

Exertional Heat Illness Among Overweight U.S. Army Recruits In Basic Training

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Introduction: Heat illness has not declined in the U.S. military despite preventive measures. The increase in overweight recruits entering the U.S. military may lead to an increase in heat-related events. This study compares the risk of heat illness among U.S. Army recruits who exceeded body fat standards at accession to those who met standards. **Methods:** Recruits with excess body fat and qualified applicants to the Army were required to take a preaccession fitness test during the study period (February 2005 through September 2006). The test included a 5-min step test and 1-min push-up challenge, scored as pass or fail. Incidence and outpatient usage for heat illness (any heat illness, heat stroke, heat exhaustion, and other heat illness) at 90 d of service were compared in 9667 male recruits of whom 826 had excess body fat and 8841 were qualified. There were too few heat events among women for analysis. **Results:** The incidence odds ratio among male recruits with excess body fat compared to qualified male recruits was 3.63 (95% CI: 1.92, 6.85). Men with excess body fat had an increased incidence of heat illness with a rate ratio of 7.25 (95% CI: 4.17, 12.61). **Discussion:** Although there were few heat illness events, the results indicate a significantly increased risk of heat illness and outpatient utilization among male recruits with excess body fat. It was estimated that approximately 70% of the relative risk for heat illnesses in men with excess body fat during basic training was associated with exceeding body fat standards. These findings may have implications for military accession and training.

Keywords: military, obesity, heatstroke, physical fitness.

HEAT ILLNESS continues to be a serious problem in occupations requiring physical exertion in hot or humid environments such as agricultural and forestry workers (13,14), amateur and professional athletes (5,9), and military service members (2,21). Despite knowledge about risk factors for the prevention of heat illness, there has not been a substantial decrease in the incidence in heat stroke or heat exhaustion in the U.S. military over the past 5 yr, estimated in 2008 at 0.21 and 1.04 per 1000 person-years, respectively (2). The proportion of individuals who are overweight [body mass index (BMI), between 25 kg · m⁻² and 30 kg · m⁻²] or obese (BMI ≥ 30) in the age targeted for military recruitment increased from 22.8 to 27.1% and 2.8–6.8%, respectively, over the period 1993 to 2006 (10). Furthermore, the prevalence of service members considered overweight and obese by outpatient medical encounter codes more than doubled since 2003 (1). The increase in the number and percentage of overweight and obese recruits entering the U.S. military may lead to an increase in both number and rate of heat illness.

Obese and less fit individuals have a higher risk of heat illness (11). Individuals with more body fat are less heat tolerant and are also slower to acclimatize to heat (3,19). Increased BMI has been shown to increase the incidence of heat illness in several military studies (4,21). In a study of Marine recruits, a higher risk of developing heat illness was found in those men and women who had the slowest run times and an increased risk was observed for those men with the highest BMI. Although only 18% of the recruits were in the highest risk group, that group accounted for almost half of the heat illnesses (8). A case-control study conducted in the Singapore Defense Force found that obese soldiers (defined as BMI > 27) had a fourfold increased odds of heat illness compared to those with a BMI less than or equal to 27 (4).

The Assessment of Recruit Motivation and Strength (ARMS) is a prospective study offering more individuals the opportunity to serve in the U.S. Army by allowing those who exceed body fat standards to enlist if they can pass a physical fitness test. Additional details on the study and findings on the risk of attrition among ARMS study subjects are published elsewhere (16). The purpose of this study was to compare the risk of heat illness by 90 d of service between subjects who exceeded body fat standards but passed the test and qualified individuals, examine risks of specific heat illnesses, and to assess healthcare utilization by each group.

METHODS

This study was reviewed and approved by the Walter Reed Army Institute of Research Institutional Review Board. To be included in the study, subjects had to be 18 or more years of age and provide written informed consent.

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Study Design and Population

All study subjects were active duty members of the U.S. Army who entered for the first time between February 2005 and September 2006 at six Military Entrance Processing Stations (MEPS): Atlanta, GA; Buffalo, NY; Chicago, IL; Sacramento, CA; San Antonio, TX; and San Diego, CA. Subjects were followed for 90 d after entry, as this approximates the 10-wk period of basic combat training, plus 1 to 2 wk spent in administrative in-processing prior to training initiation. During the study period all persons entering the Army through one of the study sites were required to take a preaccession physical fitness test (ARMS test) consisting of a 5-min step test and a minimum number of pushups to be completed in 1 min. Additional information on the fitness test is available elsewhere (17). Applicants exceeding weight for height and body fat percent limits (maximum of 30% for men and 36% for women during the study period) were required to pass the test before being allowed to enlist. If they passed they were given a waiver for accession.

The final status for waivers among those exceeding body fat standards was granted, recommended, or denied. Individuals granted the waivers exceeded body fat standards and passed the ARMS test. Individuals whose waiver status was either recommended (passed ARMS) or denied (failed ARMS) accessed at a later date after having lost enough weight and/or body fat to meet Army accession standards and, therefore, were not required to pass the ARMS test to access. Qualified applicants were also required to take the test, but they were not obligated to pass in order to access. These data were collected for study comparison purposes only. Their performance on the test had no impact on their enlistment eligibility.

The comparison groups in this study were based on the Army's two-tiered screen for weight and body fat (7). If an applicant was within the allowable accession weight for height for his or her age and gender, then this applicant was a "qualified" recruit (QR). The corresponding BMI based on maximum accession weight for height ranges from just under $25 \text{ kg} \cdot \text{m}^{-2}$ to $28.5 \text{ kg} \cdot \text{m}^{-2}$. Of note, a BMI between 25 and 30 is categorized as "overweight" by recognized criteria (15). If an applicant exceeded weight for height standards, body fat percentage was calculated by specific anatomic measurements and gender-specific formulae (6). For Army applicants, the maximum allowable body fat percentage varies by age and gender (7). A qualified applicant, for example, can be overweight or obese by BMI classification but pass the body fat screen. Therefore, this recruit would be considered "qualified." Applicants who failed both the weight for height and the body fat screen in this study were classified as having "excess body fat" (XBF).

Data Sources

Enlistment and discharge data were provided by the Center for Accession Research, U.S. Army Accession Command. Outpatient and inpatient medical encounter data were supplied by the U.S. Army Medical Command

Patient Administration Systems and Biostatistics Activity Standard Ambulatory Data Record and the Standard Inpatient Data Record, respectively. All diagnoses from each record and outpatient and admission data were captured.

Definition of Heat Illness

The endpoints included heat stroke (International Classification of Diseases, 9th Revision 992.0), heat exhaustion (992.3-5), and other heat illnesses: heat syncope (992.1), heat cramps (992.2), heat fatigue, transient (992.6), heat edema (992.7), other specified heat effects (992.8), and unspecified effects of heat and light (992.9). Exertional heat illnesses are those typically associated with strenuous activity. Because the recruits are in basic training, it is presumed that any heat illness would have occurred in the context of training and would, therefore, be an exertional heat illness. Basic training is approximately 10 wk long (9 wk of training plus approximately 1 wk at reception) and includes intense physical and combat training and field exercises. Although rhabdomyolysis can be a heat-related illness, it was excluded as an endpoint because there are many other causes that are not necessarily associated with heat exposure (20).

For evaluating the overall incidence we used the first medical encounter event with any of these diagnoses. Some individuals had repeated visits on the same day or had multiple records generated for the same visit for the same or other heat illness diagnoses. As it is possible for multiple records to be generated for a single visit, we considered records with a different heat illness primary diagnosis to reflect a separate health care encounter while those with the same primary diagnosis were not counted. For analyses of utilization, all individual medical encounters were captured and defined as all visits on separate days with any heat illness diagnosis or another visit on the same day with a different heat illness diagnosis. Incidence was defined as the number of events per 100 recruits within the first 90 d of military service while utilization was defined as the number of medical encounters per 100 person years follow-up.

Independent Variables

The primary predictor of interest was ARMS waiver status (XBF versus QR). Those who were recommended (passed ARMS) and those who were denied (failed ARMS) were included in the qualified group based on their meeting Army body fat accession standards prior to starting basic combat training. Other covariates of interest were recorded at the time of testing and included gender, age (18-19, 20-24, 25-29, and 30+ yr), race (black, white, or other), current use of tobacco products (no or yes: cigarettes, cigars, or smokeless tobacco), and BMI [underweight (< 18.5); normal weight (18.5-24.9); overweight (25-29.9); obese (> 30)] (15). Because there were so few heat events among women, they were excluded from the study analyses.

Outcome Variables

The outcome variables used included the first occurrence of any heat illness, each specific diagnosis, and the total number of ambulatory encounters for heat illness occurring in the study period. The number hospitalized with heat illness and length of stay in days during the study period was also evaluated.

Statistical Analysis

Comparisons between ARMS study groups (QR and XBF) were analyzed with Chi-square, Fisher's exact, *t*-test, or Wilcoxon as appropriate. Incidence was based on the first heat illness using the relative risk with 95% confidence interval (95% CI) to compare the risks between groups. While relative risk gives a measure of the strength of an association and causality, attributable risk denotes the additional risk of disease (heat illness) due to the exposure (being XBF) and attributable risk percent, a measure of the proportion of the incidence of heat illness due to exceeding body fat standards (12). Multiple logistic regression was used to calculate the adjusted odds ratio (OR) of heat illness among XBF relative to QR, controlling for the other variables.

The utilization rate ratio was calculated by dividing the rate among XBF recruits by the rate among QR, assuming a Poisson distribution of the utilization rates. Utilization rate is the ratio of incidence counts and the total service years within the given period for XBF recruits or for QR, respectively. All analyses were performed using SAS (SAS Institute, Cary, NC; version 9.1) (18).

RESULTS

As shown in **Table I**, almost 90% of male recruits were under 25 yr of age and 73% were white. There was no difference ($P > 0.10$) found in age between the XBF and

TABLE I. CHARACTERISTICS OF MALE STUDY SUBJECTS: RECRUITS WITH EXCESS BODY FAT VERSUS QUALIFIED RECRUITS.

Variables and Levels		Excess Body Fat	Qualified
		(N = 826)	(N = 8841)
		(%)	(%)
Age	18-19	43.8	44.6
	20-24	45.7	42.4
	25-29	8.8	9.7
Race*	30 and above	1.7	3.3
	White	73.9	73.2
	Black	7.5	12.0
	Other	18.6	14.8
BMI*	Underweight	0.0	2.7
	Normal	0.2	50.3
	Overweight	11.9	32.5
	Obese	87.9	14.5
Tobacco use*	Yes	24.0	28.1
	No	76.0	71.9

The Chi-square test was used to examine the distribution between ARMS study groups.

* Significance ($P < 0.05$).

QR groups in terms of mean (21.2 and 21.4, respectively) or median (20.3 for both). Differences in distribution were found between study groups for race and tobacco use. Mean body fat percent (SD) was 27.6 (2.0) in the XBF group, but was not obtained in the QR group as they met the weight for height standard. There were 47% of qualified recruits who were classified as overweight or obese by BMI, but met either the weight for height or the body fat standard. Mean BMI (SD) for XBF compared to QR was 32.9 (2.6) and 25.2 (4.2), respectively. Because BMI was highly correlated with ARMS status, it was not assessed in the same model.

There were 13 incident cases of heat illness among the XBF recruits (1.6%) and 38 among the QR (0.4%). As presented in **Table II**, the XBF group was at approximately 3.7 times higher risk of any heat illness compared to the QR group. When those who were recommended or denied an ARMS waiver and accessed as meeting body fat standards were excluded from the QR group, the relative risk increased to 4.16 (95% CI 2.18, 7.92) for any heat illness in the subjects. The heat incidence in male study subjects was 0.53%. The attributable risk of heat illness was 1.15 per 100 and the attributable risk percent of heat illness due to exceeding body fat standards was 73.2% in the subjects.

Mean BMI was compared among those with any heat illness to those with none, by ARMS status (QR and XBF) (results not shown). No significant differences were found. Among QR and BMI categories ($BMI \geq 25$ compared to < 25), the risk of heat illness was also not significant [relative risk: 1.12 (95% CI: 0.60, 2.12)]. XBF recruits had significantly higher utilization overall for all categories of heat illness (**Table III**), with a rate ratio greater than 7.

Table IV presents the adjusted OR among men for excess body fat, controlling for age, race, and tobacco use. Those who exceeded body fat standards had a greater than threefold increase in risk of heat illness. None of the control variables were significant risk factors.

There were three hospitalizations in the QR group and six in the XBF group within 90 d. The average length of stay was 3.3 and 1.7 d, respectively. Heat stroke was the diagnosis for one of the QR individuals and three of the XBF hospitalizations.

DISCUSSION

Although there were few events, we found that men exceeding the Army guidelines for body fat percent, but who passed the study physical fitness test, were at significantly increased risk of heat illness for each of the three categories of heat illness examined in this study and also had significantly higher medical utilization for heat illness. None of the control variables was significantly associated with heat illness. The study was designed as operational research, using all those who met Army accession weight and body fat standards and were not required to pass the ARMS test as the referent group compared to those who did not meet the standards but passed the ARMS test. When those who were recom-

TABLE II. INCIDENCE AND RELATIVE RISK OF HEAT ILLNESS AMONG MEN BY QUALIFICATION STATUS WITHIN 90 DAYS OF ENTRY.

Heat Illness Category*	Incidence Among Recruits with Excess Body Fat	Incidence Among Qualified Recruits	Relative Risk (95% CI)
	[N (%)]	[N (%)]	
Heat Stroke	4 (0.48)	2 (0.02)	21.41 (3.93, 116.9)
Heat Exhaustion	6 (0.73)	19 (0.21)	3.38 (1.35, 8.44)
Other Heat Illness	9 (1.09)	23 (0.26)	4.19 (1.94, 9.02)
All Heat Illness	13 (1.57)	38 (0.43)	3.66 (1.96, 6.85)

* Categories are not mutually exclusive.

mended for and those who were denied ARMS waivers (and were not required to pass the ARMS test because they later met the body fat or weight accession standard) were excluded from analysis the risk of any heat illness in the subjects increased by approximately 15%. These findings should be considered in future heat illness prevention research and operational planning related to accession and training of individuals who have any history of exceeding accession body fat standards.

Even though the total number of events was low, the increased likelihood associated with exceeding body fat standards has potentially important implications for the Army. This study involved 9875 men, of which 9% did not meet weight for height and body fat standards. The Army inducts approximately 80,000 men and women annually and the percent that are overweight or obese has been increasing. ARMS has been in effect as an Army-wide program since October 2005 for applicants who exceed body fat standards. If the findings from this study can be generalized to the entire recruit population, based on estimates of the attributable risk percent, it is possible that approximately 70% of the relative risk for heat illness in men during basic combat training will be associated with exceeding body fat standards. Given the overall heat illness incidence of 0.53% in male study subjects, this would reduce recruit training heat illness incidence to approximately 0.43%, assuming the study sample is representative of the male recruit training population.

There is no empirical data on the study physical fitness test used that demonstrates that it differentiates between overweight or obese individuals who are physically fit (and presumably at reduced risk of heat illness) and those who are not. Ethical considerations and human subjects' protection regulations precluded studying heat illness risk among recruits who are both unfit and overweight or obese, which would have allowed us

to isolate the impact of passing the fitness test among all XBF. Therefore, QR were considered the most appropriate comparison group available. Additional research is required to validate this screening tool to determine the optimal combination of duration (currently 5 min), step height, and tempo (currently one step every 2 s), to identify individuals who exceed current weight for height and body fat standards but who can successfully perform and survive in the physically demanding military environment. Based on our findings the test as currently operationalized does not adequately accomplish that task regarding the risk of heat illness among male recruits.

There were several limitations to this study. We were not able to determine the relative risk of heat illness among women as so few events were observed, particularly among those who exceeded body fat standards. We were also not able to link the incidence of heat illness to specific training conditions, either environmental conditions (temperature, humidity, light, and wind speed) or events (road marches, running, or other demanding activities). We were also not able to relate incident heat illness to BMI at the time of the event, as individuals may have lost or gained weight after accession. We did not have accession body fat percent on QR, as it is usually only obtained when an individual exceeds weight for height standards. Therefore, we could not consider the effect of body fat on the risk of heat illness.

Although qualified individuals passing the fitness test are at a statistically significantly increased risk of heat illness, the prudence of initiating and operating such a screening program cannot be determined with morbidity data alone. Changing the body fat standard, with fitness screening, allows more individuals to qualify for military service given the epidemic of obesity in the United States. Appropriate economic decision analyses should be conducted to determine the balance between

TABLE III. HEAT ILLNESS MEDICAL UTILIZATION* AMONG MALE RECRUITS BY QUALIFICATION STATUS WITHIN 90 DAYS OF ENTRY.

HI Category	Number of Visits		Visits per 100 person-yr		Rate Ratio	95% CI	
	Excess Body Fat	Qualified	Excess Body Fat	Qualified		Lower	Upper
All Heat	45	67	22.62	3.12	7.25	4.17	12.61
Heat Stroke	17	8	8.55	0.37	23.11	9.10	58.71
Exhaustion	9	26	4.52	1.21	3.74	1.58	8.82
Other HI	19	33	9.55	1.54	6.20	3.10	12.42

HI: heat illness.

* All outpatient encounters were considered, including same day visits.

TABLE IV. ADJUSTED ODDS RATIOS FOR HEAT ILLNESS IN MALE RECRUITS BY QUALIFICATION STATUS.

Variable	Level	Odds Ratio (95% CI)
Qualification Status	Qualified	Referent
	Excess Body Fat	3.63 (1.92–6.85)
Age (yr)	< 20	Referent
	≥ 20	0.91 (0.52–1.58)
Race	White and other	Referent
	Black	0.75 (0.27–2.10)
Tobacco Use	None	Referent
	Any	1.03 (0.54–1.94)

the risks and associated costs (including costs of training and lost duty time) and the benefits of a larger pool of potential military applicants. Longer follow-up of the ARMS cohort through the first tour of duty (3 to 5 yr of military service) and into deployment is essential. This research will allow the development of evidence-based accession weight for height and body fat standards to include minimizing morbidity related to the risk of heat illness in overweight and obese recruits.

In summary, this study indicates that there are significantly increased risks of any heat illness in each subcategory of heat illness among male XBF who passed the ARMS test pre-enlistment compared to QR regardless of performance on the ARMS test. There was also a significantly higher level of outpatient health care utilization among male recruits who exceeded body fat standards. We were not able to assess the risk of heat illness among female recruits due to sparse data. These results are consistent with previous military research showing increased risk of heat illness among overweight recruits. This study differs in that it evaluates a group exceeding body fat standards and it was not based solely on BMI categories. We will also continue to follow this cohort through its first tour of duty, with a focus on the specific types of heat-related illnesses and health care utilization.

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