Positive Effects of Basic Training on Cognitive Performance and Mood of Adult Females

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**Objective:** This study investigated whether a stressful military training program, the 9- to 10-week U.S. Army basic combat training (BCT) course, alters the cognitive performance and mood of healthy young adult females.

**Background:** Structured training programs including adolescent boot camps, sports training camps, learning enrichment programs, and military basic training are accepted methods for improving academic and social functioning. However, limited research is available on the behavioral effects of structured training programs in regard to cognitive performance and mood.

**Method:** Two separate, within-subject studies were conducted with different BCT classes; in total 212 female volunteers were assessed before and after BCT. In Study 1, Four-Choice Reaction Time, Match-to-Sample, and Grammatical Reasoning tests were administered. The Psychomotor Vigilance Test (PVT) was administered in Study 2. The Profile of Mood States (POMS) was administered in both studies.

**Results:** In Study 1, reaction time to correct responses on all three of the performance tests improved from pre- to post-BCT. In Study 2, PVT reaction time significantly improved. All POMS subscales improved over time in the second study, whereas POMS subscales in the first study failed to meet criteria for statistically significant differences over time.

**Conclusion:** Cognition and mood substantially improved over military basic training. These changes may be a result of structured physical and mental training experienced during basic training or other factors not as yet identified.

**Application:** Properly structured training may have extensive, beneficial effects on cognitive performance and mood; however, additional research is needed to determine what factors are responsible for such changes.

**Keywords:** army, stress fatigue, depression, reaction time, vigilance, learning, boot camp, structured training, soldiers

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**INTRODUCTION**

The transition from civilian to military life requires adaptation to a novel way of life that includes intense and continuous supervision, mandatory physical training, group living, institutional feeding, separation from family and friends, and strict discipline. This transition is stressful as demonstrated by elevated levels of self-reported anxiety and the stress hormone cortisol at the start of basic combat training (BCT; Lieberman, Kellogg, & Bathalon, 2008). Basic training typically occurs at a time in life, late adolescence and early adulthood, of rapid development and substantial vulnerability (Lieberman, Kellogg, et al., 2008; Vickers, Hervig, Walton-Paxton, Kanfer, & Ackerman, 1997).

U.S. Army BCT, like most military basic training courses, is designed to improve the physical fitness and cognitive and social skills of recruits so they can effectively perform their duties (U.S. Department of the Army, 2007, 2010). Key objectives of this training include ensuring recruits will work effectively as a team and follow orders. A fundamental goal of basic training is ensuring recruits are committed to collective group values and behave accordingly (McGurk, Cotting, Britt, & Adler, 2006). Recruits are supervised by drill sergeants who create an environment of intense discipline and continuously monitor their performance and most other aspects of behavior. This training environment is designed to transform recruits into soldiers who are competent to perform their assigned duties and committed to their organization (McGurk et al., 2006; U.S. Department of the Army, 2010).

The U.S. Army BCT course is 9 to 10 weeks long and includes aerobic and muscular strength
and endurance training. Physical training sessions are structured and occur 4 to 6 days per week for 1 to 1.5 hr. Aerobic training includes activities such as running, sprinting, and marching. Strength and endurance training includes activities such as calisthenics, sit-ups, and push-ups. Recruits also participate in activities such as rappelling, obstacle course running, and prolonged standing in formation as well as other physically demanding activities (Knapik et al., 2003).

In addition to physical training, BCT develops practical skills that appear to have substantial cognitive components, such as land navigation, marksmanship, battle drills, and simulated casualty evacuations. These activities are intended to develop cognitive capabilities such as decision making, problem solving, and situational analysis. Most of these activities require integration of multiple cognitive functions. For example, skills such as memorization, problem solving, decision making, and rapid responding to relevant stimuli are implicit aspects of training soldiers to react to simulated battle scenarios. During actual military operations, soldiers must quickly make many complex decisions to ensure mission success (McGurk et al., 2006).

The effects of structured military training programs on specific aspects of cognitive performance, such as reaction time, vigilance, learning, memory, and reasoning, of either adolescents or young adults have not been extensively examined, although we have demonstrated that mood state substantially improves in young women participating in one especially rigorous form of U.S. military basic training, U.S. Marine Corps BCT (Lieberman, Kellogg, et al., 2008; Lieberman, Kellogg, Kramer, Bathalon, & Lesher, 2011). Over this 12-week-long course, various aspects of mood, such as vigor, fatigue, and depression, assessed by a validated self-report questionnaire, gradually improved. Research findings from numerous nonmilitary domains such as nutrition, psychopharmacology, and environmental medicine suggest improved mood state is often associated with improved cognitive performance and that degraded mood is associated with impaired cognitive function. However, the strength of the associations observed varies from study to study depending on the specific aspects of mood and performance examined (Childs & de Wit, 2008; Fiedler, 2005; Fogt, Kalns, & Michael, 2010; Lieberman et al., 2005; Lieberman, Tharion, Shukitt-Hale, Speckman, & Tulley, 2002; Magill et al., 2003).

The military basic training environment, which is highly standardized, provides a unique opportunity to assess the effects of structured training programs on the cognitive status of participants. If such training is globally effective, then standardized tests of cognitive performance as well as mood state should improve over the course of training. The two studies reported here each assessed cognitive performance and mood pre-BCT and post-BCT in female volunteers attending U.S. Army BCT to determine whether such training alters their cognitive function and mood.

**METHOD**

This study was approved by the Human Use Review Committee at the U.S. Army Research Institute of Environmental Medicine and conducted at Fort Jackson, South Carolina. Volunteers participated in these studies after providing their free and informed voluntary consent. Investigators adhered to U.S. Army Regulation 70-25 and U.S. Army Medical Research and Materiel Command Regulation 70-25 on the use of volunteers in research. Command staffs were not present during consent briefings.

**Study 1**

A total of 109 female volunteers in one BCT class completed Study 1. This study was conducted as part of a larger study designed to assess the nutritional status of female U.S. Army volunteers, as females are especially at risk of certain nutritional deficiencies, especially iron deficiency (Karl et al., 2010). Descriptive characteristics of the volunteers can be found in Table 1. Of the volunteers, 54% had a high school education, 33% had completed some college, 6% had obtained an associate’s degree, 6% had a bachelor’s degree, and 1% had a graduate degree. Pre-BCT data were collected within 1 week of volunteers’ arrival at BCT, and post-BCT data were collected less than 1 week prior to
The initial testing was performed before the volunteers were assigned to a specific BCT company; hence, it represented a baseline level of mood and performance prior to starting BCT. The testing took place during the reception phase of BCT, a 3- to 5-day period when basic trainees are in-processed. The process involves completion of administrative forms, medical screening, orientation, clothing issue, and haircuts. The final testing session occurred during the last week of training, after all requirements for graduation had been met.

Volunteers completed a battery of tests that evaluated various aspects of cognitive performance, including choice reaction time, attention, pattern recognition, working memory, and logical reasoning. Cognitive tests were administered on IBM-compatible laptop computers. A standardized mood questionnaire (the Profile of Mood States; POMS) was also administered. Volunteers practiced all tests prior to each test session, and all testing was conducted in climate-controlled classrooms. The order of testing, timing, and procedures for testing were identical from the pretest to the posttest sessions. Tests administered in the first study (in order) were: Four-Choice Reaction Time, Match-to-Sample, Grammatical Reasoning, and POMS. In the second study, the Psychomotor Vigilance Test was administered first, followed by the POMS.

**Tests of cognitive performance and mood.** The specific tests were selected to assess basic aspects of cognitive performance, such as choice reaction time to simple stimuli, and more complex elements of cognitive function including visual working memory and grammatical reasoning. The capabilities they measure are essential for a variety of real-world activities such as typing, motor vehicle operation, test taking, and problem solving. We tested volunteers in similar circumstances pre- and post-BCT: early in the morning before breakfast, in a large group, and in the absence of drill sergeants or other military supervisory personnel.

***Four-Choice Reaction Time (FCRT) test.*** This test assessed the ability to respond rapidly and accurately to simple visual stimuli (Dollins et al., 1993). Volunteers were presented with a series of visual stimuli at one of four different spatial locations on the computer screen and asked to indicate the correct spatial location of each stimulus by pressing one of four adjacent keys on the computer keyboard. There was a 400 ms pause between stimuli, with a limit of 2,000 ms to react to each stimulus. Measurements recorded included reaction time to correct responses and the percentage of correct answers (accounting for incorrect responses and timed out responses). A total of 500 trials were administered to each subject. The test session took approximately 5 min to complete.

***Match-to-Sample (MS) test.*** This test assessed short-term spatial memory (working memory) and pattern recognition skills (Lieberman et al., 2002; Shurtleff, Thomas, Schrot, Kowalski, & Harford, 1994). The volunteers responded by pressing the down arrow key on the computer keyboard when the word “READY” appeared on the screen. Volunteers were then presented with a $6 \times 6$ matrix of a red and green checkerboard on a color screen. The matrix was presented for 6 s, removed and then followed by a variable delay interval of either 2 or 12 s randomly during which the screen was blank except for the word “delay” at the bottom of the screen. A total of 40 stimuli were presented. The 12 s delay condition was more difficult. After the delay, two matrices were presented on the screen: the original sample matrix and a second matrix that differed slightly in that the color sequence of

<table>
<thead>
<tr>
<th></th>
<th>Age (Years)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
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<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Study 1</td>
<td>109</td>
<td>20.5</td>
<td>3.7</td>
</tr>
<tr>
<td>Study 2</td>
<td>103</td>
<td>22.0</td>
<td>4.7</td>
</tr>
</tbody>
</table>
two of the squares was reversed. Volunteers were asked to select the comparison matrix that matched the original sample matrix by responding on the right or left arrow key of the computer keyboard. The test session lasted approximately 5 min. A response (left or right arrow key on the computer keyboard) had to be made within 10 s; otherwise a time-out error was recorded. The percentage of correct responses was recorded (accounting for incorrect responses and time-out errors), as well as reaction time to correct responses.

**Grammatical Reasoning (GR).** This test assessed language-based logical reasoning and has been used to assess the effects of various independent variables on cognitive function (Baddeley, 1968). On each trial, the letters AB or BA followed a statement. The volunteer had to decide whether or not each statement correctly described the order of the two letters. The “T” key on the keyboard was pressed for correct (statement is true) and the “F” key was pressed for incorrect (statement is false). Statements could be positive/negative or active/passive, and a given letter may have preceded/followed the other letter. For example, “B is not preceded by A . . . AB” would have been a false statement and “A follows B . . . BA” would have been a true statement (Baddeley & Hitch, 1974). A session lasted for 32 trials and took approximately 5 min to complete. Variables measured included reaction time to correct answers and the percentage of correct answers (accounting for incorrect answers and time-out errors).

**Profile of Mood States.** The POMS is a widely used, validated, standardized, computer- or paper-and-pencil-administered inventory of mood states (McNair, Lorr, & Droppleman, 1971). Volunteers rated a series of 65 mood-related adjectives on a 5-point scale, in response to the question, “How are you feeling right now?” The adjectives fell into six factor-analytically derived mood subscales: tension–anxiety (TA), depression–dejection (DD), anger–hostility (AH), vigor–activity (VA), fatigue–inertia (FI), and confusion–bewilderment (CB). As is standard with the POMS, a total mood disturbance (TMD) score was determined by subtracting the vigor score (weighting vigor negatively) from the sum of the five negative mood factors.

### Study 2

A total of 103 volunteers from a second BCT class participated in this study. They were part of a larger study, in which some participants received nutritional supplements to assess the effects of iron supplementation versus placebo treatment on blood markers of iron status, such as hemoglobin and ferritin, as well as inflammation (Karl et al., 2010). Only data from placebo-treated volunteers are presented in this paper; their demographic characteristics are reported in Table 1. Of the volunteers, 52% had a high school education, 39% had some college coursework, 4% had an associate’s degree, and 6% had a bachelor’s degree. Data were collected as described for Study 1. However, to vary the cognitive domains from those assessed in the first study, and due to time constraints, testing in Study 2 was limited to a single, brief cognitive task—the Psychomotor Vigilance Test (PVT)—and the POMS.

**Psychomotor Vigilance Test.** The PVT is frequently used to assess alertness. It is a test of simple visual reaction time (Dinges et al., 1997). The test required volunteers to sustain attention by responding to a stimulus (a black circle with a diameter of 35 mm) on a computer screen by pressing a button. Stimuli were presented at random intervals over the course of 7 min, and the volunteer was asked to respond as rapidly as possible when a stimulus appeared. The total number of stimuli presented at each test session varied slightly between test sessions due to the randomized delay intervals between stimuli, the standard procedure for this task (Dinges et al., 1997). Parameters measured included reaction time to correct answers and the percentage of correct answers (accounting for time-out errors of > 500 ms and premature responses).

### Statistical Analyses

In this investigation, the significance of the differences between pre- and post-BCT was assessed by means of *t* tests for all dependent variable elements except those associated with the MS test of Study 1. Cohen’s *d* was used as an estimate of effect size. In Study 1, all volunteers (*N* = 109) completed the POMS, 107 completed the FCRT and MS test, and 104 completed the GR test.
In Study 2, all volunteers (N = 103) completed the POMS and 78 completed the PVT. Some volunteers could not be tested because they were not available to the investigators for a sufficient period of time or testing equipment malfunctioned. Analysis of the MS data contrasted the 2 s and 12 s delay periods over the pre- and post-BCT phases of the study by way of a 2 (delay periods) × 2 (phase) repeated measures ANOVA. Partial eta squares (η²) were calculated as a measure of effect size. The SPSS version 20 (IBM, Armonk, NY) statistical analysis program was used to analyze the data.

RESULTS

Study 1

Mean reaction times and accuracy scores and associated standard deviations are presented in Table 2 for the FCRT and the GR. Data are presented for all combinations of test type and phase (pre-BCT; post-BCT) of the study.

Four-Choice Reaction Time test. Mean FCRT was significantly faster post-BCT when compared to pre-BCT, \( t(106) = 2.439, p = .016, d = 0.47 \). The mean percentages of correct responses neared 100% and did not change significantly across the two phases of the study (\( p > .05 \)).

Grammatical Reasoning. A significant phase difference was not obtained in regard to response accuracy (\( p > .05 \)). However, mean reaction time to correct responses on the GR improved significantly from pre-BCT to post-BCT, \( t(103) = 7.008, p < .001, d = 1.36 \).

Match-to-Sample test. Mean percentages of correct responses and associated standard deviations in the 2 s delay and 12 s delay conditions for both phases of the study are presented in Table 3. An ANOVA of the data of Table 3 revealed that the overall percentage of correct responses was significantly higher for the 2 s (\( M = 79.6 \)) than the 12 s (\( M = 75.75 \)) delay condition, \( F(1, 106) = 17.443, p < .001, \text{partial } \eta^2 = .141 \). The main effect of phase and the Delay Time × Phase interaction were not statistically significant (\( p > .05 \) in both cases).

Mean reaction times to correct detections and associated standard deviations in the 2 s and 12 s delay conditions for both phases of the study are presented in Table 4. An ANOVA of the data of Table 4 revealed that overall reaction time was significantly faster for the 2 s delay condition (\( M = 3.88 \) s) than for the 12 s delay condition (\( M = 4.24 \) s), \( F(1, 106) = 53.537, p < .001, \text{partial } \eta^2 = .336 \), and that overall reaction time was significantly faster post-BCT than pre-BCT, \( F(1, 106) = 6.550, p = .012, \text{partial } \eta^2 = .058 \). The interaction between delay time and phase was not significantly different (\( p > .05 \)).

Profile of Mood States. To control for family-wise error rates, a Bonferroni correction was applied over the seven subscales. This resulted in a critical \( p \) value of .007 or less to be statistically significant at the .05 level. Although there was some evidence of improvements in the subscales of fatigue and confusion at the end of BCT (Table 5), \( p \) values failed to reveal significance when the Bonferroni correction was applied.

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TABLE 2: Mean and Standard Deviation of Speed and Accuracy Scores for Four-Choice Reaction Time (FCRT) and Grammatical Reasoning (GR) Tests, Study 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-BCT</th>
<th>Post-BCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCRT (N = 107)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RT (ms)</td>
<td>537.73</td>
<td>523.95</td>
</tr>
<tr>
<td>Correct %</td>
<td>99.58</td>
<td>99.74</td>
</tr>
<tr>
<td>GR (N = 104)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RT (s)</td>
<td>4.54</td>
<td>3.97</td>
</tr>
<tr>
<td>Correct %</td>
<td>73.71</td>
<td>75.12</td>
</tr>
<tr>
<td>Note. BCT = basic combat training.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ F(1, 106) = 17.443, p < .001, \text{partial } \eta^2 = .141 \]
There were significant improvements in reaction time to correct answers from pre-BCT ($M = 0.335$ s, $SD = 0.048$) to post-BCT ($M = 0.318$ s, $SD = 0.034$), $t(77) = 3.986, p < .001, d = .91$. The percentage of correct answers was not significantly different from pre-BCT ($M = 92.68$, $SD = 0.119$) to post-BCT ($M = 94.84$, $SD = 0.063$).

Profile of Mood States. In Study 2, there were significant improvements in all POMS subscales from pre-BCT to post-BCT after applying a Bonferroni correction. The subscales were also significantly different when analyzing only the results of 78 volunteers who took both the POMS and the PVT. Tension, depression, anger, fatigue, confusion, and total mood all decreased, and vigor increased (Table 6).

### DISCUSSION

These two studies document positive changes from pre-BCT to post-BCT in cognitive performance and mood of young, healthy, adult women volunteers involved in the stressful process of transitioning from a civilian to military career. We observed positive changes in multiple aspects of cognitive performance and mood. Reaction times to correct responses for the FCRT, GR, MS, and PVT performance tests improved significantly, whereas mood states improved significantly in the second test, but not in the first test. We are not aware of any previous studies of young adults demonstrating improvements in a wide range of cognitive functions, including parameters such as working memory and logical reasoning, occurring over the course of military or other structured training programs. The importance of overcoming the physical and mental stressors of training, while continuing to gain the knowledge necessary for effective performance in combat, is paramount in military training. The multiple stressors present at the pre-BCT stage could potentially have the opposite effects on cognitive function, possibly leading to degradation, as opposed to enhancement, of performance and mood. Exposure to acute or chronic stress degrades many aspects of cognitive performance and mood (Haslam, 1984; Lieberman, Castellani, & Young, 2009; Lieberman et al., 2005; Morgan, Doran, Steffian,

### TABLE 3: Mean and Standard Deviation of Match-to-Sample Percentage Correct, Study 1

<table>
<thead>
<tr>
<th></th>
<th>Pre-BCT</th>
<th>Post-BCT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Correct answers (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 s delay</td>
<td>78.6</td>
<td>10.8</td>
</tr>
<tr>
<td>12 s delay</td>
<td>74.7</td>
<td>12.7</td>
</tr>
<tr>
<td>All delay</td>
<td>76.7</td>
<td>11.8</td>
</tr>
</tbody>
</table>

*Note. BCT = basic combat training.*

### TABLE 4: Mean and Standard Deviation of Match-to-Sample Reaction Time, Study 1

<table>
<thead>
<tr>
<th></th>
<th>Pre-BCT</th>
<th>Post-BCT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Reaction time (s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 s delay</td>
<td>3.99</td>
<td>0.81</td>
</tr>
<tr>
<td>12 s delay</td>
<td>4.32</td>
<td>0.80</td>
</tr>
<tr>
<td>All delay</td>
<td>4.16</td>
<td>0.81</td>
</tr>
</tbody>
</table>

*Note. BCT = basic combat training.*
One purpose of this investigation was to confirm previous findings of positive outcomes in basic training while adding additional variables for analysis. Toward that end, significant increases in the speed with which the volunteers were able to make correct responses were observed in the cognitive performance tests employed herein. In combat, soldiers must be able to identify a target, make a quick decision as to whether the threat is real (friend or foe), and act on that decision (discharge weapon or stand fast). Reaction time is also a valued and critical motor skill required for simple and complex tasks including improvised explosive device recognition, first aid skills, piloting manned/unmanned missions, driving, computer operations, and a wide variety of other military occupational specialties.

The improvements in mood states of tension, depressions, anger, fatigue, confusion, and vigor observed in Study 2 are consistent with previous findings of statistically significant improvements in all aspects of mood during 12 weeks of U.S. Marine basic training (Lieberman, Kellogg, et al., 2008). The most severely stressful portion of basic training, when self-doubt and lack of confidence are greatest, immediately precedes the start of training, which is also consistent with our findings (Bourne, 1967; McGurk et al., 2006). In aggregate, the widespread beneficial effects of BCT observed suggest that U.S. Army basic training may enhance the overall cognitive status of participants. The changes we observed may enhance long-term resilience of soldiers, based on the improvement of mental status from initial

### TABLE 5: Contrast of Beginning and End of Training Mean and Standard Deviation for POMS, Study 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-BCT M</th>
<th>Pre-BCT SD</th>
<th>Post-BCT M</th>
<th>Post-BCT SD</th>
<th>t (df)</th>
<th>Uncorrected p</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA</td>
<td>10.31</td>
<td>5.89</td>
<td>9.60</td>
<td>5.39</td>
<td>1.283</td>
<td>(108) .202</td>
</tr>
<tr>
<td>DD</td>
<td>8.50</td>
<td>9.20</td>
<td>7.52</td>
<td>8.26</td>
<td>1.058</td>
<td>(108) .293</td>
</tr>
<tr>
<td>AH</td>
<td>7.72</td>
<td>8.67</td>
<td>9.09</td>
<td>8.67</td>
<td>1.722</td>
<td>(108) .088</td>
</tr>
<tr>
<td>VA</td>
<td>11.11</td>
<td>7.23</td>
<td>11.39</td>
<td>6.70</td>
<td>0.390</td>
<td>(108) .697</td>
</tr>
<tr>
<td>FI</td>
<td>13.41</td>
<td>7.45</td>
<td>11.61</td>
<td>7.32</td>
<td>2.429</td>
<td>(108) .017</td>
</tr>
<tr>
<td>CB</td>
<td>8.16</td>
<td>5.25</td>
<td>7.09</td>
<td>4.53</td>
<td>2.310</td>
<td>(108) .023</td>
</tr>
<tr>
<td>TMD</td>
<td>36.99</td>
<td>33.72</td>
<td>33.51</td>
<td>31.09</td>
<td>1.124</td>
<td>(108) .264</td>
</tr>
</tbody>
</table>

Note. N = 109. AH = anger–hostility; BCT = basic combat training; CB = confusion–bewilderment; DD = depression–dejection; FI = fatigue–inertia; POMS = Profile of Mood States; TA = tension–anxiety; TMD = total mood disturbance; VA = vigor–activity.

### TABLE 6: Contrast of Baseline and End of Training Mean and Standard Deviation for POMS, Study 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-BCT M</th>
<th>Pre-BCT SD</th>
<th>Post-BCT M</th>
<th>Post-BCT SD</th>
<th>t (df)</th>
<th>Uncorrected p</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA</td>
<td>12.92</td>
<td>7.04</td>
<td>7.50</td>
<td>5.01</td>
<td>8.608</td>
<td>(102) &lt;.001</td>
<td>1.70</td>
</tr>
<tr>
<td>DD</td>
<td>11.27</td>
<td>13.02</td>
<td>3.92</td>
<td>5.38</td>
<td>6.569</td>
<td>(102) &lt;.001</td>
<td>1.30</td>
</tr>
<tr>
<td>AH</td>
<td>9.27</td>
<td>9.38</td>
<td>6.10</td>
<td>7.41</td>
<td>3.427</td>
<td>(102) &lt;.001</td>
<td>0.68</td>
</tr>
<tr>
<td>VA</td>
<td>9.43</td>
<td>6.81</td>
<td>12.26</td>
<td>7.35</td>
<td>3.966</td>
<td>(102) &lt;.001</td>
<td>0.79</td>
</tr>
<tr>
<td>FI</td>
<td>12.83</td>
<td>7.57</td>
<td>7.40</td>
<td>5.80</td>
<td>7.593</td>
<td>(102) &lt;.001</td>
<td>1.49</td>
</tr>
<tr>
<td>CB</td>
<td>9.01</td>
<td>5.60</td>
<td>4.74</td>
<td>3.05</td>
<td>8.882</td>
<td>(102) &lt;.001</td>
<td>1.76</td>
</tr>
<tr>
<td>TMD</td>
<td>45.87</td>
<td>40.41</td>
<td>17.40</td>
<td>25.17</td>
<td>8.081</td>
<td>(102) &lt;.001</td>
<td>1.60</td>
</tr>
</tbody>
</table>

Note. N = 103. AH = anger–hostility; BCT = basic combat training; CB = confusion–bewilderment; DD = depression–dejection; FI = fatigue–inertia; POMS = Profile of Mood States; TA = tension–anxiety; TMD = total mood disturbance; VA = vigor–activity.
entry into BCT to graduation, although this study does not definitively establish this. Certain civilian training activities, such as “boot camps,” may have similar positive effects on cognitive performance and mood. Although the relationships between cognitive test variables and mood were examined, those results were not included in this paper due to space limitations. Interested parties may contact the first author regarding covariation of mood and performance over time.

We hypothesize the improvements in cognitive function and mood observed in volunteers during BCT may be the result of participation in a structured, stressful program specifically designed to improve coping skills, work ethic, physical fitness, teamwork, and pride in the soldiers’ military units. Although little information is available with respect to the specific elements of BCT responsible for the positive changes we observed, data available on other populations, such as adolescents and elderly people participating in structured training programs, may provide some insight. Studies of teenagers and older adults suggest the key elements leading to improvements in cognitive function and mood state are (a) creating a structured, collaborative environment that allows for positive reinforcement by peers and supervisors; (b) positive perception of social support; (c) successful achievement of goals; and (d) positive group dynamics (Angevaren, Aufdemkampe, Verhaar, Aleman, & Vanhees, 2008; Ball et al., 2002; Meade & Steiner, 2010; Schachman, Lee, & Lederman, 2004; Taylor-Piliae et al., 2010).

Another element of BCT that is likely to contribute to its success is physical training. Although excess physical training can have adverse effects on mood state (Kuipers, 1996), physical training has repeatedly been demonstrated to improve cognition and mood state (O’Connor & Puetz, 2005; Smith et al., 2010).

One potential weakness of this investigation is the possibility of learning effects across test sessions since the same cognitive tests were administered twice over the course of BCT. However, the 8-week separation between tests should have minimized any learning effect associated with repeat testing. In previous work conducted by our laboratory (Lieberman, Caruso, et al., 2008), we demonstrated that all of the tests we used were stable over the course of 3 days of repeated testing as only small changes in cognitive performance occurred across the seven separate test sessions administered in close temporal proximity in that study. Moreover, the PVT has been used in numerous studies that have demonstrated that repeated administrations are not subject to learning effects from test session to test session (Dorrian, Rogers, & Dinges, 2005; Rosekind et al., 1994).

There are several other limitations to this study. The study would have benefited from inclusion of a control group not undergoing training; however, recruiting such a group matching the BCT population and undergoing the same training was not possible. Also, conducting testing more frequently would help identify the phases of BCT that had the greatest impact on performance and mood. In addition, mood and cognitive performance are degraded by sleep loss, and in females mood state and cognitive function are known to be influenced by menstrual cycle phase (Balkin et al., 2004; Farage, Osborn, & MacLean, 2008; Lieberman et al., 2002; Lieberman et al., 2005). We could not control for the duration and quality of sleep in the night(s) prior to testing or control for menstrual cycle effects, so these factors may have affected the results. We also could not study soldiers who dropped out of BCT over the course of the study, and this may have affected our results. Future studies should address how these factors may influence mood and cognitive function in young adult females participating in BCT.

Another problematic aspect of the study is related to the differences in mood we observed between the different groups tested. The volunteers in Study 2 showed statistically significant improvements in all aspects of mood, whereas those in Study 1 failed to show dramatic improvements. This is in spite of both groups receiving the same program of instruction and military-related experiences over the same length of time. Hypothetically, these differences could be due to the interactions between soldiers in training with each other and also with the drill sergeants who were leading and instructing them. It should also be noted that in both studies we conducted, baseline POMS subscale scores for tension, depression, and confusion were
much lower than those for individuals entering U.S. Marine Corps BCT (Lieberman, Kellogg, et al., 2008) and moderately lower than established norms for college-aged females (McNair et al., 1971) but baseline levels of vigor were higher. Current investigations by the Army have focused on peer evaluations of both drill sergeants and BCT soldiers, which may help to serve as a control for future studies.

The study serves as a basis for future studies investigating mood and cognitive function changes during BCT and other structured military and civilian training programs. Positive mood changes and cognitive functioning in BCT have been demonstrated in this and other studies (Lieberman, Kellogg et al., 2008; McClung, Karl, Cable, Williams, Nindl, et al., 2009), but these should be replicated and extended. In addition, the fundamental cause or causes of these changes should be determined. For example, changes in physiological and nutritional status during BCT may affect mood and cognitive performance. Resilience, measured through scales such as the Connor–Davidson Resiliency Scale (Connor & Davidson, 2003), should also be investigated during BCT as it may be an important factor modifying cognitive performance and mood. Controlling for nicotine and caffeine withdrawal, especially in the early phases of BCT, would also be appropriate. The effects of drill sergeant influence could be determined by repetitive testing with the same cadre or using instruments that assess drill sergeant performance and soldier-to-soldier interactions. We also suggest, for comparison to this study, future studies investigate soldiers further along in their military careers when they are enrolled in more stable environments than BCT.

CONCLUSION

These two studies indicate substantial improvements in key aspects of both mood and cognitive performance occur during BCT. To our knowledge, no reports exist documenting the beneficial changes in cognitive performance over the course of BCT, nor are there reports that structured civilian programs for young adults, which include mental and physical training, enhance cognitive function. BCT provides a unique opportunity to study changes in cognitive performance in a real-world, replicable environment. A better understanding of the effects of structured training and other factors that change over the course of BCT on cognitive function and specific elements that produce positive changes is essential for developing effective tools to optimize soldier performance and resilience as well as development of similar capabilities in civilian populations.

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KEY POINTS

- Structured training programs are considered to have a variety of beneficial effects, but limited data on their effects on cognitive function are available.
- The behavioral effects of military basic combat training, one stressful form of structured training, have not been extensively examined.
- This study assessed cognitive performance and mood of two groups of female basic recruits before and after military basic combat training.
- Various aspects of cognitive performance, including choice reaction time, psychomotor vigilance, spatial working memory, pattern recognition, and logical reasoning, as well as mood, improved over the course of basic combat training.
This study suggests that properly structured military training may positively and extensively alter the cognitive function of soldiers. Additional research is required to confirm this hypothesis and determine the factors responsible for these changes.

REFERENCES


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