MSMR

MEDICAL SURVEILLANCE MONTHLY REPORT

April 2022 | Vol. 29 | No. 4

IN THIS ISSUE:

A PUBLICATION OF THE ARMED FORCES HEALTH SURVEILLANCE DIVISION

www.health.mil/MSMR

Exertional Heat Illness at Fort Benning, GA: Unique Insights from the Army Heat Center

David W. DeGroot, PhD (LTC, MS, USA); Kaemmer Henderson, MS; Francis G. O'Connor, MD, MPH (COL (ret), MC, USA)

The Army Heat Center at Fort Benning, GA was established to identify and disseminate best practices for the prevention, field care, evacuation, hospital care, and return to duty of exertional heat casualties. During the 2017–2021 surveillance period, there were 1,911 heat casualties treated at Ft. Benning's Martin Army Community Hospital. Most patients were junior enlisted and officer personnel who were engaged in initial entry training. Heat exhaustion, heat injury, heat stroke, and hyponatremia accounted for 52.6%, 18.4%, 18.2%, and 2.0% of total heat illnesses, respectively. The annual proportion of heat casualties that were due to heat exhaustion rose steadily during the surveillance period, reaching 77.7% in 2021, while the incidence of heat injury and heat stroke did not increase during this period. Data are presented on the occurrence of clusters of heat illness, the association of cases of heat stroke with arduous physical activities, and the seasonal variation in incidence of heat illnesses. It is important that unit leaders and trainers understand the risk factors for heat illness among those being trained and that early first aid measures be employed in the field (especially rapid cooling).

WHAT ARE THE NEW FINDINGS?

During the 5-year surveillance period, the emphasis on surveillance and prevention of heat illnesses at Ft. Benning has been associated with a reduction in the numbers of cases of the more severe types of heat illness (heat stroke and heat injury) and a simultaneous increase in the numbers of cases of heat exhaustion, a milder form of heat illness.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

The added emphasis on surveillance and prevention of heat illness among service members whose duties involve strenuous physical exertion in a warm or hot environment can reduce the incidence and severity of heat illnesses in that population. Successful application of these force protection measures can contribute to the physical readiness of service members in both training and operational settings.

Exertional heat illness (hereafter referred to as heat illness) spans a spectrum from relatively mild conditions such as heat cramps and heat exhaustion, to more serious and potentially life-threatening conditions such as heat injury and exertional heat stroke (hereafter heat stroke).[1,2] As detailed elsewhere in this and in previous issues of the *Medical Surveillance Monthly Report* (*MSMR*), after peaking in 2018, the annual incidence rates for heat exhaustion and exertional heat stroke have declined in each of the subsequent years.[3–5] These reports demonstrate that Fort Benning typically has the highest frequency of heat illnesses across the entire Department of Defense. Numerous risk factors for heat illnesses have been identified, including, but not limited to, environmental conditions, acclimatization status, aerobic fitness, body composition, age, sex, medication usage, tobacco use, mild illness, and individual effort/motivation.[6–10] Knowledge of these and other risk factors, however, has done little to significantly reduce the incidence rate of heat illnesses during military training.

The Army Heat Center at Fort Benning was initially established as an ad hoc effort by Benning Martin Army Community Hospital (BMACH) clinicians in 2016, after the death of a trainee due to hyponatremia.[11,12] In 2019, a sustainable approach to managing heat illnesses was established with the assignment of a research physiologist as Heat Center Director and funding for several support personnel. The mission of the Heat Center is to identify and disseminate best practices for the prevention, field care, evacuation, hospital care, and return to duty of exertional heat illness casualties. The Army Heat Center team aims to break the "tragedy loop." This term refers to a cycle that begins with a tragic heat illness death that prompts a renewed focus on prevention, resulting in a short period of improvement in heat illness incidence. However, this reduction in incidence is followed by a subsequent heat illness death because of the reassignment of training personnel whose institutional memory of previous deaths is lost.[12]

A cornerstone of the Heat Center's program is a detailed, accurate accounting of each heat illness casualty treated at BMACH, following the public health approach to injury prevention.[13] In order to ensure complete and accurate data, each heat illness casualty is interviewed during a routine follow-up encounter with the BMACH Heat Center's health care provider. These data are stored in the Exertional Heat Illness Repository, an IRB-approved data repository containing information on every heat illness casualty since 2017, with ongoing efforts to add earlier casualties. In addition to facilitating accurate diagnostic classification and reporting, the Heat Center team issues the initial limited duty profile, which guides the return to duty decision-making process. The purpose of the present study was to examine the characteristics of heat illnesses at Fort Benning, GA from 2017–2021 using data from the BMACH Heat Illness Repository, with special emphasis on annual trends, clusters of casualties, the type of activity being engaged in when heat illnesses occurred, and illness severity.

METHODS

Data were obtained from the BMACH Exertional Heat Illness Repository (EIRB protocol #20-09914). The BMACH Human Protections Director reviewed the proposal specific to this project and determined that IRB review was not required for this retrospective review of existing, deidentified data. All heat casualties treated at BMACH from Jan 2017 through December 2021 were included in the analysis. Data elements extracted from the repository protocol included each casualty's age, sex, unit of assignment, activity associated with the heat illness (e.g., foot march, run, physical readiness training), peak core temperature, diagnosis, mode of evacuation to BMACH, and dates of hospital admission and discharge. The diagnostic criteria used for heat exhaustion, heat injury, and exertional heat stroke are detailed in TB MED 507 Heat Stress Control and Heat Casualty Management.[14] Minor heat-related illnesses (HRI) include diagnoses such as dehydration, heat syncope, and heat cramps. As of 2021, soldiers diagnosed with minor HRI were no longer directed for follow-up care at the Heat Clinic, therefore there are no reports of HRI in 2021. ICD-10 diagnosis codes for "other effects of heat and light" (ICD-10: T67.8) only appear in 2017 and likely represent improper coding of casualties, as the diagnostic criteria for this condition are ill-defined.

Clustering of cases was also assessed in this report. A cluster of heat illness casualties was defined as 4 or more on a given day. Once clusters were identified, the count by specific diagnosis and by unit (to the company-level) was determined. Denominator (unit size) data were not available for the calculation of incidence rates in this analysis.

Heat illness severity can be evaluated using several metrics. For this report, core (rectal) temperature (T_c) and the average and maximum length of hospitalization were examined. Core temperature (T_c) is measured via rectal thermistor by Emergency Medical Services (EMS) personnel upon arrival at the scene of a reported heat illness casualty.

RESULTS

From 2017 through 2021, there were 1,911 total heat casualties treated at BMACH **(Table 1)**. There were 1,703 men and 208 women in the cohort, which consisted primarily of junior enlisted (E1–E4; n=1,262) and company-grade-officer (O1–O3; n=288) soldiers. Similarly, the cohort consisted primarily of younger service members with a mean age of 22.3 years (SD=4.9 years); there were 7 heat illness casualties aged 40 or older, all of whom were cadre members as opposed to trainees **(data not shown)**.

More than half (52.6%) of heat illness casualties documented during the 5-year period were heat exhaustion (n=1,007) **(Table 1, Figure 1)**. Counts and relative proportions of heat exhaustion increased each year during the period; in 2021, heat exhaustion accounted for more than three-quarters (77.7%) of the total number of heat illness casualties. Heat injury, heat stroke, and hyponatremia accounted for 18.4%, 18.2%, and 2.0%, respectively, of total heat illnesses. There were 349 heat stroke casualties during the period. After peaking in 2018 (n=95) and 2019 (n=96), the number of heat stroke casualties was 46% lower in 2020 (n=52) and 2021 (n=51) **(Table 1)**. Counts of heat injury casualties also decreased during the period; the number of hyponatremia cases remained relatively low throughout the period. Minor HRI casualties were reported from 2017 through 2020. No minor HRI casualties were recorded in 2021.

There were 178 days in which 4 or more heat illness casualties were reported. Clusters of 10 or more heat illness casualties occurred on 19 days during the surveillance period **(Figure 2)**. The largest cluster consisted of 20 casualties, from 7 different companies **(data not shown)**. The 19 clusters included 243 total heat illness casualties; among these, 32 (13.1%) were diagnosed with heat stroke **(Figure 2)**. On days with multiple heat stroke casualties, casualties occurred across several training companies, such that there was only a single instance of 3 heat stroke casualties within a given company during the 5-year surveillance period **(data not shown)**. Heat illness clusters occurred during the hottest months of each year, July through September.

Local Fort Benning policy states that EMS is the only authorized mode of

TABLE 1. Frequency of heat casualties, by diagnosis and year, Benning Martin Army Community Hospital, Fort Benning, GA, 2017–2021

Diagnosis	2017	2018	2019[a]	2020	2021	Total
Heat exhaustion	130	159	185	248	285	1,007
Heat injury	58	51	192	26	25	352
Heat stroke	55	95	96	52	51	349
Hyponatremia	13	9	2	8	6	38
Minor HRI[b]	36	28	37	33	—	134
Other heat effects[c]	29	—	—	—	—	29
Total	321	344[c]	512	367	367	1,911[d]

[a] The Army Heat Center formally started in July 2019; data prior to that date were collected as part of an ad hoc effort by Benning Martin Army Community Hospital staff

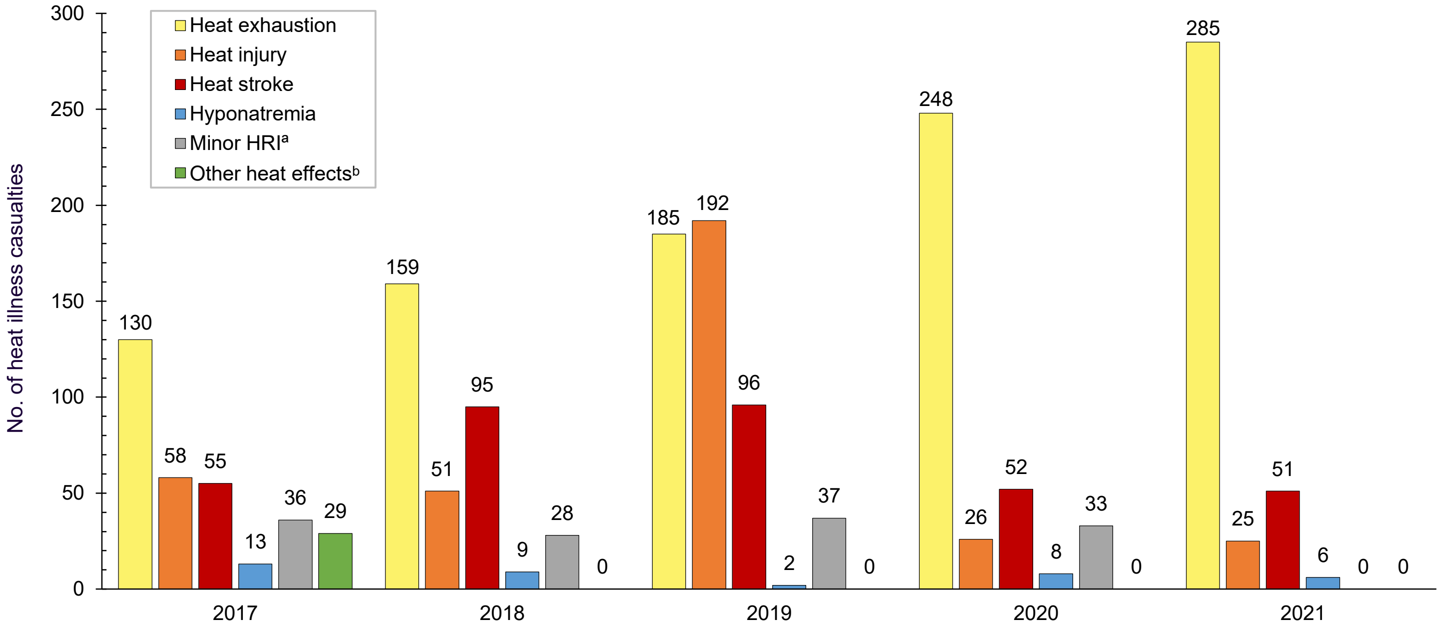
[b] Minor HRI includes diagnoses such as dehydration, heat syncope, and heat cramps. Soldiers diagnosed with minor HRI were no longer directed for follow-up care at the Heat Clinic in 2021.

[c] Diagnoses of "other effects of heat and light" only appear in 2017 and likely represents improper coding of casualties.

[d] Diagnosis field was blank for 2 heat illness casualties.

HRI, heat-related illness.

FIGURE 1. Frequency of heat illness casualties, by diagnosis and year, Benning Martin Army Community Hospital, Fort Benning, GA, 2017–2021

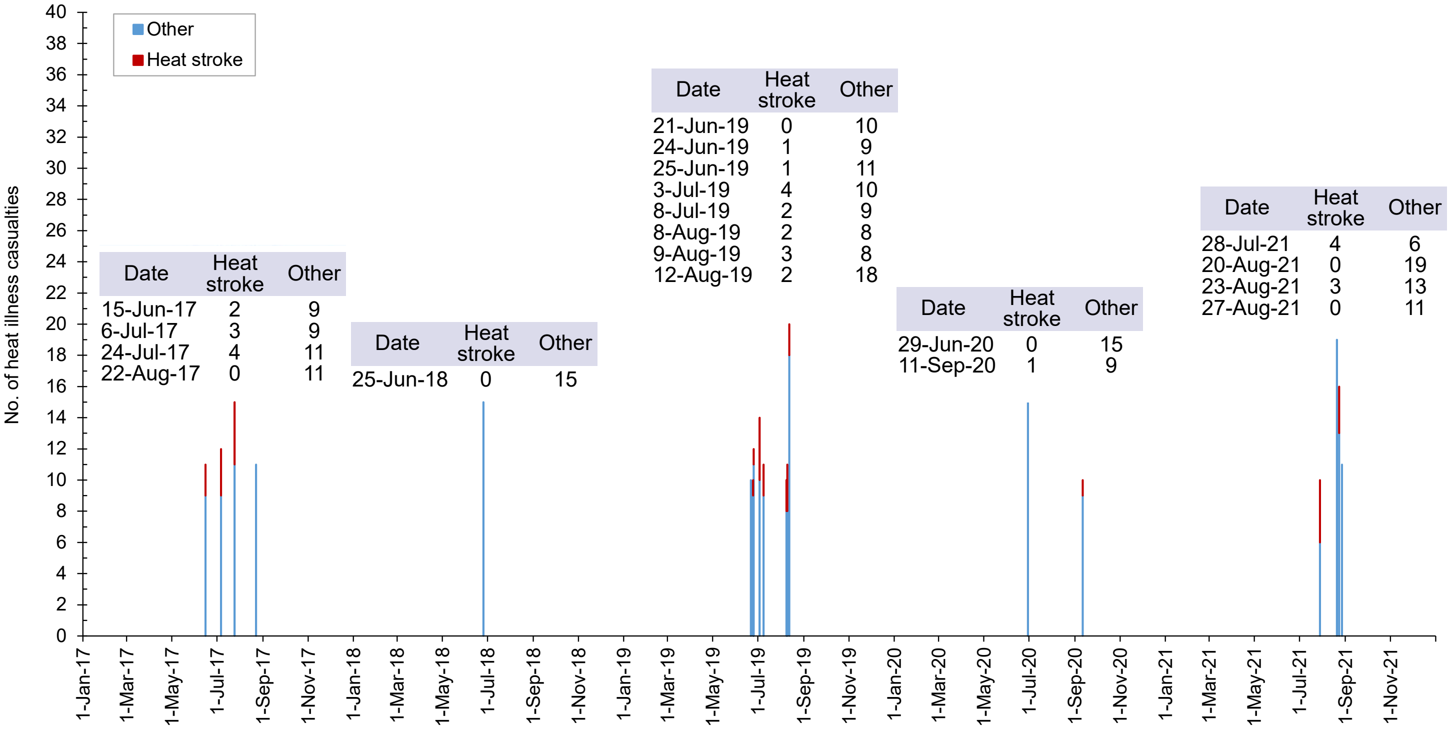


[a]Minor HRI includes diagnoses such as dehydration, heat syncope, and heat cramps. Soldiers diagnosed with minor HRI were no longer directed for follow-up care at the Heat Clinic in 2021.

[b]Diagnoses of "other effects of heat and light" only appear in 2017 and likely represents improper coding of casualties.

No., number; HRI, heat-related illnesses.

FIGURE 2. Heat illness clusters with 10 or more heat illness casualties on a given day (n=19), Benning Martin Army Community Hospital, Fort Benning, GA, 2017–2021



Date	Heat stroke	Other
15-Jun-17	2	9
6-Jul-17	3	9
24-Jul-17	4	11
22-Aug-17	0	11

Date	Heat stroke	Other
25-Jun-18	0	15

Date	Heat stroke	Other
21-Jun-19	0	10
24-Jun-19	1	9
25-Jun-19	1	11
3-Jul-19	4	10
8-Jul-19	2	9
8-Aug-19	2	8
9-Aug-19	3	8
12-Aug-19	2	18

Date	Heat stroke	Other
29-Jun-20	0	15
11-Sep-20	1	9

Date	Heat stroke	Other
28-Jul-21	4	6
20-Aug-21	0	19
23-Aug-21	3	13
27-Aug-21	0	11

No., number.

evacuation to BMACH; in 2017, this metric was rarely noted in the Heat Illness Repository. From 2018 through 2020, 87.3%–88.6% of all suspected heat casualties were transported via EMS. In 2021, this proportion increased to 95.4%.

Frequency of heat illness casualties by diagnosis and type of activity showed that foot marches and running events accounted for more than four-fifths (81.7%) of all heat stroke casualties **(Table 2)**. Specifically, marches with loads and runs greater than 4 miles accounted for about two-thirds (65.9%) of all heat stroke casualties. Field training/exercises, which includes a wide range of activities that do not fit into any of the other categories examined, was a predominant activity type for heat exhaustion, heat injury, and hyponatremia casualties.

Seventy-five percent (75.2%; 1,437/1,911) of all heat illness casualties were treated and released the same day (i.e., not hospitalized) while 93.3% (940/1,007) of heat exhaustion casualties were treated and released the same day **(Table 3)**. Of the heat illness casualties who were hospitalized, 83.8% had hospitalizations lasting 2 days or less **(Table 3)**. Compared to other diagnoses, heat stroke accounted for the most hospitalizations (52.7%; n=250); however, most hospitalized heat stroke casualties (90.8%; n=227) had lengths of stay of 3 days or less. Twenty-three of the hospitalized heat stroke casualties had lengths of stay of 4 or more days and 6 had hospital stays longer than 1 week (the longest hospitalization lasted 2 weeks). During the study period, there was 1 fatality due to heat stroke.

Core temperature data were missing for 12.7% (n=242) of total heat illness casualties. In 2017, 22% of all casualties had T_c >40 °C (104.0 °F); however, by 2021 only 10% reported a T_c>40 °C (104.0 °F) **(data not shown)**. Additionally, in 2017, 13 cases were profoundly hyperthermic, (T_c>42.0 °C [107.6 °F]) but no casualties exceeded this threshold in 2021.

TABLE 2. Frequency of heat illness casualties, by diagnosis and event, Benning Martin Army Community Hospital, Fort Benning, GA, 2017–2021

Event	Heat exhaustion	Heat injury	Heat stroke	Hyponatremia	Minor HRI	Other heat effects	Missing	Total
March (with load)	212	93	115	13	24	8	2	467
Field training/exercises[a]	288	79	30	16	29	5	.	447
Run (≤4 miles)	89	32	37	.	15	4	.	177
Run (>4 miles)	60	38	115	.	6	.	.	219
Miscellaneous/unspecified	99	23	9	3	18	5	.	157
PT/PRT	89	19	10	1	11	.	.	130
Land navigation	68	27	9	4	13	1	.	122
March (no load)	41	14	10	.	3	3	.	71
Run (uspecified distance)	31	13	8	.	7	2	.	61
Formation	15	7	2	1	4	.	.	29
APFT	9	3	3	.	3	.	.	18
Training (indoor)	6	4	1	.	1	1	.	13
Total	1,007	352	349	38	134	29	3	1,911

[a] Field training/exercises includes events such as obstactle courses, weapons ranges, and Airborne School training events.

HRI, heat-related illness; APFT, Army Physical Fitness Test; PT, physical training; PRT, physical readiness training.

TABLE 3. Frequency of lengths of hospitalization, by primary diagnosis, Benning Martin Army Community Hospital, Fort Benning, GA, 2017–2021

	Length of stay (days)										
	1		2		3		4		≥5		
Diagnosis	No.	%	No.	%	No.	%	No.	%	No.	%	Total
Heat exhaustion	48	71.6	11	16.4	5	7.5	3	4.5	—	—	67
Heat injury	70	64.8	30	27.8	5	4.6	2	1.9	1	0.9	108
Heat stroke	115	46.0	80	32.0	32	12.8	8	3.2	15	6.0	250
Hyponatremia	20	74.1	4	14.8	3	11.1	—	—	—	—	27
Minor HRI	13	59.1	6	27.3	2	9.1	—	—	1	4.5	22
Total	266	56.1	131	27.6	47	9.9	13	2.7	17	3.6	474

HRI, heat-related illness.

EDITORIAL COMMENT

There were several novel findings from this study. The severity of heat illness, specifically the number of heat stroke casualties, was the lowest since the formal creation of the Army Heat Center in July 2019. Clusters of heat illness casualties were infrequent, occurred during the hottest months of the year, and the predominant diagnosis during clusters was heat exhaustion. Clusters did not occur at the company level, but across battalions. Results indicated that clusters were generally due to weather conditions rather than to specific actions or inactions of individual units or companies. Furthermore, there were no clusters of heat stroke casualties during the surveillance period. Foot march and run events, particularly foot marches with load and runs of greater than 4 miles, were identified as events most frequently associated with heat stroke casualties. Finally, heat stroke casualties accounted for the most hospitalizations compared to other heat illnesses; however, most hospitalizations for heat stroke (78%) lasted no more than 1 to 2 days.

Because heat stroke casualties are at greatest risk of potential severe damage and mortality, each occurrence should be investigated. Despite the decrease in heat stroke counts during the study period, 1 death occurred and 4 heat stroke casualties were reported to have hospitalization lengths of stay greater than 9 days (likely due to prolonged end-organ damage, such as acute kidney injury, acute liver injury or exertional rhabdomyolysis). A significant proportion (81.7%) of heat stroke casualties occurred during run or foot march events. Local Fort Benning policy does not include these events in what are considered "high risk" activities for illness or injury, and therefore onsite medical coverage is not required for these events.

Given the potentially fatal nature of heat stroke and the requirement for rapid, aggressive cooling, the lack of medical coverage during run and foot march events is concerning.[15–17] Results suggest that revision of local Fort Benning policy to categorize foot march and run events as high risk (particularly marches with load and run events greater than 4 miles) may be warranted. The presence of 68W combat medics during these events would augment the cadre's ability to observe for and react to a suspected heat casualty, as well as improve response time and treatment. Non-medical personnel at Fort Benning are not permitted to obtain core temperature and rectal temperature is the only authorized method for assessing a suspected heat casualty. Additionally, cold water immersion is the gold standard for treatment of a heat stroke casualty; however, this method requires continuous core temperature monitoring in order to avoid over-cooling the casualty.[18,19] Having medical personnel onsite, with continuous core temperature monitoring capability, would allow for increased utilization of cold water immersion for treatment and may result in improved outcomes.

Medical coverage during foot march and run events was a topic of discussion during the 2022 Fort Benning Heat Forum, held on 22 February. This event was attended by all Brigade- and Battalion-level leadership teams from across the installation. Additionally, the Fort Benning garrison safety office has since initiated a review of what are considered "high risk" events requiring onsite medical coverage, including foot march and run events.

There are several factors to consider when assessing the annual trends of heat illnesses during the surveillance period. The global COVID-19 pandemic presents a confounding influence on assessing annual trends in heat casualties during the study period as well as the impact of the Heat Center program. Heat acclimatization results in reduced thermal and cardiovascular strain, typically requires 7–14 days to fully develop, and is associated with reduced heat illness incidence.[20,21] For much of 2020, a recently arrived enlisted recruit (the largest trainee population at Fort Benning) had a 14-day restriction of movement (ROM) period at the Reception Battalion. Once in-processing and the ROM period were completed, trainees without signs or symptoms of COVID-19 infection were permitted to ship to their training companies and start basic training. It has been speculated that during the ROM period, trainees who arrive from cooler environments become at least partially heat acclimatized and are subsequently at lower risk of becoming a heat illness casualties during the initial weeks of basic training. Early in the pandemic, temporary duty (TDY) travel to Fort Benning for certain schools was cancelled and the only individuals who could attend were those who were already present on the installation, such as recent graduates of initial entry training. During the summer of 2020, U.S. Army Ranger School did not experience a single exertional heat stroke casualty; there would typically have been 1–3 heat stroke casualties per Ranger School class during other summers during the surveillance period **(data not shown)**. When TDY travel for Ranger School resumed with the September 2020 class, there were 3 heat stroke casualties, all of whom were in TDY status from a cooler and/or less humid home duty station. While it may be impractical for all trainees in a TDY status to arrive 2 weeks early to allow time for full heat acclimatization, it is important for trainees and unit leaders alike to understand the inherent heat illness risk for an unacclimatized trainee.

In addition to the impact of COVID-19 mitigation measures described above, other measures may also have influenced the trends in heat illness occurrence. While the wearing of a surgical mask has minimal impact on thermoregulatory responses to mild exercise in the heat, thermal sensation (one's perception of how hot or cold they feel) can be negatively affected.[22] Given the widespread wearing of face coverings during the pandemic and the subjective nature of heat exhaustion symptoms, such as generalized weakness, headache, fatigue, and lightheadedness,[2,14] it may be difficult, if not impossible to quantify the impact of face coverings on the observed frequency of heat illnesses.

Caution is warranted when assessing annual changes in heat illness frequency other than those that are related to COVID-19. Prior to mid-2019, annotation of the details of each incident were accomplished with a team approach, in which numerous individuals contributed. With the formal establishment of the Heat Center, responsibilities were assigned, and standardized procedures were implemented. With the establishment of the Heat Clinic in early 2020, every heat casualty was seen by the Center's Physician Assistant for their first follow-up encounter. During this office visit, additional details regarding the circumstances around the incident were obtained and any missing or conflicting information in the electronic medical record was reconciled.

Additionally, beginning the fall of 2020, standardized heat illness prevention, recognition and response training has been provided to all drill sergeants during their Brigade-level in-processing. A key message communicated during this training is that drill sergeants are encouraged to err on the side of caution and to activate EMS and initiating cooling measures if they suspect a trainee is a heat casualty. Given the subjective nature of many symptoms of heat exhaustion[14] and considering that other more objective symptoms may resolve by the time the suspected casualty is evaluated in the Emergency Department, it is plausible that heat exhaustion is over-diagnosed. Heat Center staff have previously shown that as many as 30% of all heat illness casualties are incorrectly coded.[23] While clinical staff have taken steps to correct this deficiency, it is possible that coding errors were more frequent during 2017–2019. The two-fold increase in heat exhaustion casualties during the surveillance period may be the result of improved recognition, over-diagnosis, and/or improved ICD-10 coding rather than a true increase in the number of heat exhaustion casualties. The dramatic increase in heat injury casualties in 2019 and subsequent drop in 2020 reinforce this point. Conversely, the increase in heat exhaustion may also be attributed to fewer casualties progressing in severity to heat stroke due to improvements described in this report (most notably, improved education, training, and surveillance).

There is an abundance of data demonstrating that the treatment priority for a suspected heat illness casualty is rapid, aggressive cooling.[18,19] Drill sergeants and other cadre at Fort Benning are provided training on the 'ice sheet' protocol, the application of bed linens soaked in ice cold water to the suspected heat illness casualty. Fort Benning Maneuver Center of Excellence policy requires application of ice sheets and activation of EMS whenever a heat casualty is suspected by unit cadre. As a result, depending on the response time, the initial core temperature recorded by EMS is likely lower than the true peak, but may also be suggestive of improved responsiveness by unit cadre. Profound hyperthermia, defined as core temperature >42 °C (107.6 °F) is a predictor of poor prognosis.[24,25] The reduction from 13 casualties which exceeded this threshold in 2017, down to 0 casualties in 2021 may reflect a combination of a positive impact of educational efforts, earlier recognition and response, improved utilization of the ice sheet protocol, or some combination of these factors. Regardless of the underlying cause, the lower frequency of extreme hyperthermia in recent years is interpreted as a positive trend that should be sustained.

The lack of denominator data for calculating incidence rates is a limitation of the current study. However, the size of the trainee and cadre populations at Fort Benning have remained relatively stable over the duration of the surveillance period. The exception is one station unit training (OSUT) for infantry and armor enlisted initial entry training, which expanded from 14 to 22 weeks in late 2019. As a result, since the expansion there are more initial entry trainees present at any one time, leading to a larger denominator for calculation of incidence rates. The observed decrease in the frequency of heat illnesses likely would have been confirmed had denominator data been available.

To some extent, heat illnesses are inevitable during military training in hot and/or humid environments, such as at Fort Benning, GA. Despite the efforts of leadership and cadre members, intrinsic and/or extrinsic motivational factors may inspire soldiers to exert themselves in such a way as to increase their risk of heat illness.[20,25] During military training, soldiers are expected to physically test their limits and to pass minimum standards to progress to the next phase of training or to graduate from a course. Leaders must be aware that even when all reasonable preventive measures have been applied, the risk of a soldier becoming a heat injury casualty may remain elevated. In certain circumstances, it may be wise to instruct trainees that "just meeting the minimum" standard is enough and that a high heat risk day is not an appropriate opportunity to attempt to maximize one's performance or to set a personal best time on an event.

In conclusion, data in this report demonstrate a general trend of decreasing severity and frequency of heat illness casualties at Fort Benning, GA during the surveillance period. While external factors beyond the influence of the Heat Center may have affected the trends, there is reason for cautious optimism that the education, training, and surveillance efforts have had a positive impact. Continued surveillance to confirm these trends and to identify future areas of improvement are warranted.

Author affiliations: Martin Army Community Hospital, Fort Benning, GA (LTC DeGroot and Ms. Henderson); Uniformed Services University of the Health Sciences, Bethesda, MD (Dr. O'Connor).

REFERENCES

1. Leon LR, Bouchama A. Heat stroke. *Compr Physiol.* 2015;5(2):611–647.
2. Epstein Y, Yanovich R. Heatstroke. *N Engl J Med.* 2019;380(25):2449–2459.
3. Armed Forces Health Surveillance Division. Update: Heat illness, active component, U.S. Armed Forces, 2020. *MSMR.* 2021;28(4):10–15.
4. Armed Forces Health Surveillance Branch. Update: Heat illness, active component, U.S. Armed Forces, 2019. *MSMR.* 2020;27(4):4–9.
5. Armed Forces Health Surveillance Branch. Update: Heat illness, active component, U.S. Armed Forces, 2018. *MSMR.* 2019;26(4):15–20.
6. Nelson DA, Deuster PA, O'Connor FG, Kurina LM. Timing and Predictors of Mild and Severe Heat Illness among New Military Enlistees. *Med Sci Sports Exerc.* 2018;50(8):1603–1612.
7. Westwood CS, Fallowfield JL, Delves SK, Nunns M, Ogden HB, Layden JD. Individual risk factors associated with exertional heat illness: A systematic review. *Exp Physiol.* 2020.
8. Alele FO, Malau-Aduli BS, Malau-Aduli AEO, M JC. Epidemiology of Exertional Heat Illness in the Military: A Systematic Review of Observational Studies. *Int J Environ Res Public Health.* 2020;17(19):7037.
9. Carter R, III, Cheuvront SN, Williams JO, et al. Epidemiology of hospitalizations and deaths from heat illness in soldiers. *Medicine and Science in Sports and Exercise.* 2005;37(8):1338–1344.
10. Gardner JW, Kark JA, Karnei K, et al. Risk factors predicting exertional heat illness in male Marine Corps recruits. *Medicine and Science in Sports and Exercise.* 1996;28(8):939–944.
11. DeGroot DW, O'Connor FG. Commentary: The Warrior Heat- and Exertion-Related Event Collaborative and the Fort Benning Heat Center. *MSMR.* 2020;27(4):2–3.
12. Galer M. The Heat Center Initiative. *US Army Risk Management Quarterly.* 2019;Spring:6–8.
13. Jones BH, Canham-Chervak M, Sleet DA. An evidence-based public health approach to injury priorities and prevention recommendations for the U.S. Military. *Am J Prev Med.* 2010;38(1 Suppl):S1–10.
14. Headquarters, Department of the Army and Air Force. Technical Bulletin, Medical 507, Air Force Pamphlet 48-152. Heat Stress Control and Heat Casualty Management. 7 March 2003.
15. Belval LN, Casa DJ, Adams WM, et al. Consensus Statement- Prehospital Care of Exertional Heat Stroke. *Prehosp Emerg Care.* 2018;22(3):392–397.
16. Tustin AW, Cannon DL, Arbury SB, Thomas RJ, Hodgson MJ. Risk Factors for Heat-Related Illness in U.S. Workers: An OSHA Case Series. *J Occup Environ Med.* 2018;60(8):e383–e389.
17. Sithinamsuwan P, Piyavechviratana K, Kitthaweesin T, et al. Exertional heatstroke: early recognition and outcome with aggressive combined cooling--a 12-year experience. *Mil Med.* 2009;174(5):496–502.
18. Demartini JK, Casa DJ, Stearns R, et al. Effectiveness of cold water immersion in the treatment of exertional heat stroke at the Falmouth road race. *Med Sci Sports Exerc.* 2015;47(2):240–245.
19. Casa DJ, McDermott BP, Lee EC, Yeargin SW, Armstrong LE, Maresh CM. Cold water immersion: the gold standard for exertional heatstroke treatment. *Exerc Sport Sci Rev.* 2007;35(3):141–149.
20. Stacey MJ, Parsons IT, Woods DR, Taylor PN, Ross D, S JB. Susceptibility to exertional heat illness and hospitalisation risk in UK military personnel. *BMJ Open Sport Exerc Med.* 2015;1(1):e000055.
21. Sawka MN, Leon LR, Montain SJ, Sonna LA. Integrated Physiological Mechanisms of Exercise Performance, Adaptation, and Maladaptation to Heat Stress. *Compr Physiol.* 2011;1(4):1883–1928.
22. Kato I, Masuda Y, Nagashima K. Surgical masks do not increase the risk of heat stroke during mild exercise in hot and humid environment. *Ind Health.* 2021;59(5):325–333.
23. DeGroot DW, Mok G, Hathaway NE. International Classification of Disease Coding of Exertional Heat Illness in U.S. Army Soldiers. *Mil Med.* 2017;182(9):e1946–e1950.
24. Shibolet S, Coll R, Gilat T, Sohar E. Heatstroke: its clinical picture and mechanism in 36 cases. *Q J Med.* 1967;36(144):525–548.
25. Epstein Y, Druyan A, Heled Y. Heat injury prevention--a military perspective. *J Strength Cond Res.* 2012;26 Suppl 2:S82–86.

Update: Heat Illness, Active Component, U.S. Armed Forces, 2021

In 2021, there were 488 incident cases of heat stroke and 1,864 incident cases of heat exhaustion among active component service members of the U.S. Armed Forces. The unadjusted annual rates of incident heat stroke and heat exhaustion peaked in 2018 and then declined in 2019 and 2020. Between 2020 and 2021, the rate of incident heat stroke was relatively stable (0.37 cases per 1,000 person-years [p-yrs]) while the rate of heat exhaustion increased slightly (1.40 cases per 1,000 p-yrs). In 2021, subgroup-specific rates of incident heat stroke and heat exhaustion were highest among male service members, those less than 20 years old, Marine Corps and Army members, recruit trainees, and those in combat-specific occupations. During 2017–2021, a total of 312 heat illnesses were documented among service members in the U.S. Central Command (CENTCOM) area of responsibility (AOR); 6.4% (n=20) were diagnosed as heat stroke. Commanders, small unit leaders, training cadre, and supporting medical personnel must ensure that the military members whom they supervise and support are informed about the risks, preventive countermeasures, early signs and symptoms, and first-responder actions related to heat illnesses.

WHAT ARE THE NEW FINDINGS?

From 2020 to 2021, the rate of incident heat stroke was relatively stable while the rate of heat exhaustion increased slightly. The annual numbers of heat illnesses diagnosed in the CENTCOM AOR have generally trended downward since 2017. Sizeable proportions of heat stroke and heat exhaustion cases were not identified by way of mandatory reports through the Disease Reporting System internet (DRSi).

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

Heat illness can degrade operational readiness by causing considerable morbidity, particularly during training of recruits and of soldiers and Marines in combat arms specialties. This analysis demonstrates again the magnitude of risks of heat illnesses among active component service members and the enhanced risks associated with sex, age, location of assignment, and occupational categories. Recognition of these risk factors should inform the preventive measures that military leaders, trainers, and service members routinely employ.

Heat illness refers to a group of disorders that occur when the elevation of core body temperature surpasses the compensatory limits of thermoregulation.[1] Heat illness is the result of environmental heat stress and/or exertion and represents a set of conditions that exist along a continuum from less severe (heat exhaustion) to potentially life threatening (heat stroke).

Heat exhaustion is caused by the inability to maintain adequate cardiac output because of strenuous physical exertion and environmental heat stress.[1,2] Acute dehydration often accompanies heat exhaustion but is not required for the diagnosis.[3] The clinical criteria for heat exhaustion include a core body temperature greater than 100.5°F/38°C and less than 104°F/40°C at the time of or immediately after exertion and/or heat exposure, physical collapse at the time of or shortly after physical exertion, and no significant dysfunction of the central nervous system. If any central nervous system dysfunction develops (e.g., dizziness or headache), it is mild and rapidly resolves with rest and cooling measures (e.g., removal of unnecessary clothing, relocation to a cooled environment, and oral hydration with cooled, slightly hypotonic solutions).[1–4]

Heat stroke is a debilitating illness characterized clinically by severe hyperthermia (i.e., a core body temperature of 104°F/40°C or greater), profound central nervous system dysfunction (e.g., delirium, seizures, or coma), and additional organ and tissue damage.[1,4,5] The onset of heat stroke should prompt aggressive clinical treatments, including rapid cooling and supportive therapies such as fluid resuscitation to stabilize organ function.[1,5] The observed pathologic changes in several organ systems are thought to occur through a complex interaction between heat cytotoxicity, coagulopathies, and a severe systemic inflammatory response.[1,5] Multiorgan system failure is the ultimate cause of mortality due to heat stroke.[5]

Timely medical intervention can prevent milder cases of heat illness (e.g., heat exhaustion) from becoming severe (e.g., heat stroke) and potentially life threatening. However, even with medical intervention, heat stroke may have lasting effects, including damage to the nervous system and other vital organs and decreased heat tolerance, making an individual more susceptible to subsequent episodes of heat illness.[6–8] Furthermore, the continued manifestation of multiorgan system dysfunction after heat stroke increases patients' risk of mortality during the ensuing months and years.[9,10]

Strenuous physical activity for extended durations in occupational settings as well as during military operational and training exercises exposes service members to considerable heat stress because of high environmental heat and/or a high rate of metabolic heat production.[11,12] In some military settings, wearing needed protective clothing or equipment may make it biophysically difficult to dissipate body heat.[13,14] The resulting body heat burden and associated cardiovascular strain reduce exercise performance and increase the risk of heat-related illness.[11,15]

Over many decades, lessons learned during military training and operations in hot environments as well as a substantial body of research findings have resulted in doctrine, equipment, and preventive measures that can significantly reduce the adverse health effects of military activities in hot weather.[16–22] Although numerous effective countermeasures are available, heat-related illness remains a significant threat to the health and operational effectiveness of military members and their units and accounts for considerable morbidity, particularly during recruit training in the U.S. military.[11,23,24] Moreover, with the projected rise in the intensity and frequency of extreme heat conditions associated with global climate change, heat-related illnesses will likely represent an increasing challenge to the military.[25–28]

In the U.S. Military Health System (MHS), the most serious types of heat-related illness are considered notifiable medical events. Notifiable cases of heat illness include heat exhaustion and heat stroke. All cases of heat illness that require medical intervention or result in change of duty status are reportable.[4]

This report summarizes reportable medical events of heat illness as well as heat illness-related hospitalizations and ambulatory visits among active component service members during 2021 and compares them to the previous 4 years. Episodes of heat stroke and heat exhaustion are summarized separately.

METHODS

The surveillance period was January 2017 through December 2021. The surveillance population included all individuals who served in the active component of the Army, Navy, Air Force, or Marine Corps at any time during the surveillance period. All data used to determine incident heat illness diagnoses were derived from records routinely maintained in the Defense Medical Surveillance System (DMSS). These records document both ambulatory health care encounters and hospitalizations of active component service members of the U.S. Armed Forces in fixed military and civilian (if reimbursed through the MHS) treatment facilities worldwide. In-theater diagnoses of heat illness were identified from medical records of service members deployed to Southwest Asia or the Middle East and whose health care encounters were documented in the Theater Medical Data Store. Because heat illnesses represent a threat to the health of individual service members and to military training and operations, the Armed Forces require expeditious reporting of these reportable medical events through any of the service-specific electronic reporting systems; these reports are routinely transmitted and incorporated into the DMSS.

For this analysis, a case of heat illness was defined as an individual with 1) a hospitalization or outpatient medical encounter with a primary (first-listed) or secondary (second-listed) diagnosis of heat stroke (International Classification of Diseases, 9th Revision [ICD-9]: 992.0; International Classification of Diseases, 10th Revision [ICD-10]: T67.0*) or heat exhaustion (ICD-9: 992.3–992.5; ICD-10: T67.3*–T67.5*) or 2) a reportable medical event record of heat exhaustion or heat stroke.[29] Because of an update to the Disease Reporting System internet (DRSi) medical event reporting system in July 2017, the type of reportable medical events for heat illness (i.e., heat stroke or heat exhaustion) could not be distinguished using reportable medical event records in DMSS data. Instead, information on the type of reportable medical event for heat illness during the entire 2017–2021 surveillance period was extracted directly from the records of the DRSi. It is important to note that *MSMR* analyses carried out before 2018 included diagnosis codes for other and unspecified effects of heat and light (ICD-9: 992.8 and 992.9; ICD-10: T67.8* and T67.9*) within the heat illness category "other heat illnesses." These codes were excluded from the current analysis and the April *MSMR* analyses of 2018–2021.

Each individual could be considered an incident case of heat illness only once per calendar year. If an individual had a diagnosis for both heat stroke and heat exhaustion during a given year, only 1 diagnosis was selected, prioritizing heat stroke over heat exhaustion. Encounters for each individual within each calendar year then were prioritized in terms of record source with hospitalizations prioritized over reportable events, which were prioritized over ambulatory visits. Incidence rates were calculated as incident cases of heat illness per 1,000 person-years (p-yrs) of active component service. Percent change in incidence was calculated using unrounded rates.

For surveillance purposes, recruit trainees were identified as active component members who were assigned to service-specific training locations during the relevant basic training periods (e.g., 8 weeks for Navy basic training). Recruit trainees were considered a separate category of enlisted service members in summaries of heat illnesses by military grade overall.

Records of medical evacuations from the U.S. Central Command (CENTCOM) area of responsibility (AOR) (i.e., Southwest Asia/Middle East) to a medical treatment facility outside the CENTCOM AOR were analyzed separately. Evacuations were considered case defining if affected service members had at least 1 inpatient or outpatient heat illness medical encounter in a permanent military medical facility in the U.S. or Europe from 5 days before to 10 days after their evacuation dates.

It should be noted that medical data from sites that were using the new electronic health record for the Military Health System, MHS GENESIS, between July 2017 and October 2019 are not available in the DMSS. These sites include Naval Hospital

Oak Harbor, Naval Hospital Bremerton, Air Force Medical Services Fairchild, and Madigan Army Medical Center. Therefore, medical encounter data for individuals seeking care at any of these facilities from July 2017 through October 2019 were not included in the current analysis.

RESULTS

In 2021, there were 488 incident cases of heat stroke and 1,864 incident cases of heat exhaustion among active component service members **(Table 1)**. The crude overall incidence rates of heat stroke and heat exhaustion were 0.37 and 1.40 per 1,000 p-yrs, respectively. In 2021, subgroup-specific incidence rates of heat stroke were highest among male service members, those less than 20 years old, those of other/unknown race/ethnicity (includes American Indian/Alaska Native service members, Asian/Pacific Islander service members, and those of unknown race/ethnicity), Marine Corps and Army members, recruit trainees, and those in combat-specific occupations **(Table 1)**. The overall rate of heat stroke among female service members was 43.1% lower than the rate among male service members. The overall rates of incident heat stroke among Marine Corps and Army members were more than 8 times the rates among Air Force and Navy members. There were only 25 cases of heat stroke reported among recruit trainees, but their incidence rate was more than 2.5 times that of other enlisted service members and officers.

The crude overall incidence rate of heat exhaustion among female service members was slightly (8.1%) lower than the rate among males **(Table 1)**. In 2021, compared to their respective counterparts, service members less than 20 years old, Marine Corps and Army members, recruit trainees, and service members in combat-specific occupations had notably higher overall rates of incident heat exhaustion.

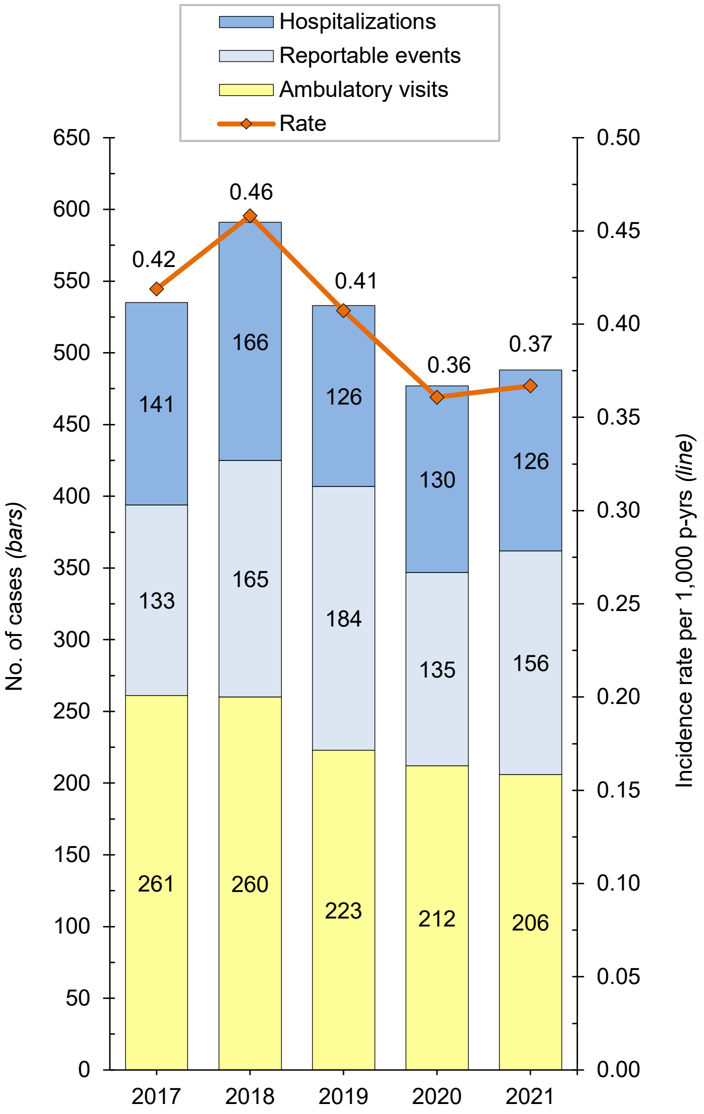
Crude (unadjusted) annual incidence rates of heat stroke increased slightly from 0.42 per 1,000 p-yrs in 2017 to 0.46 cases per 1,000 p-yrs in 2018, but then dropped to 0.36 cases per 1,000 p-yrs in 2020 before leveling off at 0.37 per 1,000 p-yrs in 2021

TABLE 1. Incident cases[a] and incidence rates[b] of heat illness, active component members, U.S. Army, Navy, Air Force, and Marine Corps, 2021

	Heat stroke		Heat exhaustion		Total heat illness diagnoses	
	No.	Rate[b]	No.	Rate[b]	No.	Rate[b]
Total	488	0.37	1,864	1.40	2,352	1.77
Sex						
Male	436	0.40	1,563	1.42	1,999	1.82
Female	52	0.23	301	1.31	353	1.53
Age group (years)						
<20	64	0.71	513	5.65	577	6.36
20–24	242	0.57	848	1.98	1,090	2.55
25–29	119	0.38	294	0.95	413	1.33
30–34	40	0.19	127	0.60	167	0.79
35–39	15	0.09	57	0.36	72	0.45
40+	8	0.06	25	0.19	33	0.26
Race/ethnicity group						
Non-Hispanic White	260	0.36	1,029	1.41	1,289	1.77
Non-Hispanic Black	75	0.35	295	1.38	370	1.73
Hispanic	84	0.36	332	1.42	416	1.78
Other/unknown[c]	69	0.45	208	1.36	277	1.81
Service						
Army	320	0.67	1,053	2.20	1,373	2.87
Navy	13	0.04	121	0.35	134	0.39
Air Force	26	0.08	156	0.47	182	0.55
Marine Corps	129	0.72	534	2.98	663	3.69
Military status						
Recruit	25	1.02	381	15.58	406	16.60
Enlisted	368	0.34	1,346	1.26	1,714	1.60
Officer	95	0.40	137	0.58	232	0.99
Military occupation						
Combat-specific[d]	200	1.08	595	3.22	795	4.31
Motor transport	12	0.30	60	1.48	72	1.77
Pilot/air crew	1	0.02	5	0.11	6	0.13
Repair/engineering	45	0.11	231	0.58	276	0.70
Communications/intelligence	70	0.25	248	0.87	318	1.11
Health care	30	0.27	89	0.79	119	1.06
Other/unknown	130	0.49	636	2.40	766	2.89
Home of record[e]						
Midwest	85	0.38	326	1.45	411	1.82
Northeast	76	0.46	241	1.46	317	1.92
South	207	0.36	845	1.46	1,052	1.82
West	107	0.34	415	1.31	522	1.64
Other/unknown	13	0.31	37	0.87	50	1.17

[a] One case per person per calendar year.
[b] Rate per 1,000 person-years.
[c] Includes those of American Indian/Alaska Native, Asian/Pacific Islander, and unknown race/ethnicity.
[d] Infantry/artillery/combat engineering/armor.
[e] As self-reported at time of entry into service.

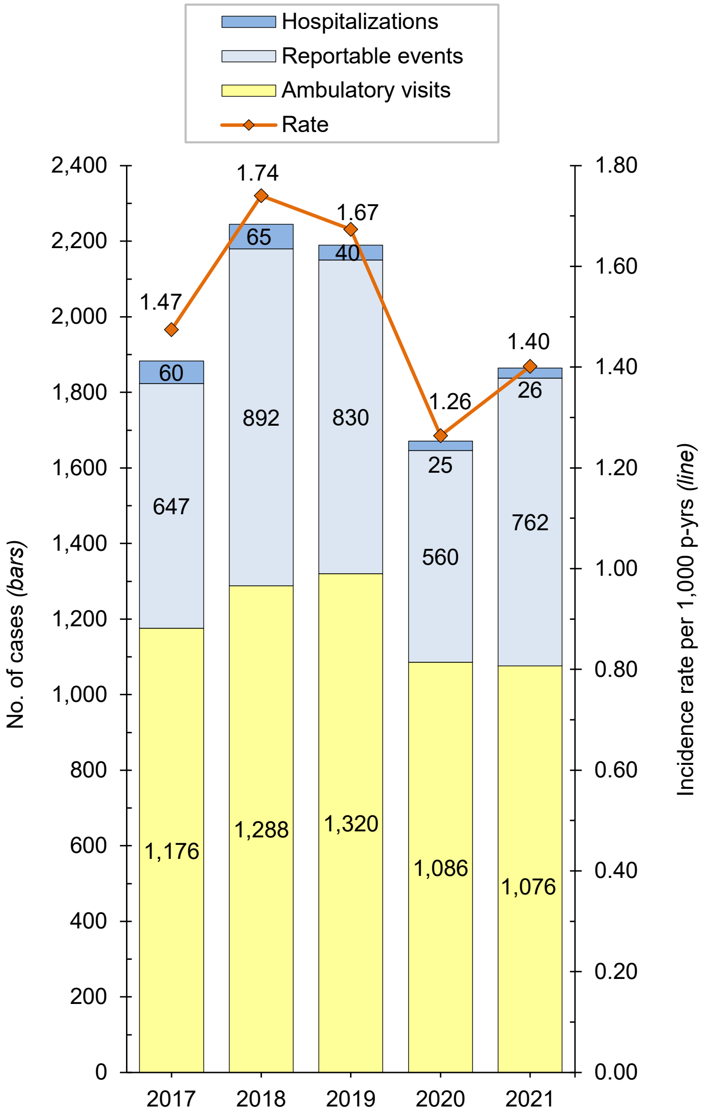
FIGURE 1. Incident cases[a] and incidence rates of heat stroke, by source of report and year of diagnosis, active component, U.S. Armed Forces, 2017–2021



[a]Diagnosis codes were prioritized by severity and record source (heat stroke>heat exhaustion; hospitalizations>reportable events>ambulatory visits).

No., number; p-yrs, person-years.

FIGURE 2. Incident cases[a] and incidence rates of heat exhaustion, by source of report and year of diagnosis, active component, U.S. Armed Forces, 2017–2021



[a]Diagnosis codes were prioritized by severity and record source (heat stroke>heat exhaustion; hospitalizations>reportable events>ambulatory visits).

No., number; p-yrs, person-years.

(Figure 1). In the last year of the surveillance period, there were fewer heat stroke-related ambulatory visits than in any of the previous 4 years. The proportions of total heat stroke cases from hospitalizations remained relatively stable during 2017–2021 (range: 23.6%–28.1%). The proportions of total heat stroke cases from reportable medical events ranged from 24.9% to 34.5% and the proportions from ambulatory visits varied between 41.8% and 48.8%.

Crude annual rates of incident heat exhaustion increased from 1.47 per 1,000 p-yrs in 2017 to a peak of 1.74 per 1,000 p-yrs in 2018, fell to 1.26 per 1,000 p-yrs in 2020, and then increased to 1.40 per 1,000 p-yrs in 2021. **(Figure 2)**. During the 5-year surveillance period, the proportions of total heat exhaustion cases from reportable medical events fluctuated between 33.5% and 40.9% and the proportions of cases from ambulatory visits varied between 57.4% and 65.0%. However, the proportions of heat exhaustion cases from hospitalizations remained relatively stable (range: 1.4%–3.2%).

Heat illnesses by location

During the 5-year surveillance period, a total of 12,477 heat-related illnesses were diagnosed at more than 250 military installations and geographic locations worldwide **(Table 2)**. Of the total heat illness cases,

TABLE 2. Heat illness events[a] by location of diagnosis/report (with at least 100 cases during the period), active component, U.S. Armed Forces, 2017-2021

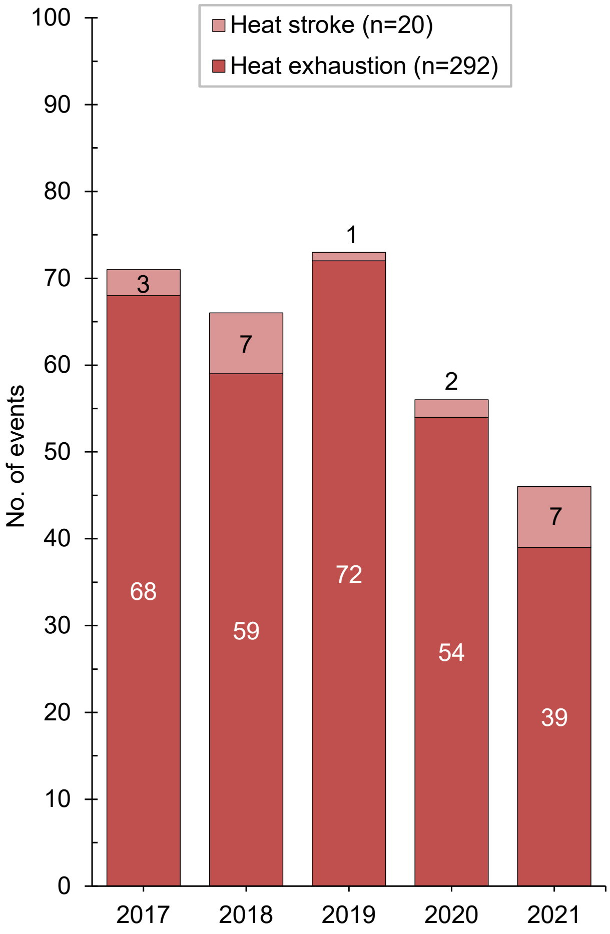
Location of diagnosis	No.	% total
Fort Benning, GA	2,033	16.3
MCB Camp Lejeune/ Cherry Point, NC	1,038	8.3
Fort Bragg, NC	936	7.5
Fort Campbell, KY	792	6.3
Fort Polk, LA	614	4.9
MCRD Parris Island/ Beaufort, SC	530	4.2
NMC San Diego, CA	526	4.2
MCB Camp Pendleton, CA	457	3.7
Fort Hood, TX	407	3.3
MCB Quantico, VA	340	2.7
JBSA-Lackland, TX	331	2.7
Okinawa, Japan	284	2.3
Fort Stewart, GA	224	1.8
Fort Jackson, SC	215	1.7
NH Twentynine Palms, CA	214	1.7
Fort Sill, OK	155	1.2
Fort Schafter, HI	151	1.2
Fort Irwin, CA	140	1.1
Fort Leonard Wood, MO	138	1.1
Fort Bliss, TX	116	0.9
Fort Riley, KS	104	0.8
Outside the U.S.[b]	418	3.4
All other locations	2,320	18.6
Total	12,477	100.0

[a] One heat illness per person per year.

[b] Excluding Okinawa, Japan.

No., number; MCB, Marine Corps Base; MCRD, Marine Corps Recruit Depot; NMC, Naval Medical Center; JBSA, Joint Base San Antonio; NH, Naval Hospital.

FIGURE 3. Numbers of heat illnesses diagnosed in the CENTCOM AOR, active component, U.S. Armed Forces, 2017–2021



No., number

5.6% occurred outside of the U.S., including 284 in Okinawa and 418 at 59 other locations in Europe, East Asia, Southwest Asia, Africa, and Cuba. Four Army installations in the U.S. accounted for more than one-third (35.1%) of all heat illnesses during the period: Fort Benning, GA (n=2,033); Fort Bragg, NC (n=936); Fort Campbell, KY (n=792); and Fort Polk, LA (n=614). Seven other locations accounted for an additional 29.1% of heat illness events: Marine Corps Base (MCB) Camp Lejeune/Cherry Point, NC (n=1,038); Marine Corps Recruit Depot Parris Island/Beaufort, SC (n=530); Naval Medical Center San Diego, CA (n=526); MCB Camp Pendleton, CA (n=457); Fort Hood, TX (n=407); MCB Quantico, VA (n=340); and Joint Base San Antonio-Lackland Air Force Base, TX (n=331). Of these 11 locations with the most heat illness events, 7 are located in the southeastern U.S. The 21 locations with more than 100 cases of heat illness accounted for over three-quarters (78.1%) of all active component cases during 2017–2021.

Heat illnesses in the CENTCOM AOR

During the 5-year surveillance period, a total of 312 heat illnesses were diagnosed and treated in the CENTCOM AOR (i.e., Southwest Asia/Middle East) **(Figure 3)**. Of the total cases of heat illness, 6.4% (n=20) were diagnosed as heat stroke. Deployed service members who were affected by heat illnesses were most frequently male (n=241; 77.2%); non-Hispanic White (n=183; 58.7%); 20–24 years old (n=168; 53.8%); in the Army (n=138; 44.2%); enlisted (n=301; 96.5%); and in repair/engineering (n=101; 32.4%) or communications/intelligence (n=65; 20.8%) occupations **(data not shown)**. During the surveillance period, 2 service members were medically evacuated for heat illnesses from the CENTCOM AOR; 1 of the evacuations took place in spring (May 2017) and 1 in November 2020.

EDITORIAL COMMENT

This annual update of heat illnesses among service members in the active component documented that the unadjusted annual rates of incident heat stroke and heat exhaustion peaked in 2018 and then declined in 2019 and 2020. Between 2020 and 2021, the rate of incident heat stroke was relatively stable while the rate of heat exhaustion increased slightly.

There are significant limitations to this update that should be considered when interpreting the results. Similar heat-related clinical illnesses are likely managed differently and reported with different diagnostic codes at different locations and in different clinical settings. Such differences undermine the validity of direct comparisons of rates of nominal heat stroke and heat exhaustion events across locations and settings. Also, heat illnesses during training exercises and deployments that are treated in field medical facilities are not completely ascertained as cases for this report. In addition, recruit trainees were identified using an algorithm based on age, rank, location, and time in service. This method is only an approximation and likely resulted in some misclassification of recruit training status. Moreover, it should be noted that the guidelines for mandatory reporting of heat illnesses were modified in the 2017 revision of the Armed Forces guidelines and case definitions for reportable medical events and carried into the 2020 revision.[4] In this updated version of the guidelines and case definitions, the heat injury category was removed, leaving only case classifications for heat stroke and heat exhaustion. To compensate for such possible variation in reporting, the analysis for this update, as in previous years, included cases identified in DMSS records of ambulatory care and hospitalizations using a consistent set of ICD-9/ICD-10 codes for the entire surveillance period. However, it also is important to note that the exclusion of diagnosis codes for other and unspecified effects of heat and light (formerly included within the heat illness category "other heat illnesses") in the current analysis precludes the direct comparison of numbers and rates of cases of heat exhaustion to the numbers and rates of "other heat illnesses" reported in *MSMR* updates before 2018.

As has been noted in previous *MSMR* heat illness updates, results indicate that a sizable proportion of cases identified through DMSS records of ambulatory visits did not prompt mandatory reports through the reporting system.[23] However, this study did not directly ascertain the overlap between hospitalizations and reportable events and the overlap between reportable events and outpatient encounters. It is possible that cases of heat illness, whether diagnosed during an inpatient or outpatient encounter, were not documented as reportable medical events because treatment providers were not attentive to the criteria for reporting or because of ambiguity in interpreting the criteria (e.g., the heat illness did not result in a change in duty status or the core body temperature measured during/immediately after exertion or heat exposure was not available). Underreporting is especially concerning for cases of heat stroke because it may reflect insufficient attentiveness to the need for prompt recognition of cases of this dangerous illness and for timely intervention at the local level to prevent additional cases.

In spite of its limitations, this report demonstrates that heat illnesses continue to be a significant and persistent threat to both the health of U.S. military members and the effectiveness of military operations. Of all military members, the youngest and most inexperienced Marine Corps and Army members (particularly those training at installations in the southeastern U.S.) are at highest risk of heat illnesses, including heat stroke, exertional hyponatremia, and exertional rhabdomyolysis (see the other articles in this issue of the *MSMR*).

Commanders, small unit leaders, training cadre, and supporting medical personnel—particularly at recruit training centers and installations with large combat troop populations—must ensure that the military members whom they supervise and support are informed regarding the risks, preventive countermeasures (e.g., water consumption), early signs and symptoms, and first-responder actions related to heat illnesses.[16–22,30–32] Leaders should be aware of the dangers of insufficient hydration on the one hand and excessive water intake on the other; they must have detailed knowledge of, and rigidly enforce countermeasures against, all types of heat illnesses.

Policies, guidance, and other information related to heat illness prevention and sun safety among U.S. military members are available online through the Army Public Health Center website at

https://phc.amedd.army.mil/topics/discond/hipss/Pages/default.aspx.

REFERENCES

1. Atha WF. Heat-related illness. *Emerg Med Clin North Am*. 2013;31(4):1097–1108.
2. Simon HB. Hyperthermia. *N Engl J Med*. 1993;329(7):483–487.
3. O'Connor FG, Sawka MN, Deuster P. Disorders due to heat and cold. In: Goldman L, Schafer AI, eds. *Goldman-Cecil Medicine*. 25th ed. Philadelphia, PA: Elsevier Saunders; 2016:692–693.
4. Armed Forces Health Surveillance Branch, Defense Health Agency. In collaboration with U.S. Air Force School of Aerospace Medicine, Army Public Health Center, and Navy and Marine Corps Public Health Center. Armed Forces Reportable Medical Events. Guidelines and Case Definitions, January 2020. Accessed 3 March 2022. https://health.mil/Reference-Center/Publications/2020/01/01/Armed-Forces-Reportable-Medical-Events-Guidelines
5. Epstein Y, Yanovich R. Heatstroke. *N Engl J Med*. 2019;380(25):2449–2459.
6. Epstein Y. Heat intolerance: predisposing factor or residual injury? *Med Sci Sports Exerc*. 1990;22(1):29–35.
7. O'Connor FG, Casa DJ, Bergeron MF, et al. American College of Sports Medicine roundtable on exertional heat stroke—return to duty/return to play: conference proceedings. *Curr Sports Med Rep*. 2010;9(5):314–321.
8. Shapiro Y, Magazanik A, Udassin R, Ben-Baruch G, Shvartz E, Shoenfeld Y. Heat intolerance in former heatstroke patients. *Ann Intern Med*. 1979;90(6):913–916.
9. Dematte JE, O'Mara K, Buescher J, et al. Near-fatal heat stroke during the 1995 heat wave in Chicago. *Ann Intern Med*. 1998;129(3):173–181.
10. Wallace RF, Kriebel D, Punnett L, Wegman DH, Amoroso PJ. Prior heat illness hospitalization and risk of early death. *Environ Res*. 2007;104(2):290–295.
11. Carter R 3rd, Cheuvront SN, Williams JO, et al. Epidemiology of hospitalizations and deaths from heat illness in soldiers. *Med Sci Sports Exerc*. 2005;37(8):1338–1344.
12. Hancock PA, Ross JM, Szalma JL. A meta-analysis of performance response under thermal stressors. *Hum Factors*. 2007;49(5):851–877.
13. Caldwell JN, Engelen L, van der Henst C, Patterson MJ, Taylor NA. The interaction of body armor, low-intensity exercise, and hot-humid conditions on physiological strain and cognitive function. *Mil Med*. 2011;176(5):488–493.
14. Maynard SL, Kao R, Craig DG. Impact of personal protective equipment on clinical output and perceived exertion. *J R Army Med Corps*. 2016;162(3):180–183.
15. Sawka MN, Cheuvront SN, Kenefick RW. High skin temperature and hypohydration impair aerobic performance. *Exp Physiol*. 2012;97(3):327–332.
16. Goldman RF. Introduction to heat-related problems in military operations. In: Lounsbury DE, Bellamy RF, Zajtchuk R, eds. *Textbook of Military Medicine: Medical Aspects of Harsh Environments, Volume 1*. Falls Church, VA: Office of the Surgeon General; 2001:3–49.
17. Sonna LA. Practical medical aspects of military operations in the heat. In: Lounsbury DE, Bellamy RF, Zajtchuk R, eds. *Textbook of Military Medicine: Medical Aspects of Harsh Environments, Volume 1*. Falls Church, VA: Office of the Surgeon General; 2001:293–309.

18. Headquarters, Department of the Army and Air Force. Technical Bulletin, Medical 507, Air Force Pamphlet 48-152. Heat Stress Control and Heat Casualty Management. 7 March 2003.
19. Headquarters, United States Marine Corps, Department of the Navy. Marine Corps Order 6200.1E. Marine Corps Heat Injury Prevention Program. Washington DC: Department of the Navy; 6 June 2002.
20. Navy Environmental Health Center. Technical Manual NEHC-TM-OEM 6260.6A. Prevention and Treatment of Heat and Cold Stress Injuries. Published June 2007.
21. Webber BJ, Casa DJ, Beutler AI, Nye NS, Trueblood WE, O'Connor FG. Preventing exertional death in military trainees: recommendations and treatment algorithms from a multidisciplinary working group. *Mil Med*. 2016;181(4):311–318.
22. Lee JK, Kenefick RW, Cheuvront SN. Novel cooling strategies for military training and operations. *J Strength Cond Res*. 2015;29(suppl 11):S77–S81.
23. Armed Forces Health Surveillance Branch. Update: Heat illness, active component, U.S. Armed Forces, 2020. *MSMR*. 2021;26(4):10–15.
24. Alele FO, Bunmi SM, Aduli EOM, Crow MJ. Epidemiology of exertional heat illness in the military: A systematic review of observational studies. *Int J Environ Res Public Health*. 2020;17(19):7037.
25. Dahl K, Licker R, Abatzoglou JT, Declet-Barreto J. Increased frequency of and population exposure to extreme heat index days in the United States during the 21st century. *Environ Res Commun*. 2019;1:075002.
26. Mukherjee S, Mishra AK, Mann ME, Raymona C. Anthropogenic warming and population growth may double US heat stress by the late 21st century. *Earth's Future*. 2021;9:e2020EF001886.
27. Parsons IT, Stacey MJ, Woods DR. Heat adaptation in military personnel: mitigating risk, maximizing performance. *Front Physiol.* 2019;10:1485.
28. Kenny GP, Notley SR, Flouris AD, Grundstein A. Climate change and heat exposure: impact on health in occupational and general populations. In: Adams W, Jardine J, eds. *Exertional Heat Illness: A Clinical and Evidence-Based Guide*. Cham, Switzerland: Springer Nature; 2020:225–261.
29. Armed Forces Health Surveillance Branch. Surveillance case definition: Heat illness. Accessed on 3 March 2022. https://health.mil/Reference-Center/Publications/2019/10/01/Heat-Injuries
30. Headquarters, Department of the Army Training and Doctrine Command. Memorandum. TRADOC Heat Illness Prevention Program 2018. 8 January 2018.
31. Kazman JB, O'Connor FG, Nelson DA, Deuster PA. Exertional heat illness in the military: risk mitigation. In: Hosokawa Y, ed. *Human Health and Physical Activity During Heat Exposure*. Cham, Switzerland: SpringerBriefs in Medical Earth Sciences; 2018:59–71.
32. Nye NS, O'Connor FG. Exertional heat illness considerations in the military. In: Adams W, Jardine J, eds. *Exertional Heat Illness: A Clinical and Evidence-Based Guide*. Cham, Switzerland: Springer Nature; 2020:181–210.

Update: Exertional Rhabdomyolysis, Active Component, U.S. Armed Forces, 2017–2021

Among active component service members in 2021, there were 513 incident cases of exertional rhabdomyolysis, for an unadjusted incidence rate of 38.6 cases per 100,000 person-years (p-yrs). Subgroup-specific rates in 2021 were highest among males, those less than 20 years old, non-Hispanic Black service members, Marine Corps or Army members, recruits, and those in "other" and combat-specific occupations. During 2017–2021, crude rates of exertional rhabdomyolysis reached a peak of 43.1 per 100,000 p-yrs in 2018 after which the rate decreased to 38.4 and 38.6 per 100,000 p-yrs in 2020 and 2021, respectively. Compared to those in other race/ethnicity groups, non-Hispanic Black service members had the highest overall rate of exertional rhabdomyolysis in every year of the period. Overall and annual rates were highest among Marine Corps members, intermediate among those in the Army, and lowest among those in the Air Force and Navy. Most cases of exertional rhabdomyolysis were diagnosed at installations that support basic combat/recruit training or major ground combat units of the Army or the Marine Corps. Medical care providers should consider exertional rhabdomyolysis in the differential diagnosis when service members (particularly recruits) present with muscular pain or swelling, limited range of motion, or the excretion of darkened urine after strenuous physical activity, especially in hot, humid weather.

WHAT ARE THE NEW FINDINGS?

The 513 incident cases of exertional rhabdomyolysis in 2021 represented an unadjusted annual incidence rate of 38.6 cases per 100,000 p-yrs among active component service members, the second lowest during 2017–2021. Exertional rhabdomyolysis continued to occur most frequently from mid spring through early fall at installations that support basic combat/recruit training or major Army or Marine Corps combat units.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

Exertional rhabdomyolysis is a potentially serious condition that requires a vigilant and aggressive approach. Some service members who experience exertional rhabdomyolysis may be at risk for recurrences, which may limit their military effectiveness and potentially predispose them to serious injury. The risk of exertional rhabdomyolysis can be reduced by taking into account fitness level, emphasizing graded, individual preconditioning before starting more strenuous training, and adhering to recommended work/rest ratios and hydration schedules, especially in hot, humid weather.

Rhabdomyolysis is characterized by the breakdown of skeletal muscle cells and the subsequent release of intracellular muscle contents into the circulation. The characteristic triad of rhabdomyolysis includes weakness, myalgias, and red to brown urine (due to myoglobinuria) accompanied by an elevated serum concentration of creatine kinase.[1,2] In exertional rhabdomyolysis, damage to skeletal muscle is generally caused by high-intensity, protracted, or repetitive physical activity, usually after engaging in unaccustomed strenuous exercise (especially with eccentric and/or muscle-lengthening contractions).[3] Even athletes who are used to intense training and who are being carefully monitored are at risk of this condition,[4] especially if new overexertion-inducing exercises are being introduced.[5] Illness severity ranges from elevated serum muscle enzyme levels without clinical symptoms to life-threatening disease associated with extreme enzyme elevations, electrolyte imbalances, altered mental status, acute kidney failure, disseminated intravascular coagulation, compartment syndrome, cardiac arrhythmia, and liver dysfunction.[1–3,6] A diagnosis of exertional rhabdomyolysis should be made when there are severe muscle symptoms (e.g., pain, stiffness, and/or weakness) and laboratory results indicating myonecrosis (usually defined as a serum creatine kinase level 5 or more times the upper limit of normal) in the context of recent exercise.[7]

Risk factors for exertional rhabdomyolysis include exertion in hot, humid conditions; younger age; male sex; a lower level of physical fitness; a prior heat illness; impaired sweating; and a lower level of education.[1,3,8–11] Acute kidney injury, due to an excessive concentration of free myoglobin in the urine accompanied by volume depletion, renal tubular obstruction, and renal ischemia, represents a serious complication of rhabdomyolysis.[6,12]

In U.S. military members, rhabdomyolysis is a significant threat during physical exertion, particularly under heat stress.[7,8,10,13] Moreover, although rhabdomyolysis can affect any service member, new recruits, who are not yet accustomed to the physical exertion required of basic training, may be at particular risk.[10] Each year, the *MSMR* summarizes the numbers, rates, trends, risk factors, and locations of occurrences of exertional heat injuries, including exertional rhabdomyolysis. This report includes the data for 2017–2021. Additional information about the definition, causes, and prevention of exertional rhabdomyolysis can be found in previous issues of the MSMR.[13]

METHODS

The surveillance period was January 2017 through December 2021. The surveillance population included all individuals who served in the active component of the Army, Navy, Air Force, or Marine Corps at any time during the surveillance period. All data used to determine incident exertional rhabdomyolysis diagnoses were derived from records routinely maintained in the Defense Medical Surveillance System (DMSS). These records document both ambulatory encounters and hospitalizations of active component members of the U.S. Armed Forces in fixed military and civilian (if reimbursed through the Military Health System [MHS]) treatment facilities worldwide. In-theater diagnoses of exertional rhabdomyolysis were identified from medical records of service members deployed to Southwest Asia/Middle East and whose healthcare encounters were documented in the Theater Medical Data Store.

For this analysis, a case of exertional rhabdomyolysis was defined as an individual with 1) a hospitalization or outpatient medical encounter with a diagnosis in any position of either "rhabdomyolysis" (International Classification of Diseases, 9th Revision [ICD-9]: 728.88; International Classification of Diseases, 10th Revision [ICD-10]: M62.82) or "myoglobinuria" (ICD-9: 791.3; ICD-10: R82.1) plus a diagnosis in any position of 1 of the following: "volume depletion (dehydration)" (ICD-9: 276.5*; ICD-10: E86.0, E86.1, E86.9), "effects of heat and light" (ICD-9: 992.0–992.9; ICD-10: T67.0*–T67.9*), "effects of thirst (deprivation of water)" (ICD-9: 994.3; ICD-10: T73.1*), "exhaustion due to exposure" (ICD-9: 994.4; ICD-10: T73.2*), or "exhaustion due to excessive exertion (overexertion)" (ICD-9: 994.5; ICD-10: T73.3*).[13] Each individual could be considered an incident case of exertional rhabdomyolysis only once per calendar year. Incidence rates were calculated as incident cases of rhabdomyolysis per 100,000 person-years (p-yrs) of active component service. Percent change in incidence was calculated using unrounded rates.

To exclude cases of rhabdomyolysis that were secondary to traumatic injuries, intoxications, or adverse drug reactions, medical encounters with diagnoses in any position of "injury, poisoning, toxic effects" (ICD-9: 800.*–999.*; ICD-10: S00.*–T88.*, except the codes specific for "sprains and strains of joints and adjacent muscles" and "effects of heat, thirst, and exhaustion") were not considered indicative of exertional rhabdomyolysis.[14]

For surveillance purposes, recruit trainees were identified as active component members who were assigned to service-specific training locations during the relevant basic training periods (e.g., 8 weeks for Navy basic training). Recruit trainees were considered a separate category of enlisted service members in summaries of rhabdomyolysis cases by military grade overall.

In-theater diagnoses of exertional rhabdomyolysis were analyzed separately; however, the same case-defining criteria and incidence rules were applied to identify incident cases. Records of medical evacuations from the U.S. Central Command (CENTCOM) area of responsibility (AOR) (i.e., Southwest Asia/Middle East) to a medical treatment facility outside the CENTCOM AOR also were analyzed separately. Evacuations were considered case defining if affected service members met the above criteria in a permanent military medical facility in the U.S. or Europe from 5 days before to 10 days after their evacuation dates.

It is important to note that medical data from sites that were using the new electronic health record for the Military Health System, MHS GENESIS, between July 2017 and October 2019 are not available in the DMSS. These sites include Naval Hospital Oak Harbor, Naval Hospital Bremerton, Air Force Medical Services Fairchild, and Madigan Army Medical Center. Therefore, medical encounter data for individuals seeking care at any of these facilities from July 2017 through October 2019 were not included in the current analysis.

RESULTS

In 2021, there were 513 incident cases of rhabdomyolysis likely associated with physical exertion and/or heat stress (exertional rhabdomyolysis) **(Table 1)**. The crude (unadjusted) incidence rate was 38.6 cases per 100,000 p-yrs. Subgroup-specific incidence rates of exertional rhabdomyolysis were highest among males (42.7 per 100,000 p-yrs), those less than 20 years old (81.5 per 100,000 p-yrs), non-Hispanic Black service members (56.4 per 100,000 p-yrs), Marine Corps or Army members (89.1 per 100,000 p-yrs and 53.6 per 100,000 p-yrs, respectively), and those in "other" and combat-specific occupations (75.9 and 64.5 per 100,000 p-yrs, respectively) **(Table 1)**. Of note, the incidence rate among recruit trainees (310.8 per 100,000 p-yrs) was nearly 9 times the rates among other enlisted members and officers, even though cases among this group accounted for only 14.8% of all cases in 2021.

During the surveillance period, crude rates of exertional rhabdomyolysis reached a peak of 43.1 per 100,000 p-yrs in 2018 after which the rate decreased to 38.4 and 38.6 per 100,000 p-yrs in 2020 and 2021, respectively **(Figure 1)**. The annual incidence rates of exertional rhabdomyolysis were highest among non-Hispanic Blacks during every year of the surveillance period; the rate among non-Hispanic Blacks decreased 16.8% from 67.9 per 100,000 p-yrs in 2017 to 56.4 per 100,000 p-years in 2021 **(data not shown)**. Overall and annual rates of incident exertional rhabdomyolysis were highest among service members in the Marine Corps, intermediate among those in the Army, and lowest among those in the Air Force and Navy **(Table 1, Figure 2)**. Among Marine Corps and Army members, annual rates increased in 2018, dropped in 2019, and then increased slightly in 2020 **(Figure 2)**. In 2021, rates among Marine Corps members decreased while rates in Army members increased slightly. In contrast, annual rates among Air Force and Navy members

TABLE 1. Incident cases[a] and incidence rates[b] of exertional rhabdomyolysis, active component, U.S. Armed Forces, 2021

	Hospitalizations		Ambulatory visits		Total	
	No.	Rate[b]	No.	Rate[b]	No.	Rate[b]
Total	198	14.9	315	23.7	513	38.6
Sex						
Male	185	16.8	285	25.9	470	42.7
Female	13	5.6	30	13.0	43	18.7
Age group (years)						
<20	44	25.2	98	56.2	142	81.5
20–24	54	15.7	103	29.9	157	45.6
25–29	64	20.6	68	21.9	132	42.6
30–34	21	9.9	28	13.2	49	23.1
35–39	11	6.9	13	8.1	24	15.0
40+	4	3.1	5	3.9	9	7.0
Race/ethnicity group						
Non-Hispanic White	100	13.7	152	20.9	252	34.6
Non-Hispanic Black	43	20.1	78	36.4	121	56.4
Hispanic	38	16.2	50	21.3	88	37.6
Other/unknown[c]	17	11.1	35	22.9	52	34.0
Service						
Army	106	22.1	151	31.5	257	53.6
Navy	22	6.4	22	6.4	44	12.9
Air Force	25	7.6	27	8.2	52	15.8
Marine Corps	45	25.1	115	64.1	160	89.1
Military status						
Recruit	15	61.3	61	249.4	76	310.8
Enlisted	154	14.4	216	20.2	370	34.6
Officer	29	12.3	38	16.1	67	28.5
Military occupation						
Combat-specific[d]	51	27.6	68	36.8	119	64.5
Motor transport	9	22.2	6	14.8	15	36.9
Pilot/air crew	3	6.4	4	8.5	7	14.9
Repair/engineering	34	8.6	46	11.6	80	20.2
Communications/intelligence	23	8.1	39	13.7	62	21.7
Health care	13	11.6	16	14.3	29	25.9
Other/unknown	65	24.6	136	51.4	201	75.9
Home of record[e]						
Midwest	36	16.0	34	15.1	70	31.0
Northeast	21	12.7	56	34.0	77	46.7
South	96	16.6	164	28.3	260	44.9
West	40	12.6	56	17.6	96	30.2
Other/unknown	5	11.7	5	11.7	10	23.5

[a] One case per person per calendar year.
[b] Rate per 100,000 person-years.
[c] Includes those of American Indian/Alaska Native, Asian/Pacific Islander, and unknown race/ethnicity.
[d] Infantry/artillery/combat engineering/armor.
[e] As self-reported at time of entry into service.

were relatively stable between 2017 and 2021 but had decreased to their lowest points in 2020. During 2017–2021, approximately three-quarters (75.6%) of the cases occurred during the 6 months of May through October **(Figure 3)**.

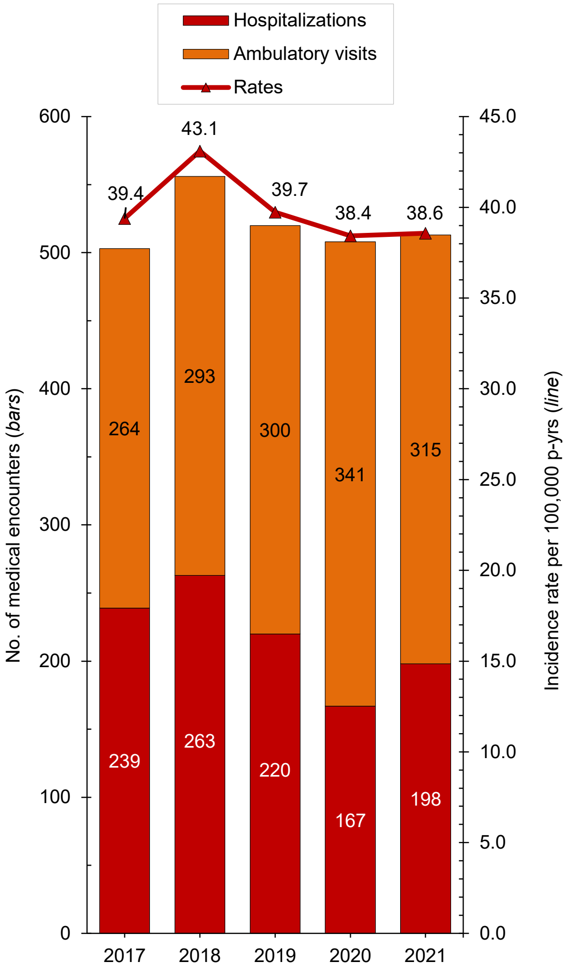
Rhabdomyolysis by location

During the 5-year surveillance period, the medical treatment facilities at 12 installations diagnosed at least 50 cases each; when combined, these installations diagnosed more than half (56.7%) of all cases **(Table 2)**. Of these 12 installations, 4 provide support to recruit/basic combat training centers (Marine Corps Recruit Depot [MCRD] Parris Island/Beaufort, SC; Fort Benning, GA; Joint Base San Antonio-Lackland, TX; and Fort Leonard Wood, MO). In addition, 7 installations support large combat troop populations (Fort Bragg, NC; MCB Camp Lejeune/Cherry Point, NC; Marine Corps Base [MCB] Camp Pendleton, CA; Fort Hood, TX; Fort Shafter, HI; Fort Campbell, KY; Fort Carson, CO). During 2017–2021, the most cases overall were diagnosed at MCRD Parris Island/Beaufort, SC (n=265), and Fort Bragg, NC (n=264), which together accounted for about one-fifth (20.3%) of all cases **(Table 2)**.

Rhabdomyolysis in the CENTCOM AOR

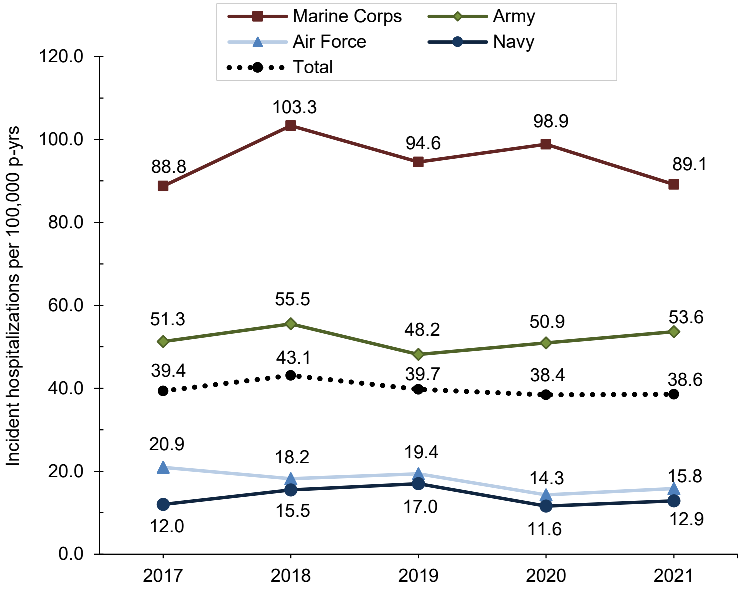
There were 7 incident cases of exertional rhabdomyolysis diagnosed and treated in the CENTCOM AOR (i.e., Southwest Asia/Middle East) **(data not shown)** during the 5-year surveillance period. Deployed service members who were most affected by exertional rhabdomyolysis were non-Hispanic Black or non-Hispanic White (n=4; 57.1% and n=3; 42.9%, respectively), male (n=5; 71.4%), 20–34 years old (n=6; 85.7%), in the Army (n=6; 85.7%), enlisted (n=6; 85.7%), and in health care occupations (n=3; 42.9%). One active component service member was medically evacuated from the CENTCOM AOR for exertional rhabdomyolysis during the surveillance period; this medical evacuation occurred in November 2020 **(data not shown)**.

FIGURE 1. Incident cases and incidence rates of exertional rhabdomyolysis, by source of report and year of diagnosis, active component, U.S. Armed Forces, 2017–2021



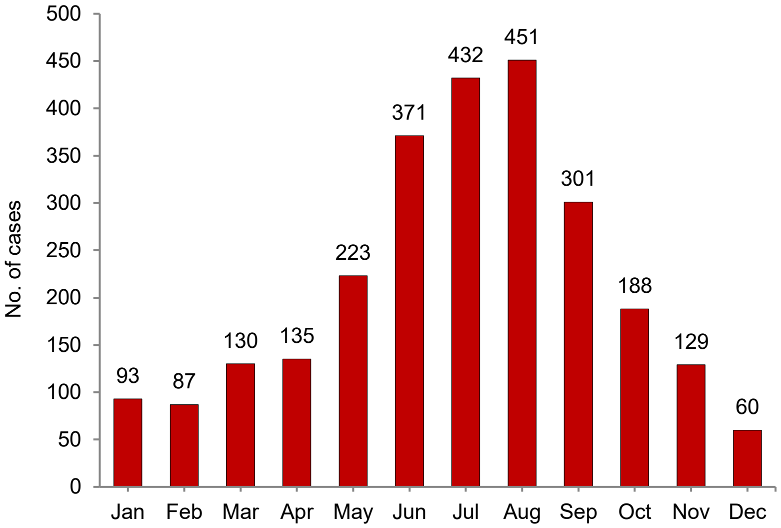
No., number; p-yrs, person-years.

FIGURE 2. Annual incidence rates of exertional rhabdomyolysis, by service, active component, U.S. Armed Forces, 2017–2021



P-yrs, person-years.

FIGURE 3. Cumulative numbers of exertional rhabdomyolysis cases, by month of diagnosis, active component, U.S. Armed Forces, 2017–2021



No., number.

EDITORIAL COMMENT

This report documents that the crude rates of exertional rhabdomyolysis reached a peak of 43.1 per 100,000 p-yrs in 2018 after which the rates decreased to 38.4 and 38.6 per 100,000 p-yrs in 2020 and 2021, respectively (10%–11.0% decrease). Exertional rhabdomyolysis occurred most frequently from mid spring through early fall at installations that support basic combat/recruit training or major Army or Marine Corps combat units.

The risks of heat injuries, including exertional rhabdomyolysis, are elevated among individuals who suddenly increase overall levels of physical activity, recruits who are not physically fit when they begin training, and recruits from relatively cool and dry climates who may not be acclimated to the high heat and humidity at training camps in the summer.[1,2,10] Soldiers and Marines in combat units often conduct rigorous unit physical training, personal fitness training, and field training exercises regardless of weather conditions. Thus, it is not surprising that recruit camps and installations with large ground combat units account for most of the cases of exertional rhabdomyolysis.

The annual incidence rates among non-Hispanic Black service members were

TABLE 2. Incident cases of exertional rhabdomyolysis by installation (with at least 30 cases during the period), active component, U.S. Armed Forces, 2017–2021

Location of diagnosis	No.	% total
MCRD Parris Island/ Beaufort, SC	265	10.2
Fort Bragg, NC	264	10.2
Fort Benning, GA	158	6.1
MCB Camp Lejeune/ Cherry Point, NC	145	5.6
MCB Camp Pendleton, CA	120	4.6
Fort Hood, TX	82	3.2
Fort Campbell, KY	81	3.1
NMC San Diego, CA	79	3.0
JBSA-Lackland AFB, TX	78	3.0
Fort Leonard Wood, MO	69	2.7
Fort Shafter, HI	67	2.6
Fort Carson, CO	66	2.5
NH Okinawa	46	1.8
Ft. Gordon, GA	45	1.7
Fort Belvoir, VA	44	1.7
Fort Polk, LA	42	1.6
NH Twentynine Palms, CA	41	1.6
Fort Bliss, TX	41	1.6
Quantico, VA	38	1.5
Fort Jackson, SC	32	1.2
Other/unknown locations	797	30.7
Total	2,600	100.0

No., number; MCRD, Marine Corps Recruit Depot; MCB, Marine Corps Base; NMC Naval Medical Center; JBSA, Joint Base San Antonio; NH, Naval Hospital.

higher than the rates among members of other race/ethnicity groups. This observation has been attributed, at least in part, to an increased risk of exertional rhabdomyolysis among individuals with sickle cell trait (SCT)[15–18] and is supported by studies among U.S. service members.[10,19,20] The rhabdomyolysis-related deaths of 2 SCT-positive service members (an Air Force member and a Navy recruit) after physical training in 2019 highlight this elevated risk.[21,22] However, although it is well established that sickle cell trait is positively associated with exertional rhabdomyolysis, its association with disease progression and severity is unclear and warrants further study.[19,20]

The findings of this report should be interpreted with consideration of its limitations. A diagnosis of "rhabdomyolysis" alone does not indicate the cause. Ascertainment of the probable causes of cases of exertional rhabdomyolysis was attempted by using a combination of ICD-9/ICD-10 diagnostic codes related to rhabdomyolysis with additional codes indicative of the effects of exertion, heat, or dehydration. Moreover, other ICD-9/ICD-10 codes were used to exclude cases of rhabdomyolysis that may have been secondary to trauma, intoxication, or adverse drug reactions. In addition, recruit trainees were identified using an algorithm based on age, rank, location, and time in service. This method is only an approximation and likely resulted in some misclassification of recruit training status.

The measures that are effective at preventing exertional heat injuries in general apply to the prevention of exertional rhabdomyolysis. In the military training setting, the risk of exertional rhabdomyolysis can be reduced by emphasizing graded, individual preconditioning before starting a more strenuous exercise program and by adhering to recommended work/rest and hydration schedules, especially in hot weather. The physical activities of overweight and/or previously sedentary new recruits should be closely monitored. Strenuous activities during relatively cool mornings following days of high heat stress should be particularly closely monitored; in the past, such situations have been associated with increased risk of exertional heat injuries (including rhabdomyolysis).[8]

Management after treatment for exertional rhabdomyolysis, including the decision to return to physical activity and duty, is a persistent challenge among athletes and military members.[10,11,23] It is recommended that those who have had a clinically confirmed exertional rhabdomyolysis event be further evaluated and risk stratified for recurrence before return to activity/duty.[7,11,23,24] Low-risk patients may gradually return to normal activity levels, while those deemed high risk for recurrence will require further evaluative testing (e.g., genetic testing for myopathic disorders).[23,24]

Commanders and supervisors at all levels should ensure that guidelines to prevent heat injuries are consistently implemented, be vigilant for early signs of exertional heat injuries, and intervene aggressively when dangerous conditions, activities, or suspicious illnesses are detected.[7] Finally, medical care providers should consider exertional rhabdomyolysis in the differential diagnosis when service members (particularly recruits) present with muscular pain or swelling, limited range of motion, or the excretion of darkened urine (possibly due to myoglobinuria) after strenuous physical activity, especially in hot, humid weather. The treatment of suspected and confirmed cases should be guided by the most current clinical practice guidelines.[7]

REFERENCES

1. Zutt R, van der Kooi AJ, Linthorst GE, Wanders RJ, de Visser M. Rhabdomyolysis: review of the literature. *Neuromuscul Disord*. 2014;24(8):651–659.
2. Beyond muscle destruction: a systematic review of rhabdomyolysis for clinical practice. Chavez L, Leon M, Einav S, Varon J. *Crit Care*. 2016;20:135
3. Rawson ES, Clarkson PM, Tarnopolsky MA. Perspectives on exertional rhabdomyolysis. *Sports Med*. 2017;47(suppl 1):33–49.
4. McKewon S. Two Nebraska football players hospitalized, treated after offseason workout. *Omaha World-Herald*. 20 January 2019. Accessed 1 March 2022. https://www.omaha.com/huskers/football/two-nebraska-football-players-hospitalized-treated-after-offseason-workout/article_d5929674-53a7-5d90-803e-6b4e9205ee60.html
5. Raleigh MF, Barrett JP, Jones BD, Beutler AI, Deuster PA, O'Connor FG. A cluster of exertional rhabdomyolysis cases in a ROTC program engaged in an extreme exercise program. *Mil Med*. 2018;183(suppl 1):516–521.
6. Bosch X, Poch E, Grau JM. Rhabdomyolysis and acute kidney injury. *N Engl J Med*. 2009;361(1):62–72.
7. O'Connor FG, Deuster P, Leggit J, et al. Clinical Practice Guideline for the Management of Exertional Rhabdomyolysis in Warfighters 2020. Bethesda, Maryland: Uniformed Services University. 2020.
8. Hill OT, Wahi MM, Carter R, Kay AB, McKinnon CJ, Wallace RF. Rhabdomyolysis in the U.S. active duty Army, 2004–2006. *Med Sci Sports Exerc*. 2012;44(3):442–449.
9. Lee G. Exercise-induced rhabdomyolysis. *R I Med J*. 2014;97(11):22–24.
10. Hill OT, Scofield DE, Usedom J, et al. Risk factors for rhabdomyolysis in the U.S. Army. *Mil Med*. 2017;182(7):e1836–e1841.
11. Knapik JJ, O'Connor FG. Exertional rhabdomyolysis: epidemiology, diagnosis, treatment, and prevention. *J Spec Oper Med*. 2016;15(3):65–71.

12. Holt S, Moore K. Pathogenesis of renal failure in rhabdomyolysis: the role of myoglobin. *Exp Nephrol*. 2000;8(2):72–76.
13. Armed Forces Health Surveillance Branch. Update: Exertional rhabdomyolysis among active component members, U.S. Armed Forces, 2014–2018. *MSMR*. 2019;26(4):21–26.
14. Armed Forces Health Surveillance Branch. Surveillance case definition. Exertional rhabdomyolysis. Accessed 1 March 2022. https://www.health.mil/Reference-Center/Publications/2017/03/01/Rhabdomyolysis-Exertional
15. Gardner JW, Kark JA. Fatal rhabdomyolysis presenting as mild heat illness in military training. *Mil Med*. 1994;159(2):160–163.
16. Makaryus JN, Catanzaro JN, Katona KC. Exertional rhabdomyolysis and renal failure in patients with sickle cell trait: is it time to change our approach? *Hematology*. 2007;12(4):349–352.
17. Ferster K, Eichner ER. Exertional sickling deaths in Army recruits with sickle cell trait. *Mil Med*. 2012;177(1):56–59.
18. Naik RP, Smith-Whitley K, Hassell KL, et al. Clinical outcomes associated with sickle cell trait: a systematic review. *Ann Intern Med*. 2018;169(9):619–627.
19. Nelson DA, Deuster PA, Carter R, Hill OT, Wolcott VL, Kurina LM. Sickle cell trait, rhabdomyolysis, and mortality among U.S. Army soldiers. *N Engl J Med*. 2016;375(5):435–442.
20. Webber BJ, Nye NS, Covey CJ, et al. Exertional Rhabdomyolysis and Sickle Cell Trait Status in the U.S. Air Force, January 2009–December 2018. *MSMR*. 2021;28(1):15–19.
21. Air Combat Command. U.S. Air Force Ground Accident Investigation Board Report. 20th Component Maintenance Squadron 20th Fighter Wing, Shaw Air Force Base, South Carolina. Fitness assessment fatality; 24 May 2019.
22. Mabeus C. Autopsy reports reveal why two recruits died at boot camp. *NavyTimes*. 8 November 2019. Accessed 1 March 2022. https://www.navytimes.com/news/your-navy/2019/11/08/autopsy-reports-reveal-why-two-recruits-died-at-boot-camp/
23. O'Connor FG, Brennan FH Jr, Campbell W, Heled Y, Deuster P. Return to physical activity after exertional rhabdomyolysis. *Curr Sports Med Rep*. 2008;7(6):328–331.
24. Atias D, Druyan A, Heled Y. Recurrent exertional rhabdomyolysis: coincidence, syndrome, or acquired myopathy? *Curr Sports Med Rep*. 2013;12(6):365–369.

Heat Stress

Understand heat stress risk factors, prevention, and treatment

All photos by ©Thinkstock unless otherwise noted.

Know your risk factors

Health Problems

- Diarrhea, vomiting, cold, or the flu
- Chronic conditions, such as diabetes and heart disease
- Being overweight or obese
- Poor physical fitness

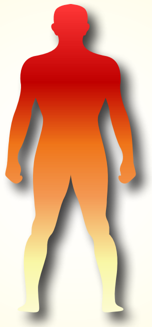
Activities

Photo by NIOSH

- High exertion
- Not enough rest breaks
- Repeated strenuous days in the heat
- Working through discomfort

Environment

- High temperatures and humidity
- Direct sun exposure
- Lack of wind or breeze
- Closeness to engines or hot equipment



Medications

Medications taken for:

- muscle spasms
- blood pressure
- diarrhea
- urine production (diuretics)
- cold, allergies, and congestion
- dizziness/vertigo
- psychosis
- depression

Other Factors

- Dehydration
- Prior heat illness
- Age over 60
- Prolonged PPE use
- Non-breathable clothing
- Alcohol use in the past 24 hours

Poor Acclimatization

Those requiring acclimatization:

- New workers
- Experienced workers used to heat but returning from time away
- Any worker experiencing sudden temperature changes (e.g., chiller failure)

Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

DHHS (NIOSH) Publication No. 2018-116

Update: Exertional Hyponatremia, Active Component, U.S. Armed Forces, 2006–2021

From 2006 through 2021, there were 1,669 incident diagnoses of exertional hyponatremia among active component service members, for a crude overall incidence rate of 7.8 cases per 100,000 person-years (p-yrs). Compared to their respective counterparts, female service members, those less than 20 years old, and recruit trainees had higher overall incidence rates of exertional hyponatremia diagnoses. The overall incidence rate during the 16-year period was highest in the Marine Corps, intermediate in the Army and Air Force, and lowest in the Navy. Overall rates during the surveillance period were highest among non-Hispanic White service members and lowest among non-Hispanic Black service members. Between 2006 and 2021, crude annual incidence rates of exertional hyponatremia peaked in 2010 (12.7 per 100,000 p-yrs) and then decreased to a low of 5.3 cases per 100,000 p-yrs in 2013. Crude annual rates fluctuated between 2016 and 2021, reaching the highest rate in 2020 (8.3 per 100,000 p-yrs) and then decreased to 6.8 per 100,000 p-yrs in 2021. Service members and their supervisors must be knowledgeable of the dangers of excessive water consumption and the prescribed limits for water intake during prolonged physical activity (e.g., field training exercises, personal fitness training, and recreational activities) in hot, humid weather.

WHAT ARE THE NEW FINDINGS?

The 2021 incidence rate for hyponatremia was lower than the overall rate for the entire period 2006–2021. The incidence rate for female service members in 2021 was lower than that of males, contrary to the overall trend for the entire period. For the first time in the 16-year surveillance period, the annual rate for members of the Marine Corps was not higher than the rates for the other services.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

To the extent that annual rates of exertional hyponatremia in recent years have been lower than rates earlier in the surveillance period, the diminished frequency of cases represents the cumulative beneficial results of leaders and trainers in the Armed Forces in preserving and protecting the health of service members in the face of heat-related threats to health.

Exertional (or exercise-associated) hyponatremia refers to a low serum, plasma, or blood sodium concentration (below 135 mEq/L) that develops during or up to 24 hours following prolonged physical activity.[1] Acute hyponatremia creates an osmotic imbalance between fluids outside and inside of cells. This osmotic gradient causes water to flow from outside to inside the cells of various organs, including the lungs (which can cause pulmonary edema) and brain (which can cause cerebral edema), producing serious and sometimes fatal clinical effects.[1,2] Swelling of the brain increases intracranial pressure, which can decrease cerebral blood flow and disrupt brain function, potentially causing hypotonic encephalopathy, seizures, or coma. Rapid and definitive treatment is needed to relieve increasing intracranial pressure and prevent brain stem herniation, which can result in respiratory arrest.[2–4]

Serum sodium concentration is determined mainly by the total content of exchangeable body sodium and potassium relative to total body water. Thus, exertional hyponatremia can result from loss of sodium and/or potassium, a relative excess of body water, or a combination of both.[5,6] However, overconsumption of fluids and the resultant excess of total body water are the primary driving factors in the development of exertional hyponatremia.[1,7,8] Other important factors include the persistent secretion of antidiuretic hormone (arginine vasopressin), excessive sodium losses in sweat, and inadequate sodium intake during prolonged physical exertion, particularly during heat stress.[2–4,9] The importance of sodium losses through sweat in the development of exertional hyponatremia is influenced by the fitness level of the individual. Less fit individuals generally have a higher sweat sodium concentration, a higher rate of sweat production, and an earlier onset of sweating during exercise.[10–12]

This report uses a surveillance case definition for exertional hyponatremia to estimate the frequencies, rates, trends, geographic locations, and demographic and military characteristics of exertional hyponatremia cases among U.S. military members from 2006 through 2021.[13]

METHODS

The surveillance period was 1 January 2006 through 31 December 2021. The surveillance population included all individuals who served in the active component of the U.S. Army, Navy, Air Force, or Marine Corps at any time during the surveillance period. All data used to determine incident exertional hyponatremia diagnoses were derived from records routinely maintained in the Defense Medical Surveillance System (DMSS). These records document both ambulatory encounters and hospitalizations of active component service members of the U.S. Armed Forces in fixed military and civilian (if reimbursed through the Military Health System (MHS)) treatment facilities worldwide. In-theater diagnoses of hyponatremia were identified from medical records of service members deployed to Southwest Asia/Middle East and whose health care encounters were documented in the Theater Medical Data Store (TMDS). TMDS records became available in the DMSS beginning in 2008.

For this analysis, a case of exertional hyponatremia was defined as 1) a hospitalization or ambulatory visit with a primary (first-listed) diagnosis of "hypo-osmolality and/or hyponatremia" (International Classification of Diseases, 9th and 10th Revisions, ICD-9:276.1; ICD-10:E87.1) and no other illness or injury-specific diagnoses (ICD-9:001–999; ICD-10:A–U) in any diagnostic position or 2) both a diagnosis of "hypo-osmolality and/or hyponatremia" (ICD-9:276.1; ICD-10:E87.1) and at least 1 of the following within the first 3 diagnostic positions (dx1–dx3): "fluid overload" (ICD-9:276.9; ICD-10:E87.70, E87.79), "alteration of consciousness" (ICD-9:780.0*; ICD-10:R40.*), "convulsions" (ICD-9:780.39; ICD-10:R56.9), "altered mental status" (ICD-9:780.97; ICD-10:R41.82), "effects of heat/light" (ICD-9:992.0–992.9; ICD-10:T67.0*–T67.9*), or "rhabdomyolysis" (ICD-9:728.88; ICD-10:M62.82).[13]

Medical encounters were not considered case-defining events if the associated records included the following diagnoses in any diagnostic position: alcohol/illicit drug abuse; psychosis, depression, or other major mental disorders; endocrine (e.g., pituitary or adrenal) disorders; kidney diseases; intestinal infectious diseases; cancers; major traumatic injuries; or complications of medical care. Each individual could be considered an incident case of exertional hyponatremia only once per calendar year. Incidence rates were calculated as incident cases of hyponatremia per 100,000 person-years (p-yrs) of active component service. Percent change in incidence was calculated using unrounded rates.

For surveillance purposes, recruit trainees were identified as active component members who were assigned to service-specific training locations during the relevant basic training periods (e.g., 8 weeks for Navy basic training). Recruit trainees were considered a separate category of enlisted service members in summaries of exertional hyponatremia by military grade overall.

In-theater diagnoses of exertional hyponatremia were analyzed separately using the same case-defining criteria and incidence rules that were applied to identify incident cases at fixed treatment facilities. Records of medical evacuations from the U.S. Central Command (CENTCOM) area of responsibility (AOR) (i.e., Southwest Asia/Middle East) to a medical treatment facility outside the CENTCOM AOR were analyzed separately. Evacuations were considered case defining if the affected service members met the above criteria in a permanent military medical facility in the U.S. or Europe from 5 days before to 10 days after their evacuation dates.

It is important to note that medical data from sites that were using the new electronic health record for the Military Health System, MHS GENESIS, between July 2017 and October 2019 are not available in the DMSS. These sites include Naval Hospital Oak Harbor, Naval Hospital Bremerton, Air Force Medical Services Fairchild, and Madigan Army Medical Center. Therefore, medical encounter data for individuals seeking care at any of these facilities from July 2017 through October 2019 were not included in the current analysis.

RESULTS

During 2006–2021, permanent medical facilities recorded 1,669 incident diagnoses of exertional hyponatremia among active component service members, for a crude overall incidence rate of 7.8 cases per 100,000 p-yrs **(Table 1)**. In 2021, there were 91 incident diagnoses of exertional hyponatremia (incidence rate: 6.8 per 100,000 p-yrs) among active component service members. During this year, male service members represented 87.9% of exertional hyponatremia cases (n=80) and had a higher annual incidence rate (7.2 per 100,000 p-yrs) than female service members (4.7 per 100,000 p-yrs) **(Table 1)**. The highest age group-specific incidence rates in 2021 were among the oldest (40+ years old) and the youngest (less than 20 years old) service members. The Army had the most cases during 2021 (n=43) and the highest incidence rate (8.9 per 100,000 p-yrs). In 2021 there were only 6 cases of exertional hyponatremia among recruit trainees resulting in a rate of 23.8 per 100,000 p-yrs. The rates among recruit trainees were higher than those of other enlisted members and officers in every year of the surveillance period **(data not shown)**.

During the 16-year surveillance period, female service members had a slightly higher overall incidence rate of exertional hyponatremia diagnoses than male service members **(Table 1)**. The overall incidence rate was highest in the Marine Corps (16.0 per 100,000 p-yrs) and lowest in the Navy (4.9 per 100,000 p-yrs). Overall rates during the surveillance period were highest among non-Hispanic White service members (8.8 per 100,000 p-yrs) and lowest among non-Hispanic Black service members (5.8 per 100,000 p-yrs). Although recruit trainees accounted for 16.8% of all exertional hyponatremia cases during 2006–2021, their overall crude incidence rate was 10.5 and 6.5 times the rates among other enlisted members and officers, respectively **(Table 1)**. During the 16-year period, 86.6% (n=1,446) of all cases were diagnosed and treated without having to be hospitalized **(Figure 1)**.

Between 2006 and 2021, crude annual rates of incident exertional hyponatremia diagnoses peaked in 2010 (12.7 per 100,000 p-yrs) and then decreased to a low of 5.3 cases per 100,000 p-yrs in 2013. The crude annual rates fluctuated between 2014 and 2021, reaching a high in 2015 (8.6 per 100,000 p-yrs) before decreasing through 2017. Crude annual rates rose again in 2018, 2019, and 2020 reaching 8.3 per 100,000 p-yrs in 2020, then decreasing to 6.8 per 100,000 p-yrs in 2021 **(Figure 1)**. During 2006–2020, annual incidence rates of exertional hyponatremia diagnoses were consistently higher in the Marine Corps compared to the other services, with the overall trend in rates primarily influenced by the trend among Marine Corps members **(Figure 2)**. However, between 2020 and 2021, the incidence rate among Marine Corps members decreased by 54.8% and fell below the rate among Army members for the first time during the surveillance period **(Figure 2)**.

TABLE 1. Incident cases[a] and incidence rates[b] of exertional hyponatremia, active component, U.S. Armed Forces, 2006–2021

	2021		Total 2006–2021	
	No.	Rate[a]	No.	Rate[a]
Total	91	6.8	1,669	7.8
Sex				
Male	80	7.2	1,403	7.7
Female	11	4.7	266	8.1
Age group (years)				
<20	10	10.8	211	14.9
20–24	23	5.3	508	7.3
25–29	16	5.1	315	6.2
30–34	12	5.6	198	5.9
35–39	13	8.1	190	7.5
40+	17	13.1	247	11.1
Race/ethnicity group				
Non-Hispanic White	62	8.4	1,117	8.8
Non-Hispanic Black	12	5.5	201	5.8
Hispanic	11	4.6	181	6.2
Other/unknown	6	3.9	170	7.3
Service				
Army	43	8.9	608	7.5
Navy	21	6.1	258	4.9
Air Force	13	3.9	322	6.2
Marine Corps	14	7.7	481	16.0
Military status				
Enlisted	62	5.7	1,033	6.0
Officer	23	9.7	355	9.6
Recruit	6	23.8	281	62.6
Military occupation				
Combat-specific[c]	23	12.4	296	9.6
Motor transport	0	0.0	33	5.1
Pilot/air crew	3	6.3	49	6.1
Repair/engineering	13	3.3	291	4.6
Communications/intelligence	19	6.6	293	6.2
Health care	7	6.2	127	6.8
Other /unknown	26	9.7	580	14.2
Home of record[d]				
Midwest	16	7.0	310	7.8
Northeast	12	7.2	248	9.0
South	46	7.9	714	7.8
West	15	4.7	331	6.7
Other/unknown	2	4.7	66	8.5

[a] One case per person per year.
[b] Rate per 100,000 person-years.
[c] Infantry/artillery/combat engineering/armor.
[d] Home of record self-reported at entry into service.

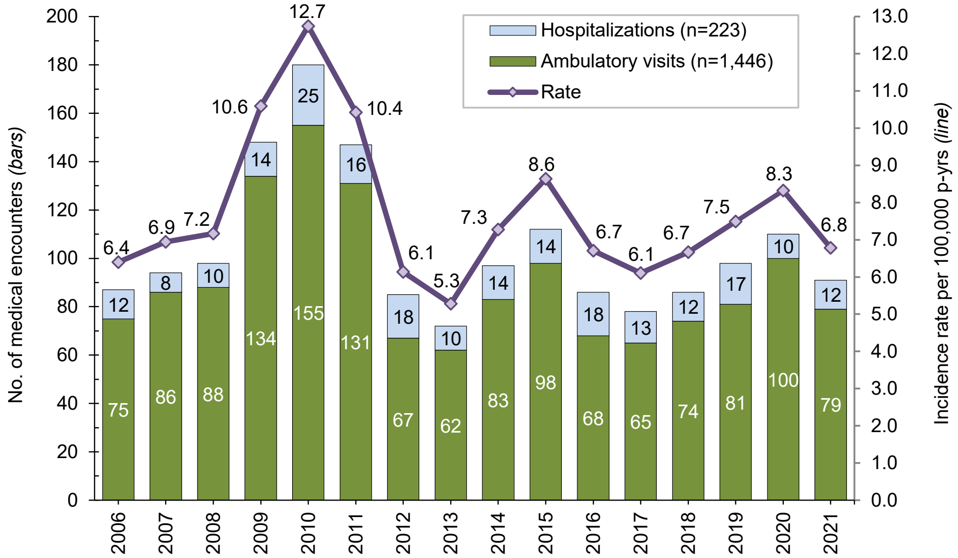
Exertional hyponatremia by location

During the 16-year surveillance period, exertional hyponatremia cases were diagnosed at the medical treatment facilities of more than 150 U.S. military installations and geographic locations worldwide; however, 16 U.S. installations contributed 20 or more cases each and accounted for 51.7% of the total cases **(Table 2)**. The installation with the most exertional hyponatremia cases overall was the Marine Corps Recruit Depot (MCRD) Parris Island/Beaufort, SC (n=205).

Exertional hyponatremia in the CENTCOM AOR

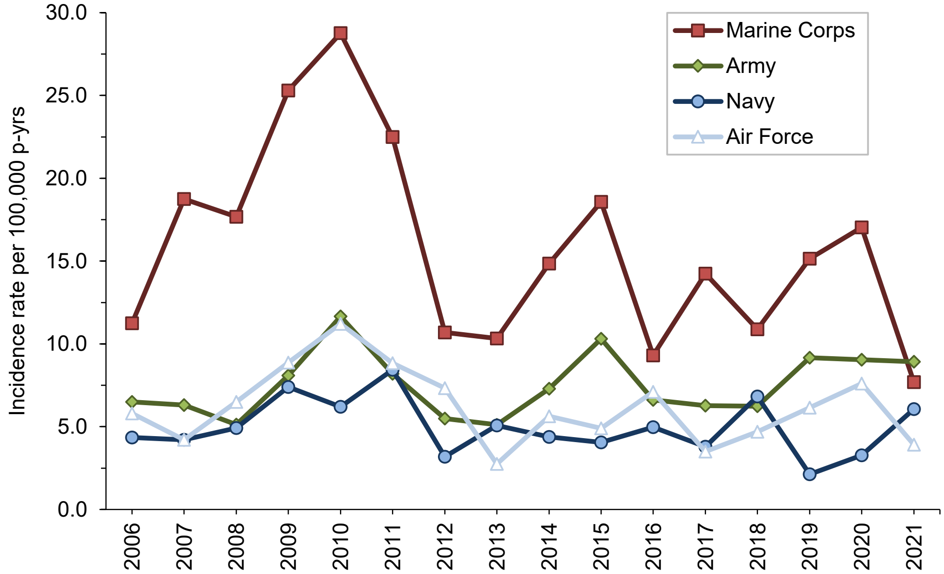
From 2008 through 2020, a total of 21 cases of exertional hyponatremia were diagnosed and treated in the CENTCOM AOR (i.e., Southwest Asia/Middle East). Only 1 new case was diagnosed in 2021. Deployed service members who were affected by exertional hyponatremia were most frequently male (n=19; 90.5%), non-Hispanic White (n=17; 81.0%), 20–24 years old (n=10; 47.6%), in the Army (n=14; 66.7%), enlisted (n=18; 85.7%), and in combat-specific (n=7; 33.3%) or communications/intelligence (n=6; 28.6%) occupations **(data not shown)**. During the entire surveillance period, 8 service members were medically evacuated from the CENTCOM AOR for exertional hyponatremia **(data not shown)**.

FIGURE 1. Annual incident cases and rates of exertional hyponatremia, active component, U.S. Armed Forces, 2006–2021



No, number; p-yrs, person-years.

FIGURE 2. Annual incidence rates of exertional hyponatremia, by service, active component, U.S. Armed Forces, 2006–2021



P-yrs, person-years.

EDITORIAL COMMENT

This report documents that after a period (2015–2017) of decreasing numbers and rates of exertional hyponatremia among active component U.S. military members, numbers and rates of diagnoses increased slightly but steadily between 2018 and 2020, but then decreased in 2021. Subgroup-specific patterns of overall incidence rates of exertional hyponatremia (e.g., sex, age, race/ethnicity, service, and military status) were generally similar to those reported in previous *MSMR* updates.[14] It is important to note that in *MSMR* analyses before April 2018, in-theater cases were included if there was a diagnosis of hypo-osmolality and/or hyponatremia in any diagnostic position. Beginning in 2018, the same case-defining criteria that were applied to inpatient and outpatient encounters were applied to the in-theater encounters. Therefore, the results of the in-theater analysis are not comparable to those presented in earlier *MSMR* updates.

Several important limitations should be considered when interpreting the results of this analysis. First, there is no diagnostic code specific for exertional hyponatremia. Thus, for surveillance purposes, cases of presumed exertional hyponatremia were ascertained from records of medical encounters that included diagnoses of hypo-osmolality and/or hyponatremia but not of other conditions (e.g., metabolic, renal, psychiatric, or iatrogenic disorders) that increase the risk of hyponatremia in the absence of physical exertion or heat stress. As such, exertional hyponatremia cases documented in this report likely include hyponatremia from both exercise- and non-exercise-related conditions. Consequently, the results of this analysis should be considered estimates of the actual incidence of symptomatic exertional hyponatremia from excessive water consumption among U.S. military members. In addition, the accuracy of estimated numbers, rates, trends, and correlates of risk depends on the completeness and accuracy of diagnoses that are documented in standardized records of relevant medical encounters. As a result, an increase in recorded diagnoses indicative of exertional hyponatremia may reflect, at least in part, increasing awareness of, concern regarding, and aggressive management of incipient cases by military supervisors and primary healthcare providers. Finally, recruit trainees were identified using an algorithm based on age, rank, location, and time in service. This method is only an approximation and likely resulted in some misclassification of recruit training status.

In the past, concerns about hyponatremia resulting from excessive water consumption were focused at training—particularly recruit training—installations. In this analysis, rates were relatively high among the youngest, and hence the most junior service members, and the highest

TABLE 2. Incident cases of exertional hyponatremia by installation (with at least 20 cases during the period), active component, U.S. Armed Forces, 2006–2021

Location of diagnosis	No.	% total
MCRD Parris Island Beaufort, SC	205	12.3
Fort Benning, GA	128	7.7
JBSA-Lackland AFB, TX	71	4.3
Fort Bragg, NC	56	3.4
MCB Camp Lejeune/ Cherry Point, NC	54	3.2
Walter Reed NMMC, MD[a]	45	2.7
NMC Portsmouth, VA	39	2.3
MCB Camp Pendleton, CA	39	2.3
NMC San Diego, CA	39	2.3
MCB Quantico, VA	37	2.2
Fort Hood, TX	28	1.7
Fort Schafter, HI	28	1.7
Fort Campbell, KY	27	1.6
Fort Belvoir, VA	25	1.5
Fort Jackson, SC	22	1.2
Fort Carson, CO	20	1.2
Other/unknown locations	806	48.3
Total	1,669	100.0

[a] Walter Reed National Military Medical Center (NMMC) is a consolidation of National Naval Medical Center (Bethesda, MD) and Walter Reed Army Medical Center (Washington, DC). This number represents the sum of the two sites prior to the consolidation (Nov 2011) and the number reported at the consolidated location.

No., number; MCRD, Marine Corps Recruit Depot; JBSA, Joint Base San Antonio; AFB, Air Force Base; MCB, Marine Corps Base; NMMC, National Military Medical Center; NMC, Naval Medical Center.

numbers of cases tended to be diagnosed at medical facilities that support large recruit training centers (e.g., MCRD Parris Island/ Beaufort, SC; Fort Benning, GA; and Joint Base San Antonio–Lackland Air Force Base, TX) and large Army and Marine Corps combat units (e.g., Fort Bragg, NC, and Marine Corps Base Camp Lejeune/ Cherry Point, NC).

In response to previous historical cases of exertional hyponatremia in the U.S. military, the guidelines for fluid replacement during military training in hot weather were revised and promulgated in 1998.[15–18] The revised guidelines were designed to protect service members from not only heat injury, but also hyponatremia due to excessive water consumption by limiting fluid intake regardless of heat category or work level to no more than 1.5 quarts hourly and 12 quarts daily.[16,17] There were fewer hospitalizations of soldiers for hyponatremia due to excessive water consumption during the year after (vs. the year before) implementation of the new guidelines.[19] In 2003, the revised guidelines were included in the multiservice Technical Medical Bulletin 507, Heat Stress Control and Heat Casualty Management that provides guidance to military and civilian healthcare providers, allied medical personnel, and military leadership.[20] A study published in 2018 found that this military fluid intake guidance remains valid for preventing excessive dehydration as well as overhydration and can be used by military health professionals and leadership to adequately maintain a normal level of hydration in service members working in the 5 designated flag conditions (levels of heat/humidity stress) while wearing contemporary uniform configurations (including protective gear/equipment) across a range of metabolic rates.[21]

During endurance events, a "drink-to-thirst" or a programmed fluid intake plan of 400–800 mL per estimated hour of activity has been suggested to limit the risk of exertional hyponatremia, although this rate should be customized to the individual's tolerance and experience.[4,8,17,19] In addition to these guidelines, reducing the availability of fluids may help prevent exertional hyponatremia during endurance events.[22,23] Carrying a maximum fluid load of 1 quart of fluid per estimated hour of activity and encouraging a "drink-to-thirst" approach to hydration may help prevent both severe exertional hyponatremia and dehydration during military training exercises and recreational hikes that exceed 2–3 hours.[4,8,22–24] Although rare, exercise-related hyponatremia and exertional heat stroke can present simultaneously with symptoms that may be hard to differentiate.[25] Encouraging a "drink-to-thirst" approach while incorporating prevention strategies for heat stroke may help mitigate such rare cases.

Female service members had relatively high rates of hyponatremia during the entire surveillance period; women may be at greater risk because of lower fluid requirements and longer periods of exposure to risk during some training exercises (e.g., land navigation courses or load-bearing marches).[9] The finding that the overall incidence of female service members experiencing exertional hyponatremia was greater than that of male service members in this analysis is similar to results found among samples of marathon runners in the general population. However, a large study of marathon runners suggested that the apparent sex difference did not remain after adjustment for body mass index and racing times.[26–28]

In many circumstances (e.g., recruit training and Ranger School), military trainees rigorously adhere to standardized training schedules regardless of weather conditions. In hot and humid weather, commanders, supervisors, instructors, and medical support staff must be aware of and enforce guidelines for work–rest cycles and water consumption.[29] The finding in this report that most cases of hyponatremia were treated in outpatient settings suggests that monitoring by supervisors and medical staff identified most cases during the early and less severe manifestations of hyponatremia.

In general, service members and their supervisors must be knowledgeable of the dangers of excessive water consumption as well as the prescribed limits for water intake during prolonged physical activity (e.g., field training exercises, personal fitness training, and recreational activities) in hot, humid weather. Military members (particularly recruit trainees and women) and their supervisors must be vigilant for early signs of heat-related illnesses and intervene immediately and appropriately (but not excessively) in such cases.[29] Finally, the recent validation of the current fluid intake guidance highlights its importance as a resource to leadership in sustaining military readiness.[21]

REFERENCES

1. Hew-Butler T, Rosner MH, Fowkes-Godek S, et al. Statement of the Third International Exercise-Associated Hyponatremia Consensus Development Conference, Carlsbad, California, 2015. *Clin J Sport Med*. 2015;25(4):303–320.

2. Montain SJ. Strategies to prevent hyponatremia during prolonged exercise. *Curr Sports Med Rep.* 2008;7(4):S28–S35.

3. Chorley J, Cianca J, Divine J. Risk factors for exercise-associated hyponatremia in non-elite marathon runners. *Clin J Sport Med*. 2007;17(6):471–477.

4. Hew-Butler T, Loi V, Pani A, Rosner MH. Exercise-associated hyponatremia: 2017 update. *Front Med (Lausanne)*. 2017;4:21.

5. Edelman IS, Leibman J, O'Meara MP, Birkenfeld LW. Interrelations between serum sodium concentration, serum osmolarity and total exchangeable sodium, total exchangeable potassium and total body water. *J Clin Invest*. 1958;37(9):1236–1256.

6. Nguyen MK, Kurtz I. Determinants of plasma water sodium concentration as reflected in the Edelman equation: role of osmotic and Gibbs-Donnan equilibrium. *Am J Physiol Renal Physiol*. 2004;286(5):F828–F837.

7. Noakes TD, Sharwood K, Speedy D, et al. Three independent biological mechanisms cause exercise-associated hyponatremia: evidence from 2,135 weighed competitive athletic performances. *Proc Natl Acad Sci U S A.* 2005;102(51):18550–18555.

8. Oh RC, Malave B, Chaltry JD. Collapse in the heat—from overhydration to the emergency room—three cases of exercise-associated hyponatremia associated with exertional heat illness. *Mil Med*. 2018;183(3–4):e225–e228.

9. Carter R III. Exertional heat illness and hyponatremia: an epidemiological prospective. *Curr Sports Med Rep*. 2008;7(4):S20–S27.

10. Buono MJ, Ball KD, Kolkhorst FW. Sodium ion concentration vs. sweat rate relationship in humans. *J Appl Physiol (1985)*. 2007;103(3):990–994.

11. Buono MJ, Sjoholm NT. Effect of physical training on peripheral sweat production. *J Appl Physiol (1985)*. 1988;65(2):811–814.

12. Nadel ER, Pandolf KB, Roberts MF, Stolwijk JA. Mechanisms of thermal acclimation to exercise and heat. *J Appl Physiol.* 1974;37(4):515–520.

13. Armed Forces Health Surveillance Branch. Surveillance Case Definition. Hyponatremia. March 2017. Accessed 10 March 2022. https://health.mil/Reference-Center/Publications/2017/03/01/Hyponatremia-Exertional

14. Armed Forces Health Surveillance Branch. Update: Exertional hyponatremia, active component, U.S. Armed Forces, 2005–2020. *MSMR*. 2021;28(4):21–26.

15. Army Medical Surveillance Activity. Case reports: Hyponatremia associated with heat stress and excessive water consumption: Fort Benning, GA; Fort Leonard Wood, MO; Fort Jackson, SC, June–August 1997. *MSMR*. 1997;3(6):2–3,8.

16. Department of the Army, Office of the Surgeon General. Memorandum, subject: Policy guidance for fluid replacement during training, dated 29 April 1998.

17. Montain S., Latzka WA, Sawka MN. Fluid replacement recommendations for training in hot weather. *Mil Med*. 1999;164(7):502–508.

18. O'Brien KK, Montain SJ, Corr WP, Sawka MN, Knapik JJ, Craig SC. Hyponatremia associated with overhydration in U.S. Army trainees. *Mil Med*. 2001;166(5):405–410.

19. Army Medical Surveillance Activity. Surveillance trends: Hyponatremia associated with heat stress and excessive water consumption: the impact of education and a new Army fluid replacement policy. *MSMR*. 1999;5(2):2–3,8–9.

20. Headquarters, Departments of the Army and Air Force (DoTAaA). Heat stress control and heat casualty management. Technical Bulletin Medical 507. Air Force Pamphlet, 48–152(I). 2003.

21. Luippold AJ, Charkoudian N, Kenefick RW, et al. Update: Efficacy of military fluid intake guidelines. *Mil Med*. 2018;183(9/10):e338–e342.

22. Hew-Butler T, Verbalis JG, Noakes TD. Updated fluid recommendation: Position statement from the International Marathon Medical Directors Association (IMMDA). *Clin J Sport Med.* 2006;16(4):283–292.

23. Thomas DT, Erdman KA, Burke LM. American College of Sports Medicine Joint Position Statement.Nutrition and athletic performance. *Med Sci Sport Exerc.* 2016;48(3):543–568.

24. Nolte HW, Nolte K, Hew-Butler T. Ad libitum water consumption prevents exercise-associated hyponatremia and protects against dehydrations in soldiers performing a 40-km route-march. *Mil Med Res*. 2019;6(1):1.

25. Oh RC, Galer M, Bursey MM. Found in the field—a soldier with heat stroke, exercise-associated hyponatremia, and kidney injury. *Curr Sports Med Rep*. 2018;17(4):123–125.

26. Almond CS, Shin AY, Fortescue EB, et al. Hyponatremia among runners in the Boston Marathon. *N Engl J Med*. 2005;352(15):1550–1556.

27. Ayus JC, Varon J, Arieff AI. Hyponatremia, cerebral edema, and noncardiogenic pulmonary edema in marathon runners. *Ann Intern Med*. 2000;132(9):711–714.

28. Hew TD, Chorley JN, Cianca JC, Divine JG. The incidence, risk factors, and clinical manifestations of hyponatremia in marathon runners. *Clin J Sport Med*. 2003;13(1):41–47.

29. Buchanan BK, Sylvester JE, DeGroot DW. Exercise associated hyponatremia practice recommendation. Updated 17 March, 2021. Accessed 10 March 2022. https://www.hprc-online.org/sites/default/files/document/HPRC_WHEC_Exercise%20Associated%20Hyponatremia%20Practice%20Recommendation_508_0.pdf

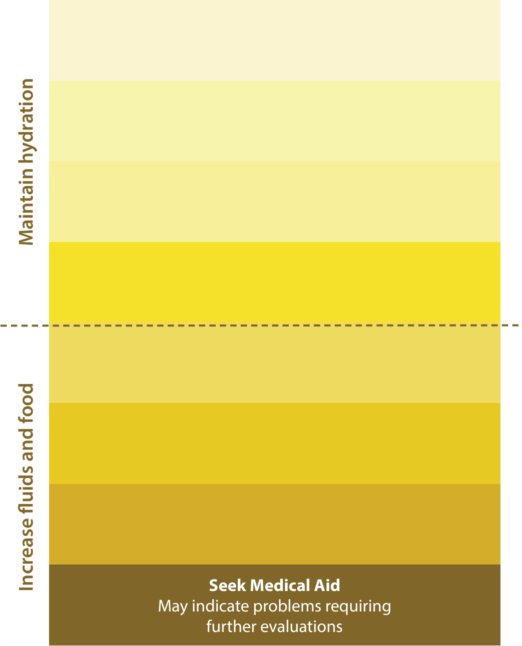
Start hydrated and stay hydrated!

Training while dehydrated increases the risk for Heat Illness and poor performance

Are you starting hydrated?
Take the Urine Color Test

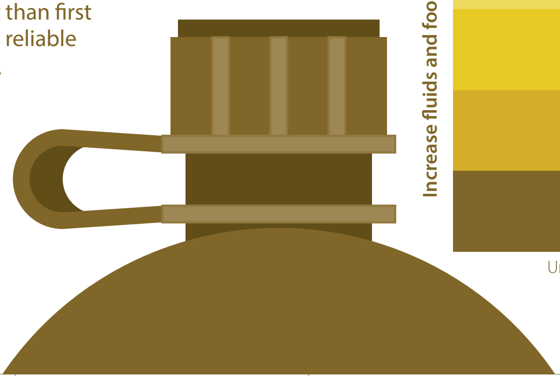
How does it work?

- **First thing in the morning,** match your urine color to the closest color in the chart. This will tell how well you have hydrated in the past 24 hours.
- Watch the urine stream, not the toilet water, as the water in the toilet will dilute your urine color.
- Below the line: **Increase fluids and food**
- Above the line: **Continue hydration using the Fluid Replacement Guide below.**
- Comparing urine color other than first thing in the morning is not a reliable indicator of hydration status.



Urine color chart is not for clinical use

Developed in coordination with the
U.S. Army Research Institute of
Environmental Medicine:
http://www.usariem.army.mil/



Work/Rest Times and Fluid Replacement Guide

Heat Category	WBGT Index, (°F)	**Easy Work** Walking on hard surface, 2.5 mph, < 30-lb. load; weapon maintenance, marksmanship training.		**Moderate Work** Patrolling, walking in sand, 2.5 mph, no load; calisthenics.		**Hard Work** Walking in sand, 2.5 mph with load; field assaults.	
		Work/Rest (minutes)	*Fluid Intake (quarts/hour)*	*Work/Rest (minutes)*	*Fluid Intake (quarts/hour)*	*Work/Rest (minutes)*	*Fluid Intake (quarts/hour)*
1	78° - 81.9°	NL	½	NL	¾	40/20 (70)*	¾ (1)*
2	82° - 84.9°	NL	½	50/10 (150)*	¾ (1)*	30/30 (65)*	1 (1¼)*
3	85° - 87.9°	NL	¾	40/20 (100)*	¾ (1)*	30/30 (55)*	1 (1¼)*
4	88° - 89.9°	NL	¾	30/30 (80)*	¾ (1¼)*	20/40 (50)*	1 (1¼)*
5	> 90°	50/10 (180)*	1	20/40 (70)*	1 (1¼)*	10/50 (45)*	1 (1½)*

Adherence to this guidance will result in sustained performance and hydration for at least 4 hours of work in the specified heat category. Fluid needs can vary based on individual differences (± ¼ qt/hr) and exposure to full sun or full shade (± ¼ qt/hr). Rest means minimal physical activity (sitting or standing) in the shade if possible. Body armor - add 5°F to WBGT index in humid climates. NBC (MOPP 4) - Add 10°F (Easy Work) or 20°F (Moderate or Hard Work) to WBGT Index. CAUTION: hourly fluid intake should not exceed 1½ qts. Daily fluid intake should not exceed 12 qts.

*Use the amounts in parentheses for continuous work when rest breaks are not possible. Leaders should ensure several hours of rest and rehydration time after continuous work. NL = no limit to work time per hour.

Source: TB5071, AFPAM 48-152 (I) March 2003.

U.S. ARMY

Public Health
Prevent. Promote. Protect.
U.S. ARMY PUBLIC HEALTH CENTER

(Also available as a tip card)

Approved for public release, distribution unlimited.

CP-070-JAN20

For more information contact your **local**
Department of Public Health

MEDICAL SURVEILLANCE MONTHLY REPORT (MSMR), in continuous publication since 1995, is produced by the Armed Forces Health Surveillance Division (AFHSD). AFHSD is a designated public health authority within the Defense Health Agency. The *MSMR* provides evidence-based estimates of the incidence, distribution, impact, and trends of illness and injuries among U.S. military members and associated populations. Most reports in the *MSMR* are based on summaries of medical administrative data that are routinely provided to the AFHSD and integrated into the Defense Medical Surveillance System for health surveillance purposes.

- *Archive:* Past issues of the *MSMR* are available as downloadable PDF files at www.health.mil/MSMRArchives.
- *Online Subscriptions:* Submit subscription requests at www.health.mil/MSMRSubscribe.
- *Editorial Inquiries*: Call (301) 319-3240 or email dha.ncr.health-surv.mbx.msmr@mail.mil.
- *Instructions for Authors:* Information about article submissions is provided at www.health.mil/MSMRInstructions.

All material in the *MSMR* is in the public domain and may be used and reprinted without permission. Citation formats are available at www.health.mil/MSMR.

Follow us:

Facebook: https://www.facebook.com/AFHSDPAGE/

Twitter: https://twitter.com/AFHSDPAGE

ISSN 2158-0111 (print)

ISSN 2152-8217 (online)

Medical Surveillance Monthly Report (MSMR)
Armed Forces Health Surveillance Division
11800 Tech Road, Suite 220
Silver Spring, MD 20904