk factors, and treatment costs for EHI in military populations.[1,3,4] Naturally, there is a higher awareness of EHI risk during the summer months, due to a greater exposure to environmental heat stress. On the opposite end of the spectrum, CWIs typically occur during cool or cold environmental conditions when heat loss is greater than heat production. There are four primary categories of CWI: hypothermia, frostbite,

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nonfreezing cold injuries, and injuries related to cold exposure.[5] Similar to EHI, risk factors and prevention strategies for CWI have been documented for military populations.[2,5] Although the risk of CWI is higher during the winter months, CWI is not exclusive to cold weather exposure and can result from exposure to wet environments such as rainfall or water immersion, even in nonfreezing temperatures.[5,6]

Army cases of EHI and CWI create the potential for substantial lost duty time, increased medical care costs, and potential disqualification for continued service.[4,7] Furthermore, there were at least 37 heat stroke deaths from 1980 to 2002, while clusters of deaths caused by CWI have also occurred.[3,6] As a result of environmental factors, tactical gear, and/or intensity of work, both EHI and CWI have been reported to occur outside their designated "season", although the proportions that occur outside the bounds of their defined seasons are unknown. The "heat season" is often operationally described as May 1 to September 30 of each year. As a preparatory measure, Army units are typically mandated to oversee EHI prevention training by April 15 on an annual basis.[8,9] Conversely, CWI prevention training is required annually in preparation for the "cold season", which is understood to occur from October 1 to April 30 of each year.[8,9] Although the justification supporting these durations may be appropriate, there may be a distorted perception of when one might incur an EHI or CWI since they can occur outside of their defined "season". Although numerous Army installations are located in a humid subtropical climate (Ft Benning, GA, Ft Bragg, NC, Ft Jackson, SC, Ft Stewart, GA, Ft Gordon, GA, Ft Hood, TX, and Ft Campbell, KY), others are found in warm summer continental (Ft Drum, NY), subtropical desert (Ft Irwin, CA and Ft Bliss, TX), subtropical steppe (Ft Carson, CO), tropical savanna (Schofield Barracks, HI), and continental subarctic (Ft Richardson, AK and Ft Wainwright, AK) climates.[10] This geographic diversity suggests that heat and cold season definitions may be location-specific.

Therefore, this study's primary purpose was to examine the proportion of EHI and CWI that occur within the commonly accepted seasonal definitions. We also report the location-specific variability, seasonal definitions, and the demographic characteristics of the populations.

METHODS

This retrospective epidemiological study was reviewed and approved by the Public Health Review Board of the Army Public Health Center. The installations included for analyses were identified from the annual updates for heat illness[11] and for cold injuries,[12] published by the Armed Forces Health Surveillance Branch. The bases with the highest frequency of EHI included Ft Benning, GA, Ft Bragg, NC, Ft Campbell, KY, Ft Hood, TX, Ft Jackson, SC, Ft Leonard Wood, MO, Ft Polk, LA, Ft Riley, KS, Ft Sill, OK, and Ft Stewart, GA. In addition to Ft Benning, GA, Ft Bragg, NC, Ft Campbell, KY, Ft Jackson, SC, and Ft Riley, KS, Ft Carson, CO, Ft Drum, NY, Ft Lewis, WA, Ft Richardson, AK, and Ft Wainwright, AK were included for analysis of CWI patterns. Active duty service members' inpatient and outpatient demographic and medical encounter visit data across 10 installations from January 1, 2008, to December 31, 2012 (EHI), or July 1, 2008, to June 30, 2013 (CWI), were captured from the Defense Medical Surveillance System (DMSS). Cases with ICD-9 codes 992.0 through 992.9 were included in the EHI cohort, while ICD-9 codes 991.0 through 991.9 were used to identify eligible CWI cases. For both EHI and CWI, data provided by DMSS included date of diagnosis, age, sex, race/ethnicity, rank, unit identification code, and codes for primary and secondary diagnoses.

Installation demographics for all 15 locations were extracted from the Defense Manpower Data Center (DMDC) and broken down by month, sex, and rank (enlisted vs. officer).

Data Analysis

Most service members necessitate one or more follow-up encounters following an initial diagnosis. To differentiate between "new" and "follow-up" encounters, a subsequent visit within 60 days of the initial diagnosis was considered as a follow-up encounter and not included for analysis. Previous military heat injury surveillance studies parallel the criteria outlined in the present study.[5] In order to determine whether the EHI transpired before, during, or after the heat season (May 1 to September 30) or the cold season (October 1 to April 30), a coding variable specific to the date of diagnosis was constructed. Exertional heat illness and CWI frequency as well as percentage distribution were determined for age, sex, race, and unit location at the time of injury. Denominator data were used to calculate incidence rates for each installation, by week (week 1 = January 1-7, week 2 = January 8-14, etc.). As the denominator data were provided by month from the DMDC, injury data from each week and denominator data from the appropriate month were utilized to determine rates for each week. Due to large differences in the number of casualties, EHI incidence rates are expressed per 1,000 person-months, while CWI data are expressed per 10,000 person-months.

Once week-by-week incidence rates were determined for each location, segmental regression was used to determine the date at which trends in EHI and CWI incidence rates significantly increased or decreased, which were interpreted to represent the start and end of each heat and cold season.[13] Briefly, segmental regression identifies the intersection of two line segments formed when an abrupt breakpoint occurs between the dependent variable (the date) as a function of the independent variable (by-week incidence rate). The breakpoint is the intersection of the two lines with the smallest residual sum of squares.[13] This analysis was conducted for all locations combined and for each individual location. Statistical analysis was performed using Microsoft Excel and SigmaPlot Version 12.3.

TABLE I. Demographics of Soldiers Who Experienced an Exertional Heat Illness (EHI), 2008 to 2012 ($n = 6,838$) and Cold Weather Injury (CWI), 2008 to 2013 ($n = 823$)

Variable	Variable level	*n* EHI	EHI % injured	*n* CWI	CWI % injured
Sex	Male	5,388	78.8	614	74.6
	Female	1,450	21.2	209	25.4
Age (years)	<20*	1,674	24.5	0	0
	20–29	4,073	59.6	463	56.3
	30–39	895	13.1	263	32.0
	40+	196	2.9	97	11.8
Race/ethnicity	White	3,891	56.9	396	48.1
	Black	1,292	18.9	73	8.9
	Asian/Pacific Islander	271	4.0	28	3.4
	American Indian/Alaskan Native			4	0.5
	Other			6	0.7
	Unknown	789	11.5	12	1.5
Rank	E1–E4	5,295	77.4	537	65.2
	E5–E9	1,005	14.7	197	23.9
	O1–O5	517	7.6	83	10.1
	O6–O10	2	0.0	2	0.2
	W1–W5	22	0.3	4	0.5

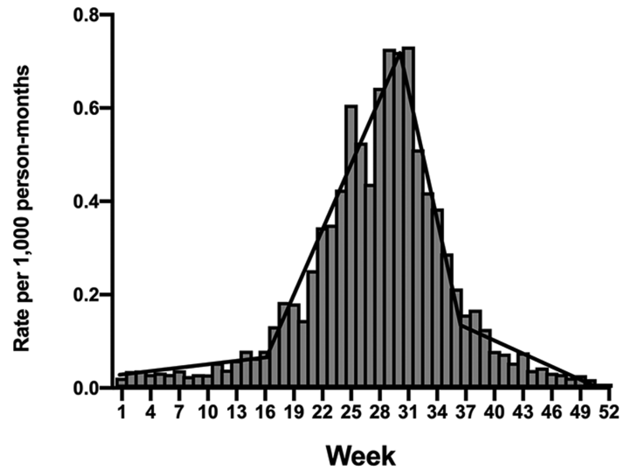

FIGURE 1. Exertional heat illness incidence rate (vertical bars), by week. Solid lines show the results of segmental regression analysis. Break points at weeks 17 and 37 indicate the start and end of the heat season.

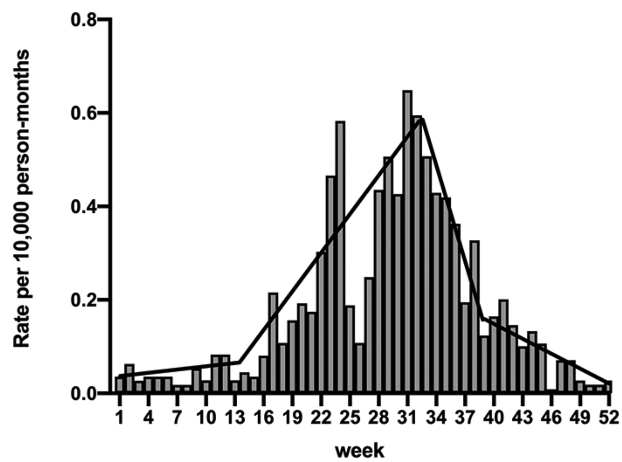

FIGURE 2. Cold weather injury incidence rate (vertical bars), by week. Solid lines show the results of segmental regression analysis. Break points at weeks 40 and 13 indicate the start and end of the cold season. Note that the cold year was considered as 1 July through 30 June.

RESULTS

With a total number of 7,827 qualifying EHI events, 6,838 service members experienced a new EHI at the 10 installations between 2008 and 2012. There were 5,388 men and 1,450 women who were EHI casualties during the study period. There were 1,044 incident CWI cases during the study period, which is almost an order of magnitude lower than the number of EHI casualties. Complete demographic characteristics of the respective EHI and CWI populations are shown in Table I.

Segmental regression analyses to identify the start and end of the overall heat and cold seasons are shown in Figures 1 and 2, respectively. Our analysis indicates that the heat season starts around April 22 and ends around September 9 (weeks 17 and 37), respectively. The cold season starts around October 3 and ends around March 24 (weeks 40 and 13).

Overall and location-specified frequency and incidence rates and EHI/CWI start and end dates are shown in Table II. Two-thirds of all EHI in this sample occurred at Ft Bragg (27.2%), Ft Benning (19.9%), and Ft Jackson (19.6%). No additional base accounted for more than 10% of the total. The installations with the greatest proportion of CWI in this sample were Ft Bragg (17.8%), Ft Wainwright (17.2%), and Ft Jackson (12.7%). The installations with the least amount of CWI in this sample were Ft Richardson (6.8%), Ft Riley (6.2%), and Ft Drum (3.7%).

The majority ($n = 6,445$, 82.3%) of EHIs were diagnosed during the "heat season" of May 1 to September 30, while 10.3% occurred before the heat season started (January 1 to April 30), and 7.3% occurred after the heat season ended (October 1 to December 31). Six hundred and twenty-nine soldiers had two or more "new" EHIs during the study period.

Overall, the highest rate of CWI occurred during the month of February ($n = 221$, 2.16 per 10,000 person-months), and the largest number of injuries occurred during the weeks between January 27 and February 2 (week 31, $n = 73$, 7.2%). Cold weather injuries occurred the least frequently during the month of June ($n = 16$, 0.15 per 10,000 person-months). Similar to EHI, 90.5% of all CWIs occurred within the traditionally defined cold season, while 5.7% occurred before and 3.8% occurred after the cold season. There were a total of 137 soldiers with two or more "new" CWIs during the investigation period. The most common primary injury diagnosis of soldiers with repeat CWI was frostbite of foot (19.0%, ICD-9

TABLE II. Start and End of Heat and Cold Seasons, by Installation

	EHI				CWI			
Installation	Start	End	*n*	Rate[a]	Start	End	*n*	Rate[b]
Ft Leonard Wood, MO	6 May	2 September	270	0.45				
Ft Polk, LA	22 April	9 September	307	0.70				
Ft Hood, TX	1 April	23 September	485	0.23				
Ft Sill, OK	6 May	16 September	362	0.54				
Ft Stewart, GA	8 April	7 October	332	0.41				
Ft Benning, GA	15 April	23 September	1,560	1.34	30 September	24 March	91	0.60
Ft Bragg, NC	6 May	12 August	2,129	0.91	13 October	31 March	186	0.63
Ft Campbell, KY	22 April	2 September	619	0.45	22 September	7 April	86	0.44
Ft Jackson, SC	15 April	2 September	1,538	2.55	1 October	7 April	133	2.21
Ft Riley, KS	6 May	23 September	225	0.29	7 October	25 February	65	0.60
Ft Drum, NY					23 December	25 May	39	0.35
Ft Lewis, WA					3 October	22 April	78	0.40
Ft Richardson, AK					10 October	7 March	71	1.58
Ft Carson, CO					11 November	7 March	115	0.80
Ft Wainwright, AK					20 September	22 May	180	5.40
EHI overall	22 April	9 September	7,827	0.71				
CWI overall					3 October	24 March	1,044	0.79

[a]Incidence rate per 1,000 person-months.
[b]Incidence rate per 10,000 person-months.
Abbreviations: CWI, cold weather injury; EHI, exertional heat illness; *n*, number of cases.

991.2) and frostbite of other and unspecified sites (18.0%, ICD-9 991.3).

DISCUSSION

The purpose of the present study was to determine the within-season trends for EHI and CWI at U.S. Army installations that historically have the greatest frequency of EHI and CWI. The "heat season" has been arbitrarily defined as occurring from May 1 to September 30, while the "cold season" has been defined as occurring from July 1 to June 30.[8,9] During these times, the incidence of EHI and CWI is expected to be highest. The primary finding of this study is that 82.3% of EHI and 90.5% of CWI occur within the bounds of the traditionally defined heat and cold seasons. However, we found that there was significant between-location variability in the start and end dates of the respective seasons, suggesting that certain locations should modify their mitigation policies and procedures accordingly. The year-round distribution of EHI indicates that while it is appropriate to emphasize prevention and mitigation efforts during the summer months, first responders and soldiers at all levels need to be cognizant that casualties can occur at any time within the calendar year, regardless of ambient environmental conditions. A recent study[4] reported direct care costs of $7.3 million over a 3-year period for heat casualties; treatment costs for CWI have not been reported in the literature. Deaths due to EHI are known to occur, as have those due to CWI, though in relatively lower numbers.[3,6] Given the possible severity, direct treatment costs and lost duty time, leaders are encouraged to provide targeted educational efforts for prevention and treatment, to include awareness that such illness/injury are possible year-round.

The present study indicates that 82.3% of EHIs and 90.5% of CWIs occurred within the traditional respective season definition. However, piecewise regression analysis suggests that the heat season should start and end ∼3 weeks earlier. Significant between-installation variability was present (Table II) with the heat season starting as early as April 1 at Ft Hood, TX and as late as May 6 in multiple locations. Similarly, for CWI, the cold season started as early as September 30 at Ft Wainwright, AK and as late as December 23 at Ft Drum, NY. Between-location variability likely reflects not only climate differences but numerous activity and population differences as well. Ft Benning, Ft Jackson, Ft Sill, and Ft Leonard Wood fall under the Army Training and Doctrine Command, with units that conduct initial entry training. The remaining 11 installations fall under Forces Command and host operational units. However, this dichotomization is not entirely accurate, as, for example, Ft Benning is a major basic training site, but tenant units include operational units such as the 75th Ranger Regiment, Third Ranger Battalion, and First Security Forces Assistance Brigade. This by-location population heterogeneity and subsequent variability of known risk factors such as age, training status, and length of service[11,12] caution us against further speculation. The result of installation-specific mitigation policies and procedures on the between-location variability is unknown. Although similar instruction is provided across the Army, it is unknown how consistently or effectively these guidelines are enforced.[9,14]

Before the present study, there were limited data supporting or refuting the arbitrary heat season definition. A recent study from the Armed Forces Health Surveillance Branch analyzed EHI trends during enlisted initial entry training at four Army installations.[15] Similar to our data, they reported year-round incidence at some locations. However, that study did not explore seasonal definitions and only considered four basic combat training installations, compared to our larger sample that included a mix of initial entry training and operational forces locations, based on the historical frequency of environmental illness. A further limitation of that study was that EHI casualties that occurred during One Station Unit Training, Advanced Individual Training, and basic officer leadership courses were excluded from the analysis. We are not aware of any previous studies examining the within-year distribution of CWI.

Although the occurrence of EHI during the winter months is not surprising, CWI incident cases during the summer months are difficult to explain. Frostbite, which represents approximately half of all CWIs in this study (data not shown), requires sub-freezing temperature or prolonged contact with a sub-freezing surface in order to occur. Hypothermia, on the other hand, may occur in nonfreezing ambient temperature, if the individual is wet, due to precipitation or water immersion, for prolonged periods of time. However, a diagnosis of hypothermia appeared in only ∼10% of the cases. Location data were determined from unit identification code information, not the location of the treating medical facility, and especially for CWI casualties from Forces Command installations, it is plausible that the service member may have been participating in a training exercise at another location, where environmental conditions that are more favorable for developing a CWI were present, when the injury occurred. Additionally, it is important to point out that only 54 CWIs occurred during the months of June to August and that these casualties were spread out over a 5-year period and 10 installations, or an average of one summer CWI per installation per year.

The presence of EHI casualties during colder months is more easily explained than CWI during warmer months. Elevated body core temperature is a characteristic of all EHIs, regardless of specific diagnoses, although attaining a threshold temperature is not necessary or recommended for diagnosis.[16] During cool or temperate conditions, given a combination of clothing factors that restrict heat dissipation and a high rate of metabolic heat production (due to exercise intensity and/or load carriage requirements), heat illness, in particular heat stroke, may occur without exposure to high environmental temperatures.[16] In the presence of other risk factors, it is easy to understand why EHI may occur in environmental conditions that are cooler, and such events are not typically expected.

The presence or absence of heat acclimatization and the initial days of heat exposure are risk factors for EHI.[9,11,16] Leaders should be aware of the risk of EHI posed to individual service members or whole units coming from a comparatively cooler environment to train or operate in a hotter environmental or when the local ambient temperature increases suddenly as during a "heat wave". Such circumstances warrant re-evaluation of the EHI risk posed by unit or individual activities.

Installations and individual units should consider specific actions to take at the start of the hot and cold seasons defined in this study, such as those suggested in TB MED 507 and Training and Doctrine Command Regulation 350-29[9,14]. For example, appropriate hot weather and cold weather protective items (clothing, shelter, and sunscreen) should be available. Medical support and evacuation plans should be reviewed and tested as conditions warrant, and "man down" practice response drills should be conducted. When ambient temperature is 75°F or higher, a policy for hourly measurement of wet bulb globe temperature is recommended. Leaders should also plan for alternate activities, locations, and/or time of day to partially mitigate the effects of extreme heat or cold stress.

Segmental regression analysis was conducted in order to determine the start and end of the heat and cold seasons at each installation and overall. This approach was first utilized in an effort to standardize the detection of thermoregulatory sweating during exercise heat stress.[13] By employing a mathematical approach that could easily be replicated by others, rather than relying on subjective, visual inspection of the data plot, inter- and intra-individual variabilities are reduced. Although this analytical approach was originally applied to a physiological response, we believe that applying it to incidence rate data is valid, as the objective of determining the breakpoint was similar.

CONCLUSIONS

The present study indicates that the traditional heat season definition should be revised to begin ∼3 weeks earlier than the current date of May 1; our data indicate that the current cold season definition is appropriate. Inter-installation variability at the start of the cold season was much larger than that for the heat season. This imprecision may be a result of the much lower frequency and incidence of CWI vs. EHI. Approximately one out of every six EHIs occurs beyond the confines of the heat season, vs. one out of every 10 CWIs, indicating that year-round awareness of the possibility of EHI is necessary. Rapid, aggressive cooling of a suspected heat stroke casualty is the cornerstone of the initial response.[16] By raising awareness that EHI can occur outside the heat season, units can better prepare by ensuring the availability of iced sheets or cold water immersion tubs and that unit personnel are appropriately trained in prevention and treatment policies and procedures. Cause of injury codes should be utilized in future studies, particularly to help explain the incident cases of CWI that occur during warm weather months. Other installations, other than those included in the present study, should also be included in future research.

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CONFLICT OF INTEREST STATEMENT

There are no conflicts from any of the authors in this article.

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