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Abstract 24
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Methods: This retrospective cohort study included all recruits who entered U.S. Air Force basic 27 training between January 2009 and December 2014. Fitness parameters among recruits with and 28 without SCT were compared using a standardized fitness assessment of a 1.5-mile timed run, one 29 minute of push-ups, and one minute of sit-ups. Performance was further compared by stratifying 30 those with SCT by their hemoglobin S percentage (20-29.99%; 30-39.99%; and ≥40%). 31
Results: Of all recruits (N=210,442) who entered training during the surveillance period, 2,161 32 (1.0%) had SCT. After adjusting for age, sex, body mass index, and ambient temperature while 33 conducting the fitness assessment, recruits with SCT were slower on their initial run than their

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Association of Sickle Cell Trait and Hemoglobin S Percentage with Physical Fitness

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Abstract

Purpose: To determine the association between sickle cell trait (SCT) as a binary variable and hemoglobin S percentage as a stratified categorical variable on aerobic and anaerobic fitness.

Methods: This retrospective cohort study included all recruits who entered U.S. Air Force basic training between January 2009 and December 2014. Fitness parameters among recruits with and without SCT were compared using a standardized fitness assessment of a 1.5-mile timed run, one minute of push-ups, and one minute of sit-ups. Performance was further compared by stratifying those with SCT by their hemoglobin S percentage (20-29.99%; 30-39.99%; and ≥40%).

Results: Of all recruits (N=210,442) who entered training during the surveillance period, 2,161 (1.0%) had SCT. After adjusting for age, sex, body mass index, and ambient temperature while conducting the fitness assessment, recruits with SCT were slower on their initial run than their peers without SCT by a mean (standard error) of 23.7 (2.5) seconds ($p<0.001$), but they completed 0.7 (0.2) more push-ups ($p<0.01$) and 1.2 (0.2) more sit-ups ($p<0.001$). When retested six weeks later, recruits with SCT improved their run time by a margin of 8.8 (2.5) seconds over their peers without SCT ($p<0.001$). Baseline physical fitness was largely consistent across strata of hemoglobin S percentages; increased percentages were modestly correlated with faster run times ($R^2=0.369$) and fewer push-ups ($R^2=0.336$) and sit-ups ($R^2=0.136$).

Conclusion: As compared to their peers, recruits with SCT had inferior aerobic fitness and superior anaerobic fitness at the outset of basic training, but these gaps were small and narrowed over six weeks of training. Stratifying recruits by their hemoglobin S percentage did not dramatically change the strength or direction of association.

Key Words
Hemoglobinopathy; military training; recruits; aerobic fitness; anaerobic fitness

Introduction

Sickle cell trait (SCT) is a hemoglobinopathy that results from inheriting one copy of the normal *HbA* gene and one copy of the *HbS* variant. Although a benign carrier state in most cases,[1] SCT is associated with rhabdomyolysis[2-4] and sudden death[5-7] in settings of extreme and prolonged exertion, such as athletic competition and military training. This increased risk is thought to be mitigated, but not eliminated, by adequate hydration, proper work-rest balance, and safe acclimatization to the environment and activity level.[8] Universal pre-participation SCT screening is required by the National Collegiate Athletic Association for student-athletes and by the U.S. military services for enlisted recruits—with the exception of the U.S. Army, which selectively screens recruits entering special operation occupations.[2]

The survival advantage conferred by hemoglobin S (Hgb S) during infection with *P. falciparum* malaria is well-established.[9] Evidence for a performance advantage with SCT or Hgb S, however, is indirect at best. It is widely observed that sprinters with West African ancestry, where malaria and SCT are highly prevalent, have dominated modern Olympic sprint competition.[10-11] On the other hand, many elite endurance runners are of East African heritage (e.g., from Kenya and Ethiopia), where falciparum malaria is less common.[12] Efforts to isolate genetic markers for sprinting or endurance running performance have been relatively unsuccessful.[13,14] One evolutionary hypothesis is that the reduced oxygen-carrying capacity associated with Hgb S led to preferential development of anaerobic energy systems and preponderance of fast-twitch muscle fibers.[10]

Aerobic and anaerobic exercise discrepancies between those with and without SCT have been reported in several small trials, but their results are contradictory.[15] These contradictory findings may be explained by the known heterogeneity of Hgb S percentage within the SCT population,[16,17] although a correlation between Hgb S percentage and fitness has not been established. If it were, warfighters and athletes may be better aligned with sprinting or endurance activities. The current study investigates this question by evaluating the independent association of SCT and Hgb S percentage on various physical fitness measures among a large population of U.S. Air Force recruits.

Methods

All recruits who entered U.S. Air Force Basic Military Training (Joint Base San Antonio – Lackland, Texas) between January 2009 and December 2014 were included in this retrospective cohort study. Per local policy, recruits were universally screened for SCT with a sickle solubility test within five days of arrival; aliquots screening positive were reflexed to hemoglobin electrophoresis testing, which provides a complete hemoglobin percentage profile. During the first and last week of training—usually separated by six weeks—recruits completed the U.S. Air Force Fitness Assessment, which includes a 1.5-mile timed run, one minute of push-ups, one minute of sit-ups, and body composition measurements (height, weight, and abdominal circumference). In order to pass the assessment, recruits were required to pass each component and achieve a minimum total score, based on age- and sex-specific cutoffs.[18]

We queried the Trainee Health Squadron's SCT database for hemoglobinopathy laboratory results and merged these with data recorded in the U.S. Air Force Basic Training Management System (BTMS): age; sex; fitness assessment dates and results; and dates of training entry and exit (i.e., by graduation or separation). Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Run time was recorded in seconds, and push-ups and sit-ups were recorded as counts. Due to manual data entry into BTMS, fitness assessment data contain occasional errors; implausible results (run time <420 or >1,800 seconds,