Physical Fitness and Depressive Symptoms during Army Basic Combat Training

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ABSTRACT

CROWLEY, S. K., L. L. WILKINSON, L. T. WIGFALL, A. M. REYNOLDS, S. T. MURACA, S. H. GLOVER, N. R. WOOTEN, X. SUI, M. W. BEETS, J. L. DURSTINE, R. D. NEWMAN-NORLUND, and S. D. YOUNGSTEDT. Physical Fitness and Depressive Symptoms during Army Basic Combat Training. *Med. Sci. Sports Exerc.*, Vol. 47, No. 1, pp. 151–158, 2015. **Introduction**: Mental health-related problems are a significant cause of attrition during basic combat training (BCT). Evidence in civilian populations suggests that physical fitness is associated with psychological benefits in civilians, but little is known about the association between physical fitness and psychological adjustment during BCT. **Methods**: This study prospectively examined the association between physical fitness and depressive symptoms in 300 BCT soldiers from May to July 2012 at Fort Jackson, Columbia, SC. Soldiers completed a baseline Army Physical Fitness Test (APFT) and survey within 1 wk of arriving at BCT and an end-of-cycle survey after 8 wk of BCT. Soldiers were assigned to the "high" fitness category if they had a passing score on the standard APFT of greater than or equal to 180 out of 300 points. Soldiers scoring less than 180 points on the APFT were assigned to the "low" fitness category. Depressive symptoms were measured using the 20-item Center for Epidemiologic Studies Depression scale. **Results**: In multivariate analyses, adjusting for baseline demographics, self-reported sleep before BCT, BCT confidence, Army identification, and depressive symptoms, the odds of reporting depressive symptoms were 60% lower for soldiers in the high fitness category (odds ratio, 0.40; 95% confidence interval, 0.19–0.84) compared with soldiers in the low fitness category. **Conclusions**: Analogous to other positive outcomes of soldier fitness, improvement of soldier physical fitness before BCT might improve soldiers' psychological health outcomes.
Key Words: DEPRESSION, MENTAL HEALTH, MILITARY, RECRUITS, SOLDIERS, STRESS

United States (US) Army basic combat training (BCT) is a 10-wk military training course designed to indoctrinate new soldiers to Army values, lifestyle, and identity (14,20). Most new soldiers are young adults, for whom the BCT environment of intense and frequent mandatory physical training, communal living, regimented eating and sleeping schedules, and sleep deprivation (26) is a stark contrast to their previous home and school environments.

In comparison with most civilian environments, BCT is uniquely stressful for soldiers, most of whom are just beginning the transition to adulthood. Many new soldiers struggle with the abrupt entry into this physically and psychologically taxing environment, which may put them at risk for the development of adverse psychological health outcomes. Despite preenlistment medical screening (29), mental health-related problems are consistently listed as a significant cause of attrition during basic military training in the US armed services (14,17).

There is a need for investigation of factors associated with improving soldier resilience during BCT. A potential avenue of exploration in the BCT environment is the association between physical fitness and psychological health. Evidence from a large body of research in civilian populations suggests that physical fitness may have a protective role in reducing the adverse psychological effects of stress (8). For example, results from a recent cross-sectional study indicated that individuals with high stress and moderate-to-high

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levels of physical fitness reported lower levels of depressive symptoms than individuals with high stress and low levels of physical fitness (12). In addition, in civilian populations, cross-sectional studies have shown that individuals with high levels of physical activity or fitness are less likely to exhibit depressive symptoms (2,22), and prospective studies have shown that more physically active/fit individuals have less risk of development of depressive symptoms (10,33) compared with individuals who are sedentary or unfit.

The study of this association in soldiers during BCT is particularly relevant because of the unique nature of the BCT environment, which is perhaps more physically and mentally demanding than any other occupational training received by US civilians. A recent qualititative survey of mental health training in Army soldiers found that soldiers reported experiencing the most stress related to performance and physical demands of BCT (1). In this study, soldiers listed "building physical stamina/endurance and strength" before BCT entry as a top recommendation for new recruits in preparing for the stressors of BCT (1). Moreover, research indicates that individuals entering BCT with low levels of physical fitness are more susceptible to physical injury, illness, and early attrition from BCT (34). Importantly, a recent study has implicated physical fitness before BCT as potentially protective against the development of psychiatric illness after deployment in active-duty Army personnel (15). This study lends support for the role of physical fitness as a potential buffer against the development of adverse mental health sequelae under stressful military conditions and the potential for protective effects of physical fitness as early as the BCT environment; however, critical information about the psychological adjustment of those soldiers during BCT was not reported. To our knowledge, there has been no research of the association between physical fitness and psychological health outcomes of soldiers within the BCT environment.

The current study, therefore, was designed to examine the association of objectively measured physical fitness levels of soldiers at the start of BCT with the odds of reporting depressive symptoms near the end of the BCT cycle. Factors that have been associated with depressive symptoms in young adults, psychological adjustment of soldiers during BCT (17,21), or the association between physical fitness and depressive symptoms in young adults were considered potential confounders and were controlled for in assessing this association. On the basis of previous research conducted in civilian (10,33) and US military populations (15), we hypothesized that soldiers entering BCT with higher physical fitness levels would be less likely to report depressive symptoms near the end of the BCT cycle compared with soldiers with lower physical fitness levels.

METHODS

Study overview. The Soldier Health Promotion to Examine and Reduce Health Disparities project was a multicenter research initiative between the Institute for Partnerships to Eliminate Health Disparities at the University of South Carolina (USC) and Fort Jackson in Columbia, South Carolina (40). The overarching goals of the Soldier Health Promotion to Examine and Reduce Health Disparities project are to examine and analyze differences across race/ethnicity, age, gender, and residence-based disparities in weight management, injury prevention, and mental health support/treatment during all phases of the military (40). For the current study, soldiers were assessed longitudinally over the course of BCT at Fort Jackson in Columbia, SC.

Soldiers' physical fitness was assessed objectively at baseline (within a few days of starting BCT) via the standard Army Physical Fitness Test (APFT). For the current study, soldier demographics, and measures of mood, sleep, and behavioral characteristics were assessed at two time points: 1) a baseline survey administered to the soldiers within the first 2 wk of soldiers' arrival at Fort Jackson and 2) an end-of-cycle survey administered to soldiers approximately 8 wk after BCT began. Survey measurement was conducted from May to July 2012. Analysis for the current study included soldiers (ages, ≥18 yr; n = 300) who had complete data for the APFT, provided complete responses for all study variables for the baseline and end-of-cycle surveys, and indicated absence of depressive symptoms at baseline.

Soldiers were initially included in the study if they had complete APFT data to constitute a total physical fitness score (see "Baseline Fitness Assessment" section in the following part of the article) and participated in at least one survey assessment. Complete APFT data were available for 971 of 1149 soldiers who participated in the APFT at baseline. Of these 971 soldiers, 916 participated in at least one of the survey assessments. We excluded 376 soldiers because of missing data for any study variables from the baseline and/or end-of-cycle surveys, thus retaining 540 soldiers who had complete data for all study variables in all three assessments (APFT, baseline survey, and end-of-cycle survey). Of the 376 soldiers removed because of missing data, 33 of those who were absent from the end-of-cycle survey assessment failed to graduate from BCT, which indicates that those soldiers may have attrited from BCT during our study. Those soldiers who were removed because of missing data (n = 376) were significantly older (mean age, 22.63 yr (SD, 4.9)) compared with the soldiers with complete data (n = 540) for all measurement time points (mean age, 21.76 yr (SD, 3.7); t (874) = −3.02; P = 0.0026). No other significant differences were found for baseline demographic and behavioral characteristics between participants with complete data and those who were removed because of missing data. To investigate the longitudinal association of baseline physical fitness with incident depressive symptoms near the end of the BCT cycle, soldiers (n = 240) reporting clinically significant depressive symptoms on the baseline survey (defined by a total score of ≥16 on the Center for Epidemiologic Studies Depression scale (CES-D)), were excluded from the cohort for longitudinal analyses, resulting in a final sample size of n = 300 soldiers for the longitudinal analyses.

Baseline survey assessment duration was approximately 90 min, which included a detailed explanation of the study by research staff from the USC. Soldiers were informed that participation in the study was voluntary. Those soldiers who chose to participate in the study were invited to sign a written informed consent approved by the institutional review board at the USC and the Directorate for Research at Fort Jackson and the US Army Medical Research and Material Command. This study was performed in accordance with the ethical standards described in the Declaration of Helsinki.

The written informed consent briefing and document emphasized that participation in the study was confidential and voluntary. Soldiers were informed that they could stop participating at any time, that they could refuse to answer questions, and that there would be no penalties or consequences for not participating or refusing to answer questions. Soldiers who chose to participate in the study signed and dated the informed consent document, and all consent documents (completed or not) were collected without soldiers disclosing their participation decision. Company drill sergeants were asked to leave the room during this consent process but returned to the room during survey administration to maintain command and control. However, they were asked to remain a distance from soldiers during the survey process to protect soldiers' confidentiality while completing the surveys.

Baseline fitness assessment. Objectively measured physical fitness data were obtained via the APFT, a three-event physical performance test used to assess physical fitness in three domains: 1) cardiorespiratory fitness, 2) upper body muscular fitness, and 3) abdominal/core muscular fitness (16). The APFT involved three timed events performed in a sequential order, as follows: a push-up event (the number of repetitions completed in 2 min), a sit-up event (the number of repetitions completed in 2 min), and, lastly, a timed 2-mile run event. Soldiers were allowed a minimum of 10-min rest and a maximum of 20-min rest between each of the events. Raw scores on each of the three components of the APFT were converted to point values on the basis of Army normative data for age and gender to yield a maximum total score of 100 on each component test (38). The three component scores were then totaled to yield a maximum total score of 300 for the total APFT score. During BCT, the standard APFT passing score to graduate from BCT is a minimum of 50 points per component event and no less than 150 points for the overall APFT score (16). Soldiers are required to take the APFT at least twice per year throughout their Army careers after graduation from BCT. During their Army careers, a minimum of 60 points per component event and no less than 180 points for the overall APFT score are then required for a passing score (38). Considering the implications for Army career, and previous literature, which has shown protective association on mental health outcomes, in individuals in the highest 40% cardiorespiratory fitness category (33), "high" fitness was defined by an APFT score of ≥180 total points (out of 300) and "low" fitness was defined as an APFT score of <180 total points (out of 300) for the current analysis. The timed two-mile run component of the APFT has been shown to be highly correlated with maximal oxygen uptake ($\dot{V}O_{2max}$, 0.91 for men and 0.89 for women) (24), commonly considered the "gold standard" for measurement of cardiorespiratory fitness (35).

Baseline survey assessment. Covariates were chosen *a priori* on the basis of previous research implicating their potential role in confounding the association between physical fitness and depressive symptoms (26,32,33,39). Demographic covariates included age, sex, race, education level (last degree completed), marital status (married or not married), and family income (annual), and psychosocial covariates included baseline measures of self-reported sleep duration, identification with the Army, BCT self-efficacy, and depressive symptoms.

Average sleep duration for the 30-d period before BCT was assessed via the Pittsburgh Sleep Quality Index (PSQI), the most widely used measure of subjective sleep quality (5). The PSQI has been used previously for the assessment of sleep in soldiers during BCT (26). For this analysis, the sleep duration component score of the PSQI was collapsed from a four-category response variable into a conceptually meaningful dichotomized variable reflecting average self-reported sleep per night >7 or ≤7 h. Self-reported sleep duration of ≤7 h per night in young adults has been associated with increased psychological distress (13) and has been identified as an independent risk factor in the persistence of psychological distress prospectively (13).

Army identification (Army ID) was measured using a five-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Army ID has been associated with psychological attachment to the Army and cognitively ambitious, achievement-oriented pursuits (19), which have implications for psychological adjustment of soldiers during BCT. Sample questions from the Army ID scale included, "The Army has a great deal of personal meaning to me", and "The Army's values are my values." Negative items from the scale were reverse-scored, and the sum of the scale was averaged across the number of items to obtain a total score from 1 to 5. Higher scores indicated a stronger identification with the Army. Internal consistency reliability (Cronbach alpha) of the nine items was 0.84.

BCT self-efficacy was conceptualized using the BCT confidence scale. The BCT confidence scale consisted of a five-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The BCT self-efficacy measure was included as a potential confounder because self-efficacy beliefs have been associated with the effect of physical training on mental health (39). Example questions from the BCT confidence scale included "I have what it takes to succeed in BCT", "Based on my ability and the amount of work I do, I think I will excel in BCT", and "Physically, I'm not strong enough to succeed in BCT." Negative items from the scale were reverse-scored, and the sum of the questionnaire was averaged across the number of items to obtain a

total score from 1 to 5. Higher scores indicated higher confidence for succeeding in BCT. Cronbach alpha of the nine items was 0.84.

Baseline depressive symptoms were assessed using the 20-item version of the CES-D. This self-report scale is designed to measure depressive symptoms in the general population (28) and has been validated for use in military populations (3). The range of possible scores is 0–60, with higher scores indicating a higher degree of depressive symptoms (28). Cronbach alpha of the 20-item CES-D was 0.81.

Assessment of outcome. For this analysis, presence or absence of depressive symptoms at the end of the BCT cycle was determined using soldiers' self-reported CES-D scores from the end-of-BCT-cycle survey. A score of ≥16 indicated presence of depressive symptoms. This cut point has been extensively used in the general population and in military populations to indicate the presence of significant depressive symptomatology (3,28).

Statistical analysis. Descriptive statistics (means, SD, and proportions) were used to describe demographic and behavioral characteristics of the study population separately for high- and low-APFT fitness soldiers. *t*-tests and chi-square tests were used to compare the means of continuous variables and the prevalence of categorical variables, respectively, between participants in APFT fitness categories.

Logistic regression analyses were conducted to test whether APFT fitness category at baseline was associated with the odds of reporting depressive symptoms at the end of the BCT cycle. Three multivariate models were tested. Model 1 was unadjusted. Model 2 controlled for age, sex, race, education level, marital status, family income (annual), BCT confidence score, and Army ID score. Model 3 adjusted for all variables in model 2 plus self-reported average sleep duration before BCT and baseline depressive symptoms. All *P* values reported were two-sided with an alpha level of 0.05. All statistical analyses were performed using SAS 9.3 (SAS Institute, Inc., Cary, NC).

RESULTS

Table 1 presents the demographic and baseline behavioral characteristics of study participants. Soldiers ranged in age from 18 to 35 yr (mean, 22.0 yr (SD, 3.7)), and 22.3% were female. At baseline, 34.7% ($n = 104$) and 65.3% ($n = 196$) of soldiers were categorized into the "low" (APFT, <180) and "high" (APFT, ≥180) fitness categories, respectively. APFT scores for the high fitness soldiers ranged from 180 to 300 points, with a mean score of 220.1 (SD, 25.5), and APFT scores for the low fitness soldiers ranged from 60 to 179, with a mean score of 149.8 points (SD, 25.6). Mean APFT for the total study sample was 195.7 (SD, 42.1).

There were significant differences between fitness categories in Army ID scores, $t\ (298) = -2.38$, $P = 0.018$, and BCT confidence scores, $t\ (298) = -6.04$, $P < 0.0001$, indicating that high fitness soldiers were more likely to report a higher degree of identification with the Army and higher BCT confidence at baseline. No other baseline differences were detected between APFT fitness categories.

TABLE 1. Baseline characteristics of study participants by APFT fitness categories.

Characteristic	Low[a]	High[b]	*P* values
Participants, *n* (%)	104 (34.67)	196 (65.33)	—
Age (yr) (mean ± SD)	21.61 ± 3.22	22.24 ± 3.90	0.130
Sex			0.606
Male, *n* (%)	79 (75.96)	154 (78.57)	
Female, *n* (%)	25 (24.04)	42 (21.43)	
Ethnicity			0.863
Non-Hispanic, *n* (%)	90 (86.54)	171 (87.24)	
Hispanic, *n* (%)	14 (13.46)	25 (12.76)	
Race			0.500
Black, *n* (%)	28 (26.92)	41 (20.92)	
White, *n* (%)	60 (57.69)	123 (62.76)	
Other, *n* (%)	16 (15.38)	32 (16.33)	
Education			0.265
High school degree, *n* (%)	42 (40.38)	73 (37.24)	
Associate degree or some college, *n* (%)	53 (50.96)	93 (47.45)	
College degree or higher, *n* (%)	9 (8.65)	30 (15.31)	
Marital status			0.382
Married, *n* (%)	14 (13.46)	34 (17.35)	
Not married, *n* (%)	90 (86.54)	162 (82.65)	
Family income (annual)			0.419
"I don't know", *n* (%)	8 (7.69)	23 (11.73)	
<$25,000, *n* (%)	28 (26.92)	57 (29.08)	
$25,000–$50,000, *n* (%)	16 (15.38)	31 (15.82)	
$50,000–$75,000, *n* (%)	13 (12.5)	13 (6.63)	
>$75,000, *n* (%)	39 (37.50)	72 (36.73)	
Sleep duration			0.261
≤7 h, *n* (%)	21 (20.19)	51 (26.02)	
>7 h, *n* (%)	83 (79.81)	145 (73.98)	
CES-D (mean ± SD)	9.50 ± 3.84	9.52 ± 3.48	0.972
Army ID (mean ± SD)	4.20 ± 0.56	4.36 ± 0.55	0.018
BCT confidence (mean ± SD)	4.25 ± 0.52	4.58 ± 0.42	<0.0001

[a]APFT total score, < 180.
[b]APFT total score, ≥ 180.

TABLE 2. Correlation matrix of major study variables.

	Age	Sex	Race	Education Level	Marital Status	Family Income	Sleep Duration	CES-D	Army ID	BCT Confidence	APFT
Age	—										
Sex	−0.043										
Race	0.017	0.070									
Education level	0.420*	−0.173**	−0.038								
Marital status	0.309*	−0.028	−0.010	0.117**							
Family income	−0.145**	−0.057	0.005	−0.066	−0.136**						
Sleep duration	−0.031	−0.095	0.064	0.006	−0.010	−0.034					
CES-D	0.008[a]	−0.047	−0.004	−0.023	0.050	−0.044	0.009				
Army ID	0.075[a]	−0.033	−0.034	−0.047	0.058	−0.006	−0.057	−0.211*,[a]			
BCT confidence	0.103[a]	0.087	−0.125**	−0.008	0.114**	−0.008	−0.106	−0.237*,[a]	0.370*,[a]		
APFT	0.055	0.030	0.055	0.062	0.050	−0.054	−0.065	−0.006	0.141**	0.322*	—

CES-D indicates baseline total score.
All values represent Spearman correlation test (except when denoted with [a]).
[a]Pearson correlation test.
*$P < 0.0001$.
**$P < 0.05$.

There were no major study variables with a correlation coefficient greater than 0.5 or less than −0.5, indicating absence of multicolinearity between the major study variables (Table 2). Table 3 displays the number of soldiers in each of the APFT fitness categories, the number of soldiers reporting depressive symptoms at the end of BCT cycle survey, and the odds ratios (OR) and 95% confidence intervals (CI) for depressive symptoms for the three logistic regression models. The unadjusted results from model 1 indicate that the odds of reporting depressive symptoms near the end of the BCT cycle were 60% lower for the high fitness with the low fitness soldiers (OR, 0.40; CI, 0.21–0.77).

Model 2 adjusted for age, sex, race, education level, marital status, family income (annual), BCT confidence score, and Army ID score. Results from model 2 indicate that the odds of reporting depressive symptoms near the end of the BCT cycle were 57% lower for the high fitness compared with the low fitness soldiers (OR, 0.43; CI, 0.21–0.89).

The results from model 3 show essentially the same association between physical fitness category and odds of reporting depressive symptoms near the end of BCT after adjustment for the variables in model 2 plus self-reported sleep duration before BCT ≤7 h per night (yes or no) and baseline depressive symptomatology. In model 3, the odds of reporting depressive symptoms near the end of BCT were 60% lower for the high fitness compared with that for the low fitness soldiers (OR, 0.40; CI, 0.19–0.84).

DISCUSSION

Summary of findings. Results show that, compared with soldiers who began BCT in the low fitness category, soldiers who began BCT in the high fitness category had significantly lower odds of reporting depressive symptoms near the end of BCT. These findings are consistent with results from recent prospective studies conducted in civilian populations, which show inverse association between cardiorespiratory fitness level and odds of reporting depressive symptoms in healthy individuals (10,33) and odds of reporting depressive symptoms in individuals who have high levels of chronic stress (12).

Physical fitness is recognized by the Army as one of the key components of increasing resiliency in soldiers throughout their military careers (7). However, unlike other factors related to the "psychological fitness" of soldiers during BCT, the psychological benefits of physical fitness have been largely ignored with respect to assessment and interventions before and during BCT (25). Because BCT is designed to develop the mental and physical stamina needed to sustain the rigors of military service and combat, examining factors which could build resilience to behavioral health problems during BCT has great significance for military health and combat readiness. New soldiers are eligible for deployment for combat operations after completing BCT and advanced individual training, and knowing soldiers' response to BCT stressors is important for prevention of chronic stress reactions and subsequent health problems. Physical fitness might therefore provide a potential target for preventive interventions aimed at increasing resiliency to BCT stressors and reducing attrition during BCT and during soldiers' military careers. Identifying soldiers with low physical fitness levels before BCT could assist the Army in implementing resiliency-enhancing programs for soldiers, which may reduce adverse reactions to BCT stressors. Focusing on physical fitness levels at BCT entry

TABLE 3. OR and 95% CI for end-of-cycle depressive symptoms according to baseline APFT fitness categories.

				Model 1[a]	Model 2[b]	Model 3[c]
APFT fitness category	*n*	Cases	Incidence (%)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Low (APFT score, <180)	104	23	22.1	1.0 (referent)	1.0 (referent)	1.0 (referent)
High (APFT score, ≥180)	196	20	10.2	0.40 (0.21–0.77)	0.43 (0.21–0.89)	0.40 (0.19–0.84)

n indicates sample size; cases indicates individuals with CES-D score ≥16 on CES-D the equivalent survey.
[a]Model 1, unadjusted model.
[b]Model 2, adjusted for age, sex, race, education level, marital status (married/not married), family income (annual), BCT confidence, and Army ID.
[c]Model 3, adjusted for all variables in model 2 plus baseline CES-D score, self-reported average sleep duration before BCT ≤7 h per night (yes or no).

could assist the Army in the development of preventive interventions, which could be beneficial for soldiers early during the BCT cycle. Early identification and intervention could potentially reduce mental health-related BCT attrition, which has significant implications for Army recruitment and military health and readiness.

Potential mechanisms. Both animal and human studies suggest that regular exercise training may lead to adaptations in the hypothalamic pituitary adrenal axis and the sympathetic nervous system in response to physical and psychological stressors (for a review, see 36). Indeed, research has indicated that the antidepressant effects of regular exercise training might be mediated through neurobiological adaptations, (e.g., increased availability of neurotransmitters including serotonin and dopamine, attenuated hypothalamic pituitary adrenal axis reactivity to stressors), which may be protective against the deleterious psychological effects of stress (for a review, see 36). In addition, studies have shown positive adaptations in the cardiovascular stress response, including faster recovery after exposure to a psychosocial stressor, in individuals who are physically fit compared with individuals who are sedentary (for reviews, see 30,36). Adaptations resulting from regular physical exercise training might therefore positively affect physiological adaptations to psychological stressors (31,32,36). Although not measured in the current study, a reduced physiologic sensitivity to BCT stressors may be one mechanism by which physical fitness may serve to buffer the deleterious effects of BCT stress in those soldiers who enter BCT with higher levels of physical fitness.

Psychological mechanisms hypothesized to underlie the psychological benefits of physical training in civilian populations include increased self-efficacy (39), coping self-efficacy (39), self-esteem (39), and increased mental toughness (11). Mental toughness, which is characterized by the capacity to be successful in coping with the stress and anxiety of challenging situations (11), may be another key component of resilience during BCT. Soldiers entering BCT with high levels of physical fitness might likewise be better equipped to cope with and adjust to the physical and mental stressors of BCT. Indeed, previous research has shown that higher self-efficacy during BCT may be associated with reduced levels of perceived stress (9) and reduced hostility and depression during BCT (9). Previous research in civilians has also shown positive association between regular participation in moderate- to vigorous-intensity physical activity and increased mental toughness in young adults (11). Future research is needed to further examine the protective and mediating effects of physical fitness on psychological health outcomes in soldiers and the role of physical fitness in resilience to BCT and other military stressors.

Analogous to associations with greater susceptibility to injury and illness, lower physical fitness is also likely associated with greater soldier susceptibility to overtraining syndrome (OTS). OTS occurs in response to a sudden and repeated increase in exercise load beyond one's customary level and is associated with adverse psychological health symptomatology (23). Although not assessed in the current study, the influence of physical training before BCT on the development of OTS during BCT may provide an additional mechanism by which soldiers' physical fitness levels at BCT entry could affect the psychological adjustment of soldiers during BCT.

Strengths and limitations. This study has several strengths, which add to the existing literature on the association between physical fitness and psychological adjustment to stress. First, to our knowledge, this is the first study on the association between physical fitness and depressive symptoms among soldiers during BCT.

Second, by conducting the study at Fort Jackson, the largest and most active Initial Entry Training Center in the US Army, soldiers in this study were representative of Army BCT soldiers. According to the US Army Training Center, Fort Jackson holds the distinction of training 50% of all soldiers, including 60% of all female soldiers entering the Army each year (37).

Third, this study used a standardized objective measure of physical fitness, whereas the majority of existing population-based studies have primarily relied on self-reported measures of physical activity (6,32). Fourth, this study controlled for covariates that may confound the association between physical fitness and depressive symptoms among BCT soldiers. In this study, Army ID and BCT self-efficacy were examined as covariates and those soldiers exhibiting depressive symptoms at baseline were excluded from the analysis. As such, we attempted to control for soldier personality types, which might predispose certain individuals to the development of depressive symptoms during BCT.

There were also limitations of this study. First, our *a priori* decision to use the total APFT score of 180 to define high and low fitness may not have adequately characterized a subset of soldiers ($n = 31$) who scored ≥180 on the APFT but who, according to Army BCT standards, actually failed the APFT because they scored less than 50 on one of the three components of the APFT. Failing the APFT may have had a negative psychological effect on these soldiers. However, most of these soldiers (19/31) missed the passing score of 50 on one component event of the APFT by ≤5 points (e.g., 1–4 sit-ups), an improvement likely attainable by the end of BCT. Moreover, we attempted to control for this confound with covariates for BCT confidence and baseline depressive symptoms.

Second, although the CES-D is a valid measure of depressive symptoms in both young adults and military populations (3,27), it is not a clinical diagnostic tool for depression. The CES-D was originally developed to identify individuals with apparently clinically significant depressive symptoms who require more intensive evaluation (28). Although the CES-D has been used in previous population-based studies to measure depressive symptoms (10,33), the CES-D data in this study should be interpreted with caution.

Third, although the prospective design of the study had advantages over cross-sectional designs, the measurements

included in this analysis were made at only two time points—near the beginning and end of BCT. Stressors experienced during BCT vary across the BCT cycle. Near the beginning of BCT, soldiers endure a stressful indoctrination process, there is a need to process a large amount of new information in a short period, and performance expectations are higher. In contrast, during the final phase of the BCT cycle, soldiers have more autonomy and less drill sergeant supervision. Therefore, soldiers reporting depressive symptoms near the end of BCT may not be reflective of all soldiers who might have exhibited depressive symptoms earlier during BCT. Thus, inclusion of a midpoint measurement of depressive symptoms may have resulted in more variability in CES-D scores over the BCT cycle and the potential to detect a curvilinear relationship relation between physical fitness levels at BCT entry and depressive symptoms at the end of the BCT cycle.

Although BCT soldiers engage in essentially identical physical training regimens during the highly structured BCT environment, because they must qualify on the same tasks (18), some soldiers in the low fitness group for the current study could have been assigned to remedial physical fitness training (17) and thus exercised more frequently than the high fitness group over the course of the study. The current study did not assess physical training over the course of BCT. However, our finding of an inverse association between initial physical fitness levels at BCT entry and depressive symptoms near the end of the BCT cycle, even in light of the potential for higher frequency of exercise training in those soldiers with lower initial fitness levels, lends further support for preaccession physical fitness as a potentially important factor in the psychological adjustment of soldiers during BCT.

Moreover, the scheduling of our baseline survey measurement, which required coordinated scheduling within the complexity and context of the BCT environment, may have captured some soldiers who, within a couple of weeks of the start of BCT, were already experiencing adverse psychological effects of stress. Our finding that 44.4% ($n = 240$) of the 540 soldiers with complete study data were excluded because of depressive symptoms at baseline indicates that future studies should strive to capture this measurement before BCT entry. In addition, survey responses at the end of BCT may not have been representative of all BCT soldiers, considering BCT attrition rates of approximately 4% that have previously been reported (34). We attempted to minimize selection bias by recruiting a large and representative sample at the study onset, anticipating both soldier attrition and potential missing data at follow up. No significant differences were found for baseline demographic and behavioral characteristics between participants with complete survey and APFT data and participants with missing data who were excluded from the analysis, except for age differences. We observed that those soldiers who were removed because of missing data were significantly older (mean age, 22.63 yr (SD, 4.9)) compared with the 540 soldiers with complete data for all three measurement time points (mean age, 21.76 yr (SD, 3.7); t (874) = −3.02; $P = 0.0026$).

A fourth limitation of this study may exist in the survey procedures. Although efforts were made to assure soldiers that their survey answers would remain anonymous, completion of the survey at Fort Jackson in the presence of drill sergeants could have had an influence on survey responses, social desirability, or the willingness of the BCT soldiers to candidly answer survey questions. Indeed, there remains a stigma of perceived "weakness" associated with mental illness in the military and a fear of jeopardizing one's military career by reporting mental health-related issues (4). Thus, measurement of depressive symptoms in this study may have resulted in a conservative estimate of the prevalence of these symptoms. Considering these limitations, we advise caution when interpreting the results of this study.

CONCLUSIONS

Our finding of an inverse association between physical fitness levels of soldiers at BCT entry and depressive symptoms near the end of the BCT cycle provides important insight into the potential role of physical fitness as a method to increase resilience and improve psychological health outcomes of soldiers during the intensely stressful environment of BCT. These results are consistent with previous cross-sectional and longitudinal studies, which show inverse association between physical fitness and the development of adverse mental health sequelae in civilian populations. Further research is needed to better understand this association in military training environments, where interventions such as preparative or graded physical training, could inform future military policies and practices aimed at improving the psychological health of soldiers during BCT.

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REFERENCES

1. Adler AB, Delahaij R, Bailey SM, et al. NATO survey of mental health training in army recruits. *Mil Med*. 2013; 178:760–6.
2. Azar D, Ball K, Salmon J, Cleland V. The association between physical activity and depressive symptoms in young women: a review. *Mental Health Phys Act*. 2008;1:82–8.
3. Boisvert JA, McCreary DR, Wright KD, Asmundson GJ. Factorial validity of the center for epidemiologic studies-depression (CES-D) scale in military peacekeepers. *Depress Anxiety*. 2003;17:19–25.
4. Britt TW, Greene-Shortridge TM, Castro CA. The stigma of mental health problems in the military. *Mil Med*. 2007;172:157–61.
5. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatr Res*. 1989;28:193–213.
6. Camacho TC, Roberts RE, Lazarus NB, Kaplan GA, Cohen RD. Physical activity and depression: evidence from the Alameda County Study. *Am J Epidemiol*. 1991;134:220–31.
7. Casey GW Jr. Comprehensive soldier fitness: a vision for psychological resilience in the U.S. Army. *Am Psychol*. 2011;66:1–3.
8. Conn VS. Depressive symptom outcomes of physical activity interventions: meta-analysis findings. *Ann Behav Med*. 2010;39:128–38.
9. Davis TW. Effects of stress, coping style, and confidence on basic combat training performance, discipline, and attrition [dissertation]. Blacksburg (VA): Virginia Polytechnic Institute, 2006. p. 48–50, 69–71. Available from: http://scholar.lib.vt.edu/theses/available/etd-03252006-135019/.
10. Dishman RK, Sui X, Church TS, Hand GA, Trivedi MH, Blair SN. Decline in cardiorespiratory fitness and odds of incident depression. *Am J Prev Med*. 2012;43:361–8.
11. Gerber M, Kalak N, Lemola S, et al. Adolescents' exercise and physical activity are associated with mental toughness. *Mental Health Phys Act*. 2012;5:35–42.
12. Gerber M, Lindwall M, Lindegård A, Börjesson M, Jonsdottir IH. Cardiorespiratory fitness protects against stress-related symptoms of burnout and depression. *Patient Educ Couns*. 2013;93:146–52.
13. Glozier N, Martiniuk A, Patton G, et al. Short sleep duration in prevalent and persistent psychological distress in young adults: the DRIVE study. *Sleep*. 2010;33:1139–45.
14. Gold MA, Friedman SB. Cadet basic training: an ethnographic study of stress and coping. *Mil Med*. 2000;165:147–52.
15. Gubata ME, Urban N, Cowan DN, Niebuhr DW. A prospective study of physical fitness, obesity, and the subsequent risk of mental disorders among healthy young adults in army training. *J Psychosom Res*. 2013;75:43–8.
16. Knapik J. The Army Physical Fitness Test (APFT): a review of the literature. *Mil Med*. 1989;154:326–9.
17. Knapik JJ, Jones BH, Hauret K, Darakjy S, Piskator E. *A Review of the Literature on Attrition from the Military Services: Risk Factors for Attrition and Strategies to Reduce Attrition (USACHPPM Report No: 12-HF-01Q3A-04)*. Aberdeen Proving Ground (MD): Army Center for Health Promotion and Preventative Medicine; 2004. p. 15–20; 57–61.
18. Knapik JJ, Sharp MA, Canham-Chervak M, Hauret K, Patton JF, Jones BH. Risk factors for training-related injuries among men and women in basic combat training. *Med Sci Sports Exerc*. 2001; 33(6):946–54.
19. Mael FA, Ashforth BE. Loyal from day one: biodata, organizational identification, and turnover among newcomers. *Personnel Psychol*. 1995;48:309–33.
20. Martin PD, Williamson DA, Alfonso AJ, Ryan DH. Psychological adjustment during Army basic training. *Mil Med*. 2006;171:157–60.
21. McGraw RK, Bearden DL. Motivational and demographic factors in failure to adapt to the military. *Mil Med*. 1988;153:325–8.
22. McKercher CM, Schmidt MD, Sanderson KA, Patton GC, Dwyer T, Venn AJ. Physical activity and depression in young adults. *Am J Prev Med*. 2009;36:161–4.
23. Meeusen R, Duclos M, Foster C, et al. Prevention, diagnosis, and treatment of the overtraining syndrome: joint consensus statement of the European College of Sport Science and the American College of Sports Medicine. *Med Sci Sports Exerc*. 2013;45(1):186–205.
24. Mello RP, Murphy MM, Vogel JA. *Relationship between the Army Two Mile Run Test and Maximal Oxygen Uptake*. Natick (MA): US Amy Research Institute of Environmental Medicine; 1984. p. 9–12.
25. Meredith LS, Sherbourne CD, Gaillot S, et al. *Promoting Psychological Resilience in the U.S. Military*. Santa Monica (CA): Rand National Defense Research Institute; 2011. p. 26,43,53–63,69.
26. Miller NL, Tvaryanas AP, Shattuck LG. Accommodating adolescent sleep-wake patterns: the effects of shifting the timing of sleep on training effectiveness. *Sleep*. 2012;35:1123–36.
27. Radloff LS. The use of the Center for Epidemiologic Studies Depression Scale in adolescents and young adults. *J Youth Adolesc*. 1991;20:149–66.
28. Radloff LS. The CES-D Scale: a self-report depression scale for research in the general population. *Appl Psychol Meas*. 1977;1:385–401.
29. Ritchie EC, Cardona RA. U.S. military enlisted accession mental health screening: history and current practice. *Mil Med*. 2007; 172:31–5.
30. Salmon P. Effects of physical exercise on anxiety, depression, and sensitivity to stress: a unifying theory. *Clin Psychol Rev*. 2001; 21:33–61.
31. Sothmann MS, Buckworth J, Claytor RP, Cox RH, White-Welkley JE, Dishman RK. Exercise training and the cross-stressor adaptation hypothesis. *Exerc Sport Sci Rev*. 1996;24:267–87.
32. Ströhle A, Hofler M, Pfister H, et al. Physical activity and prevalence and incidence of mental disorders in adolescents and young adults. *Psychol Med*. 2007;37:1657–66.
33. Sui X, Laditka JN, Church TS, et al. Prospective study of cardiorespiratory fitness and depressive symptoms in women and men. *J Psychiatr Res*. 2009;43:546–52.
34. Swedler DI, Knapik JJ, Williams KW, Grier TL, Jones BH. Risk factors for medical discharge from United States Army Basic Combat Training. *Mil Med*. 2011;176:1104–10.
35. Thompson WR, Gordon NF, Pescatello LS. *ACSM's Guidelines for Exercise Testing and Prescription*. 8th ed. New York (NY): Lippincott Williams & Wilkins; 2009. p. 72–85.
36. Tsatsoulis A, Fountoulakis S. The protective role of exercise on stress system dysregulation and comorbidities. *Ann N Y Acad Sci*. 2006;1083:196–213.
37. US Army Training Center. About Fort Jackson. [cited 2013 May 2]. Available from: http://www.jackson.army.mil/sites/info/; 2013.
38. US Department of the Army. *Physical Fitness Training Field Manual 7-22*. Washington (DC): Department of the Army; 2012. p. A-1, A-21–24.
39. White K, Kendrick T, Yardley L. Change in self-esteem, self-efficacy and the mood dimensions of depression as potential mediators of the physical activity and depression relationship: exploring the temporal relation of change. *Mental Health Phys Act*. 2009;2:44–52.
40. Williams EM, Lee MD, Preston G, et al. Development of the Soldier Health Promotion to Examine and Reduce Health Disparities (SHPERHD) project coordinating center: challenges and opportunities within a university/community partnership. *Mil Med*. 2011;176:757–62.