Toward Preventing Post-Traumatic Stress Disorder: Development and Testing of a Pilot Predeployment Stress Inoculation Training Program

Laurel Hourani, PhD, MPH; Stephen Tueller, PhD*; Paul Kizakevich, MS*; Gregory Lewis, PhD*; COL Laura Strange, ANC GaARNG (Ret.)*; Belinda Weimer, MA*; Stephanie Bryant, MS*; Ellen Bishop, MS*; Robert Hubal, PhD*; James Spira, PhD†*

ABSTRACT The objective of this pilot study was to design, develop, and evaluate a predeployment stress inoculation training (PRESIT) preventive intervention to enable deploying personnel to cope better with combat-related stressors and mitigate the negative effects of trauma exposure. The PRESIT program consisted of three predeployment training modules: (1) educational materials on combat and operational stress control, (2) coping skills training involving focused and relaxation breathing exercises with biofeedback, and (3) exposure to a video multimedia stressor environment to practice knowledge and skills learned in the first two modules. Heart rate variability assessed the degree to which a subset of participants learned the coping skills. With a cluster randomized design, data from 351 Marines randomized into PRESIT and control groups were collected at predeployment and from 259 of these who responded to surveys on return from deployment. Findings showed that the PRESIT group reduced their physiological arousal through increased respiratory sinus arrhythmia during and after breathing training relative to controls. Logistic regression, corrected for clustering at the platoon level, examined group effects on post-traumatic stress disorder (PTSD) as measured by the Post-traumatic Stress Checklist after controlling for relevant covariates. Results showed that PRESIT protected against PTSD among Marines without baseline mental health problems. Although limited by a small number of participants who screened positive for PTSD, this study supports the benefits of PRESIT as a potential preventive strategy in the U.S. military personnel.

INTRODUCTION

In recent years, the focus on post-traumatic stress disorder (PTSD) has shifted from treatment to resilience and prevention of mental health problems. Most of these studies, however, have focused on post-trauma exposure intervention,[1] including those in military populations.[2] As a result, little is known about the effectiveness of predeployment strategies to prepare personnel to cope with deployment or combat-related stressors and trauma,[3] and data to guide development of mental health prevention programs are lacking. Secondary preventive strategies, such as psychological debriefing and critical incident stress debriefing, have been employed, but these methods have largely been dismissed as ineffective and potentially harmful.[4] A review of possible primary prevention efforts suggested that stress inoculation training (SIT) may prevent PTSD, though no primary preventive techniques have been evaluated in randomized controlled trials.[5]

Several studies associated PTSD with increased physiological arousal as measured by decreased heart rate variability (HRV).[6–13] In addition, laboratory studies designed to induce stress reactions have confirmed the association between stress, lowered HRV, and increased sympathetic activity.[14–16] Literature[17,18] on the efficacy of computerized HRV biofeedback to treat various stress-related conditions provides preliminary support that increases in HRV are associated with PTSD symptom reduction and suggest that HRV biofeedback may improve physiological and psychological health for individuals with PTSD.[11,19]

In a recent meta-analysis of predictors of PTSD, results showed that individuals who described having intensely negative emotional responses during or immediately after the index traumatic event reported higher levels of PTSD symptoms or rates of current PTSD.[20] An effective strategy for reducing the stress response and increasing HRV is slow diaphragmatic breathing in healthy subjects.[21–24] Further, various stress management and relaxation techniques have shown to be effective in reducing PTSD symptoms.[25–27] These studies suggest that minimizing hyperarousal, and the associated increased sympathetic response, during or shortly after traumatic exposure may reduce or minimize the likelihood of PTSD symptoms. Together, these data suggest that HRV biofeedback training with deep slow breathing, in response to a traumatic event, might provide a basis for a pilot prevention program.

*RTI International, 3040 East Cornwallis Road, Research Triangle Park, Durham, NC 27709-2194.

†National Center for PTSD, Department of Veterans Affairs, Pacific Island Division and the Department of Psychiatry, John Burns School of Medicine, University of Hawaii,3375 Koapaka Street, I-560, Honolulu, HI 96819.

These data were presented at the Military Health Systems Research Symposium, Fort Lauderdale, FL, August 12–15, 2013, and International Society for Traumatic Stress Studies Annual Meeting, Philadelphia, PA, November 7–9, 2013. The views presented are those of the authors and do not necessarily represent the view(s) of the Department of Defense or its components.

© AMSUS – The Society of Federal Health Professionals, 2016

doi: 10.7205/MILMED-D-15-00192

Downloaded from publications.amsus.org: AMSUS - Association of Military Surgeons of the U.S. IP: 152.130.006.006 on Sep 27, 2016.
Copyright (c) Association of Military Surgeons of the U.S. All rights reserved.

Overview of SIT

SIT, a resilience-building intervention designed to enhance skills to minimize the negative sequelae of traumatic stress, is well suited for the military culture because it is easily and quickly learned in a group format.[28,29] The three stages of SIT are education,[30] skill introduction, and individual practice of the skills in conditions that emulate the stressful situation.[31] This strategy minimizes hyperarousal and provides evidence of the effectiveness of SIT as a potential primary PTSD prevention intervention.[32]

In a previous feasibility study, the authors found that Marines responded favorably to predeployment stress inoculation training (PRESIT) and interactive relaxation breathing skills training (Battle Breathing [BB] with assisted biofeedback) was preferred to the didactic training previously provided.[5] In addition, a multimedia stressor environment (MSE) successfully increased arousal as measured by heart rate. Compared with controls, previously deployed participants in the PRESIT group demonstrated greater relaxation when exposed to a repeat showing of the MSE. It was therefore suggested that PRESIT may teach practical coping skills that could help minimize the negative psychological effects of combat and operational stress before trauma exposure.

In the current study, a PRESIT program was developed and evaluated in predeploying active duty Marine Corps units to help prevent or mitigate combat stress-related casualties.[5] The study's objective was to assess the effectiveness of PRESIT training to reduce physiologic arousal, mitigate PTSD risk, and improve coping in response to deployment-related stressors. This pilot cluster randomized study addressed the following hypotheses: (1) following a training and a repeat exposure to the MSE, PRESIT participants would have reduced physiologic arousal as measured by increased cardiac vagal tone (expressed as slower heart rate and higher respiratory sinus arrhythmia [RSA]) compared with the control group; (2) compared to controls and adjusting for covariates, PRESIT participants would be less likely to meet screening criteria for PTSD following deployment; and (3) PRESIT participants would use more positive coping and report less perceived stress than controls following deployment.

METHODS

PRESIT Program Development

Combat and Operational Stress Control (COSC) Materials

Informational brochures developed by the Marine Corps COSC program were provided to all participants as the educational component of the study. Brochures identified potential stressors, described signs or symptoms, recommended self-help behaviors, and provided resources for seeking professional help. The control group received a 20-minute current best practice (CBP) standardized lecture and slide presentation based on these materials.

BB

A 20-minute group presentation provided training on two simple relaxation breathing techniques (see Hourani et al[5] for details). The first is attentional retraining, which includes relaxed breathing with eyes open to become absorbed in the present and focused on visual and auditory sensations. When appropriately used in a tactical situation, this type of attentional or focused breathing enables an individual to experience a sense of calmness but be focused in the moment without excessive reactivity or arousal. The second technique, relaxed abdominal breathing with eyes closed, is useful for achieving deep, recuperative, restorative rest, and sleep on returning home or to base, and is similar to progressive relaxation techniques.

Biofeedback

For a subset of participants in the PRESIT group (Fig. 1), stress relaxation biofeedback was used to enhance BB training between the pre- and post-MSE presentations. Visual and audio pacing for slow abdominal breathing (a ball moving up and down on a laptop screen for each inhalation/exhalation) was accompanied by visual feedback of heart rate (via a moving line graph that moved upwards with rising HRV) and an estimate of total HRV (i.e., relaxation state). The same system that recorded heart rate also provided visual feedback so that participants could control respiratory rate/autonomic arousal and enhance their focus during their MSE-simulated mission.

MSE

The MSE was a group-administered audiovisual presentation employed to test physiological reactivity and speed/accuracy performance while practicing breathing skills. Similar to other stressor environments designed to adapt to specific users (e.g., Ćosić et al[33]), a set of 12-minute stressor scenarios was scripted to be relevant to Operation Enduring Freedom deployment.[34] The MSE comprised mission objectives, anticipation of enemy engagement, vigilance to in-scene cues, sudden events (e.g., explosions), loud noises, and postevent chaos while using a game controller to respond to these stimuli.[35] The immersive scenarios integrated available footage of a stressful combat situation with prerendered three-dimensional content.[36]

Participants

The participants in this study were 351 active duty male Marines at Camp Lejeune scheduled for imminent deployment for combat operations (Fig. 1). Consistent with doctrine for squad-level training, Marines participated as squads in groups of approximately 25 to 26 (two squads at a time) and were cluster randomized to receive either the PRESIT protocol or CBP lecture. All participants had completed their required predeployment health assessment and were cleared for deployment. Consequently, it was assumed that few if

Downloaded from publications.amsus.org: AMSUS - Association of Military Surgeons of the U.S. IP: 152.130.006.006 on Sep 27, 2016.
Copyright (c) Association of Military Surgeons of the U.S. All rights reserved.

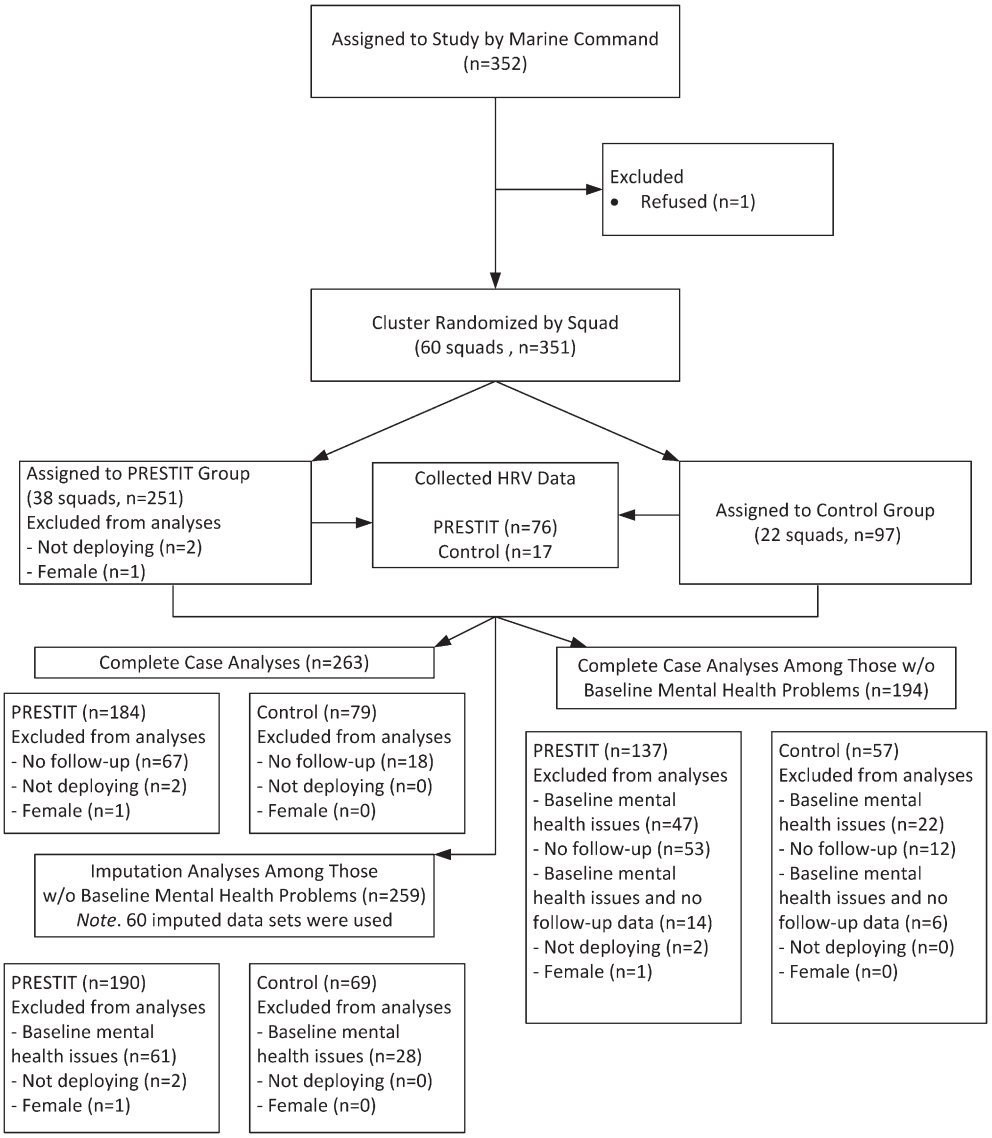

FIGURE 1. Consolidated Standards of Reporting Trials diagram of PRESIT study design.

any participants would meet screening criteria for mental health problems. The Research Triangle Institute Institutional Review Board and United States Army Medical Research and Material Command Office of Research Protections Human Research Protection Office approved the protocol as a training study of minimal risk and installation approval was obtained.

Psychophysiological Measures

To assess the immersive engagement of participants, the stress responses to the MSE were examined based on an existing Research Triangle Institute-developed field data collection system.[37] The stress response was measured with a pulse signal obtained from a photoplethysmograph sensor attached to the earlobe. Heart period (HP), the mean of all pulse-to-pulse intervals, and RSA, a component of HRV, were computed to examine changes in autonomic nervous system regulation of the heart. Higher RSA (i.e., greater high-frequency HRV) indicates greater vagal influence on cardiac output or parasympathetic activation, and a more relaxed status. Pulse interval data were inspected for artifact by an algorithm (modified from Berntson et al[38]) rather than a manual inspection because of the large volume of data collected. Data with excessive artifact were removed from the analysis to limit the impact of the editing algorithm on the derived values.

Survey Measures

The main outcome in this study was the PTSD screening score measured by the PTSD Checklist—Civilian Version (PCL-C). The civilian version rather than the military version was used to capture prior military service PTSD symptomatology. PCL-C is a 17-item PTSD screening instrument frequently used with military populations and has

Downloaded from publications.amsus.org: AMSUS - Association of Military Surgeons of the U.S. IP: 152.130.006.006 on Sep 27, 2016.
Copyright (c) Association of Military Surgeons of the U.S. All rights reserved.

demonstrated good reliability.[39] The standard cutoff score of 50 or greater was used to indicate probable PTSD. A secondary outcome, a single item from the Perceived Stress Scale[40]—"How often have you found that you could not cope with all the things that you had to do?"—was used to assess coping problems and was coded never or almost never versus sometimes/fairly or very often.

This study also assessed several independent variables. At follow-up, combat exposure was assessed with the Combat Experiences Scale from the Deployment Risk and Resilience Inventory to measure various dimensions of stress experience during combat situations.[41] Mean scores were calculated from the frequency that each type of event was experienced during their deployments. Through single yes/no items, participants were asked if they "used the PRESIT breathing techniques with your eyes open to help you manage stress" and with "your eyes closed to help you sleep or relax."

Other mental health measures assessed at baseline included the Center for Epidemiologic Studies Depression (CES-D) scale and the Patient Health Questionnaire. The CES-D scale was used with a cutoff of 16 to measure depressive symptomatology.[42] The Patient Health Questionnaire was used to assess generalized anxiety disorder (GAD) symptoms with a cutoff of 10.[43] Single items inquired about interest in learning stress management techniques; receipt of any type of counseling for a mental health or substance abuse problem before deployment, past-year use of prescribed medication for depression, anxiety, or sleeping problems by a doctor or other health professional, training in and use of other stress reduction techniques, and use of caffeinated drinks and tobacco on the day of participation in study. Sociodemographic data such as race, marital status, level of education, age, and previous deployment experience including physical injury were also obtained.

Procedures

Figure 1 shows the overall study design. The pre- and postdeployment surveys consisted of 10-page questionnaires with an average completion time of 25 minutes. Surveys, PRESIT training, and physiologic measurements were administered by trained personnel in conjunction with standard predeployment training. After a short study presentation and information exchange, consenting participants were administered the baseline survey. Because of a limited number of software licenses, HRV feedback was presented and data were collected from a random subset of participants in the control group and those receiving PRESIT training. The remaining PRESIT participants received sound and visual pacing; however, heart rate was not measured and HRV biofeedback was not provided. All participants received the 12-minute MSE presentation, in which they followed a set of instructions to respond to specific stimuli as they appeared in the moving scene using joystick controllers. All participants also received a COSC brochure. PRESIT participants received a 20-minute BB training session and a short biofeedback practice whereas personnel in the CBP group received a prepared 20-minute COSC lecture with slides and no BB training. Two study trainers alternated providing control and experimental sessions and followed prepared scripts for both protocols. Participation in the initial predeployment session lasted approximately 90 minutes.

Each participant used a small laptop computer for real-time monitoring of RSA and recording of game controller responses. All computers were time locked via a local network to the MSE displaying server to ensure accurate timing measurement. For those having their HRV recorded, the computers recorded the pulse signal continuously throughout MSE sessions. In the predeployment session, 10 distinct periods were used to test for physiological changes in response to the biofeedback training, the MSE, and the combination of the two.

Following their respective trainings, both the CBP and PRESIT participants were presented with a shorter, four-minute MSE video. During this second MSE, PRESIT participants were again asked to practice the BB techniques just learned while the participants' responses to MSE stimuli were recorded.

Two days following their initial predeployment session, participants returned for a 45-minute refresher. This session consisted of a review of the breathing techniques for the PRESIT group and educational materials content for the CBP group, followed by a brief presentation (another 4 minutes) of the MSE.

Following a 7-month Afghanistan deployment, within a week of their return to their base, 263 participants completed a follow-up survey and physiologic measures were collected from those with HRV at baseline during an abbreviated MSE.

Analyses

Physiologic data were analyzed using correlation and repeated measures analysis of variance models. Logistic regression was used for binary survey outcomes (e.g., PTSD cutoff). Standard errors in models were corrected for clustering at the platoon level (SAS PROC SURVEYLOGISTIC, Cary, North Carolina). Survey outcomes included the postdeployment indicator of PTSD (PCL-C $\geq$50) and coping problems. Total PCL-C scores were not used as an outcome due to floor effects, nor were there significant group effects using other PCL-C cutoffs. The initial analyses examined experimental and control group differences in PTSD and coping problems controlling for covariates. These covariates included Combat Experiences Scale scores, previous stress management training, prior counseling, use of stress reduction techniques, and the variables listed in Table I that were significant at the bivariate level. Figure 1 enumerates the (sub) samples for which analyses were conducted.

RESULTS

Nonrespondents to the follow-up survey reported in their baseline responses significantly more mental health counseling

Downloaded from publications.amsus.org: AMSUS - Association of Military Surgeons of the U.S. IP: 152.130.006.006 on Sep 27, 2016.
Copyright (c) Association of Military Surgeons of the U.S. All rights reserved.

TABLE I. Logistic Regression Analysis Predicting PTSD (PCL-C >50) in the Full Sample and Reduced Samples

	Full Sample			Marines With no Predeployment Mental Health Issues		
		95% CI for the OR			95% CI for the OR	
Parameter	OR	Lower	Upper	OR	Lower	Upper
Group						
Control	0.787	0.278	2.231	**6.93**	**1.63**	**29.55**
Experimental						
Received Counseling and/or Prescription						
Yes	**0.467**	**0.219**	**0.996**	**0.96**	**0.06**	**15.10**
No						
Interest in Stress Technique						
Not at All	0.816	0.343	1.943	**8.86**	**1.31**	**59.69**
A Little–Extremely Interested						
Prior Deployment						
No	1.805	0.621	5.243	**2.15**	**1.14**	**4.05**
Yes						
Caffeine Drinks on Training Day						
1 or More	0.672	0.274	1.649	0.19	0.05	0.79
None						
Age	1.002	0.881	1.138	1.31	0.89	1.93
Combat Exposure	**1.090**	**1.052**	**1.129**	**1.22**	**1.08**	**1.39**

Bold entries, significant at <0.05.

and medication use for depression, anxiety, or sleeping problems in the past year. The Commanding Officer of the deployed unit indicated that most of the nonrespondents had transferred to another command or had been discharged from the military. Among the 263 participants with follow-up data (see Complete Case Analyses in Fig. 1), those in the PRESIT group (n = 184) were more likely to have been previously deployed, had more combat experiences, and reported less interest in learning stress reduction techniques at baseline than control participants (n = 79; Table II). Methods to address the potential bias because dropout was correlated with group membership and other variables are discussed below.

Reduction of Physiologic Arousal

To address the first hypothesis and the extent to which PRESIT training reduced physiologic arousal, RSA was assessed before, during, and after the predeployment training controlling for covariates. The PRESIT and CBP groups showed similar autonomic levels before the breathing training. As shown in Figure 2, beginning with the first period of training, the PRESIT group began to diverge with increased RSA and slower heart rate (i.e., longer HPs). As hypothesized, participants in the PRESIT group exhibited lower levels of autonomic arousal. Mean levels of RSA and HP during the last three segments of training were used to calculate simple change scores (e.g., $RSA_{training}$–$RSA_{instruction}$). t tests indicated that the PRESIT group showed a significantly greater increase in HP, t (112) = 2.60, p = 0.01. Levene's test indicated unequal variance in the RSA change. Even with adjusted degrees of freedom, the PRESIT group showed significantly greater increase in RSA, t (29.5) = 4.00, $p < 0.001$. Autonomic arousal levels remained lower for the PRESIT group throughout the post-training MSE.

Effect of PRESIT on PTSD and Coping

To test the second hypothesis, logistic regression was used to estimate group effects on PTSD at follow-up controlling for covariates in full and restricted samples (Table I). After controlling for covariates, CBP participants were at 6.9 times the risk of meeting criteria for PTSD than PRESIT participants at postdeployment. In addition, participants not interested in learning stress control techniques were at 8.9 times the risk of meeting criteria for postdeployment PTSD.

Having no prior deployment and having more combat experiences during deployment were also significant predictors of meeting screening criteria for PTSD. Though the low incidence of probable PTSD at follow-up prevented the inclusion of an interaction term, among Marines with prior deployments (n = 110), 3.6% (n = 3 of 84) of PRESIT participants and 3.8% (n = 1 of 26) of CBP participants had PCL-Cs of greater than 50. Among Marines with no prior deployment (n = 77), no PRESIT participants (n = 0 of 48) had a PCL-C greater than 50, but 6.9% (n = 2 of 29) of CBP participants did. This suggests that PRESIT may have greater preventive efficacy for those without prior deployments or combat experience and requires confirmation in a larger sample with PTSD.

Because all deploying Marines had been through predeployment health screening, we did not anticipate many would meet the study's screening criteria for mental health problems. However, at baseline, 38% met screening criteria for depression, 6% for GAD, and 18% for PTSD. Because

Downloaded from publications.amsus.org: AMSUS - Association of Military Surgeons of the U.S. IP: 152.130.006.006 on Sep 27, 2016.
Copyright (c) Association of Military Surgeons of the U.S. All rights reserved.

TABLE II. Comparison of Baseline Estimates for CBP and PRESIT Respondents[a]

Variable	CBP	PRESIT	Total	CBP vs. PRESIT *p* Value
N	79	184	263	
Age (mean; range 18–39)	21.1	22	21.7	0.0322
Deployments with combat pay (mean; range 0–9)	1.42	1.45	1.44	NS
Education				NS
HS or less	70.9	72.5	72	
Some college or trade school	29.1	27.5	28	
Pay grade				NS
E1–E3	75.9	79.3	78.3	
E4–E6	24.1	20.7	21.7	
Marital status				NS
Married/living as married	29.1	35.3	33.5	
Single, never married	67.1	62	63.5	
Separated/widowed/divorced	3.8	2.7	3	
Practiced relaxation techniques				NS
Yes	60.5	56.2	57.5	
No	39.5	43.8	42.5	
Practiced martial arts				NS
Yes	36.8	31.3	32.9	
No	63.2	68.7	67.1	
Enjoy video games				NS
Yes	77	84.9	82.6	
No	18.9	12.3	14.2	
Amount of caffeinated beverages today				0.0068
None	52.1	33.7	39	
1 or More	47.9	66.3	61	
Amount of energy drinks today				0.0735
None	72.6	60.7	64.1	
1 or More	27.4	39.3	35.9	
Tobacco use today				NS
Yes	57.5	59.6	59	
No	42.5	40.4	41	
During the past month or since returning from your last deployment, how often have you found that you could not cope with all the things that you had to do				NS
Never or almost never	73.1	69.2	70.4	
Sometimes, fairly, or very often	26.9	30.8	29.6	
During past 12 months, how much work or family stress				NS
None at all, a little or some	67.9	61.4	63.4	
A lot	32.1	38.6	36.6	
During past 12 months, received counseling				NS
Yes	14.1	20	18.2	
No	85.9	80	81.8	
Received stress management				NS
Yes	80.3	74.6	76.3	
No	19.7	25.4	23.7	
Interested in learning stress reduction				0.0418
Yes	88.2	77.1	80.4	
No	11.8	22.9	19.6	
Ever deployed				0.0354
Yes	54.7	68.6	64.4	
No	45.3	31.4	35.6	
Amount of stress due to upcoming deployment				NS
None at all or a little	51.3	49.4	50	
Some, a lot	48.7	50.6	50	
Combat experience scale (Q35)				NS
Deployed but no combat exposure	17.5	6.6	9.3	
Moderate level	5	5	5	
High level	77.5	88.4	85.7	
Prescribed medication for depression, etc., past year				NS
Ever thought you would be injured or killed	24.1	25.0	24.3	NS

(continued)

Downloaded from publications.amsus.org: AMSUS - Association of Military Surgeons of the U.S. IP: 152.130.006.006 on Sep 27, 2016.
Copyright (c) Association of Military Surgeons of the U.S. All rights reserved.

TABLE II. Continued

Variable	CBP	PRESIT	Total	CBP vs. PRESIT *p* Value
Harmful or suicidal thoughts past month				NS
Yes	3.9	2.3	2.8	
No	96.1	97.7	97.2	
PCL >50				NS
Yes	22.8	16.4	18.3	
No	77.2	83.6	81.7	
Generalized Anxiety (GAD >10)				NS
Yes	19.2	19	19.1	
No	80.8	81	80.9	
Depression (CES-D >16)				NS
Yes	38	35.7	36.4	
No	62	64.3	63.6	
CES-D Score	13.1	13.7	13.5	NS
Perceived Stress Scale (mean)	15.2	16	15.8	NS

p values were calculated using a chi-square test for CBP vs. PRESIT. Nonfollow-up, did not complete post-deployment questionnaire. [a]All responses are from participants in the follow-up survey.NS, not significant to the 0.05 level.

PRESIT was designed as a prevention program to reduce physiological arousal directly after exposure to a traumatic stressor, it was not expected to impact depression or comorbid mental health problems. Indeed, the inclusion of those with baseline mental health problems may have suppressed a potential PRESIT effect.

We used several sensitivity analyses to assess the conclusion of preventive effects of BB for PTSD in personnel without mental health problems at training in the presence of a low PTSD incidence rate. These analyses included two jackknife procedures, nonparametric bootstrapping, parametric bootstrapping, and multiple imputation. These methods

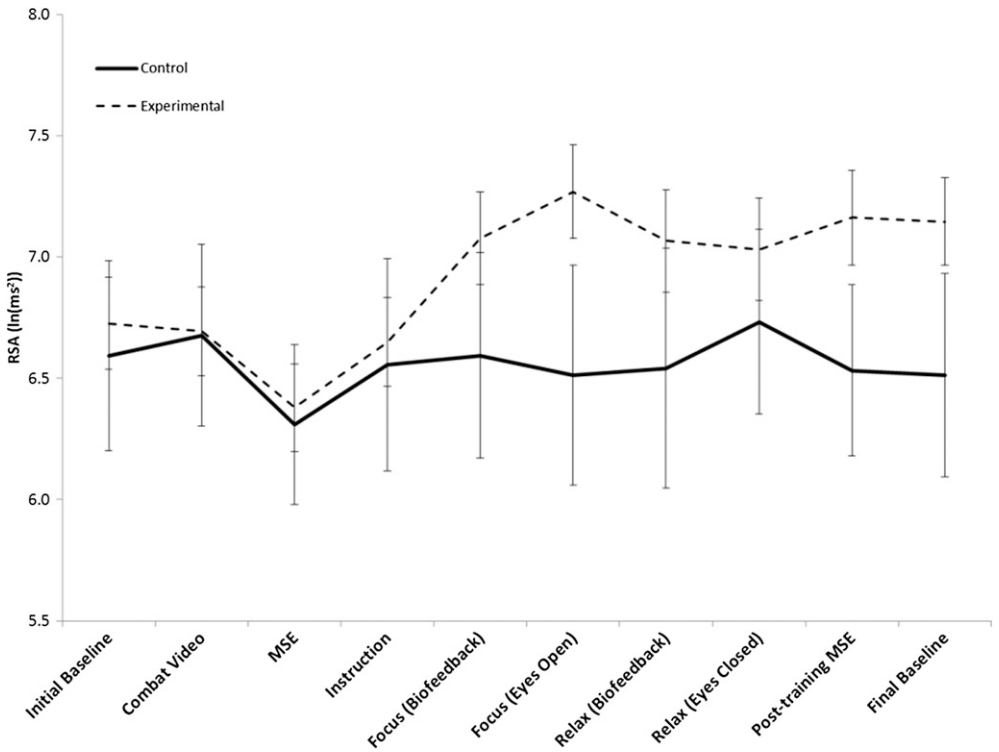

FIGURE 2. Mean RSA measures by PRESIT segment and group with error bars. Estimates control for age, deployment, counseling, interest in learning relaxation techniques, and caffeine use that day. Error bars represent ±2 standard errors of the mean. Control group, *N* = 17; Experimental, N = 76. Only participants with valid data in all segments were used in constructing the figure.

Downloaded from publications.amsus.org: AMSUS - Association of Military Surgeons of the U.S. IP: 152.130.006.006 on Sep 27, 2016.
Copyright (c) Association of Military Surgeons of the U.S. All rights reserved.

allowed us to assess how sensitive conclusions were to influential observations and model assumptions. Four of the five methods corroborated the conclusion that BB acted to prevent PTSD, though the magnitude of the effect is uncertain as reflected in the wide confidence interval for the odds ratio (OR) reported in Table I. Detailed results of the sensitivity analyses are available from the authors.

To test the third hypothesis, the effect of PRESIT training on self-reported stress and coping behaviors postdeployment was examined. There were no differences in self-reported Perceived Stress Scale scores postdeployment. However, among those without self-reported mental health problems, Marines in the CBP group had nearly twice the risk of having recent coping problems than Marines in the PRESIT group, though this effect did not reach significance. Additional post hoc analyses showed that among the full sample that included those with mental health problems at baseline, there was no difference between the experimental and control groups. Only receipt of mental health counseling or a prescription for mental health problems and combat exposure predicted probable PTSD. Further, only 15 to 18% reported using at least one BB technique during deployment and there was no significant difference in PTSD status between PRESIT group members who reported practicing BB during deployment and those who did not.

DISCUSSION

This article describes the development and testing of a novel approach to the primary prevention and mitigation of PTSD risk among predeploying Marines. At predeployment, the PRESIT group reduced their physiological arousal through increased HRV, specifically RSA, during and after BB training relative to the CBP group who received only a didactic stress management presentation. The findings from this study are consistent with others that show that HRV biofeedback reduces PTSD symptoms and improves psychological health[44,45] and extend findings[46] that using biofeedback while immersed in a stressful video game increases the effectiveness of stress management skills in soldiers.

When controlling for predeployment group differences, there was no significant difference in probable PTSD between experiment and controls groups. When excluding those with self-reported mental health problems before deployment, the CBP participants were nearly 7 times more likely than the PRESIT participants to meet screening criteria for PTSD, but the very small number of incident cases of PTSD precludes generalization. The desire to learn stress management techniques at baseline as a predictor of potential postdeployment PTSD suggests that those who had been deployed previously were more interested in learning stress management techniques. The findings of a potential moderating effect of prior deployment and combat exposure between PRESIT and PTSD suggests that PRESIT training may be optimal when provided to Marines who have not deployed and might best be applied as a preventive strategy during basic or advanced training.

Although recent studies and reviews have focused on the resilience-building programs being developed in the military, several of which include skills-based or technology-assisted learning protocols,[1,2,47–49] few have utilized predeployment intervention. This study shows that SIT that combines technological tools of simulation and biofeedback with the public health principle of population-based primary prevention through mastering self-help skills can potentially be an effective addition to military training to reduce PTSD risk among deploying troops.

Despite suggestive findings for the effectiveness of PRESIT in reducing PTSD risk among deploying Marines, this study has several limitations. One is the timing of the postdeployment PTSD screening. The first week back from deployment was the only opportunity to gain access to the returning respondents and their recent return may have influenced the modest prevalence of PTSD symptoms that may become more pronounced over time.[50] Further, because of the drawdown of troops and their changing mission, many returning Marines commented that they did not see as much tactical engagement as they expected. This may have accounted for a relatively low level of combat exposure and BB use during deployment. The resulting low incidence of probable PTSD cases and large confidence intervals (CIs) warrant caution with respect to the study findings. Future studies of larger samples should examine the effects of breathing training on PTSD rates at several periods following deployment and the benefit of the breathing techniques in response to both combat and noncombat stressors. Relatedly, the unexpected number of excluded participants with mental health problems at baseline reduced the overall healthy sample size.

Research is also warranted on the influence of motivation to learn stress management techniques on the benefit of predeployment stress training. In addition, the power to identify more subtle effects may have been affected by a limited sample of Marines experiencing their first deployment and the large number of variables requiring statistical control, including the large number of personnel with self-reported predeployment mental health problems.

In spite of these limitations, this pilot study effectively trained groups of Marines to use preventive strategies before, during, and after deployment to mitigate potential harmful psychological and physiological effects of exposure. Findings from this study provide initial evidence of the possible effectiveness of PRESIT programs in providing force health protection through primary prevention of PTSD risk. Further testing in a sample with a greater incidence of mental health cases is necessary for confirmation.

ACKNOWLEDGMENTS

We thank Ms. Jessica Nelson and Ms. Jennifer Lyden of RTI International for their assistance with conducting the study, and Mr. Justin Faerber for his

Downloaded from publications.amsus.org: AMSUS - Association of Military Surgeons of the U.S. IP: 152.130.006.006 on Sep 27, 2016.
Copyright (c) Association of Military Surgeons of the U.S. All rights reserved.

editorial assistance. We also thank the Marines of the 2dMAW, Cherry Point Marine Corps Air Station, Havelock, North Carolina, and the 2nd Battalion, 9th Marines, Camp Lejeune, Jacksonville, North Carolina, for their participation in this study. Funding was provided by Contract No. N00014-08-C-0504 Department of Defense Office of Naval Research.

REFERENCES

1. Forneris CA, Gartlehner G, Brownley KA, et al: Interventions to prevent post-traumatic stress disorder: a systematic review. Am J Prev Med 2013; 44(6): 635–50.
2. Meredith L, Sherbourne C, Gaillot S, et al: Promoting psychological resilience in the U.S. military. http://www.rand.org/pubs/monographs/MG996.html; accessed July 28, 2015.
3. Mulligan K, Fear NT, Jones N, Wessely S, Greenberg N: Psychoeducational interventions designed to prevent deployment-related psychological ill-health in Armed Forces personnel: a review. Psychol Med 2011; 41(4): 673–86.
4. Rose SC, Bisson J, Churchill R, Wessely S: Psychological debriefing for preventing post traumatic stress disorder (PTSD). Cochrane Database Syst Rev 2002; 2: CD000560.
5. Hourani L, Kizakevich PN, Hubal R, et al: Predeployment stress inoculation training for primary prevention of combat-related stress disorders. J Cyber Ther Rehabil 2011; 4(1): 101–17.
6. Cohen H, Benjamin J, Geva AB, Matar MA, Kaplan Z, Kotler M: Autonomic dysregulation in panic disorder and in post-traumatic stress disorder: application of power spectrum analysis of heart rate variability at rest and in response to recollection of trauma or panic attacks. Psychiatry Res 2000; 96(1): 1–13.
7. Minassian A, Geyer MA, Baker DG, et al: Heart rate variability characteristics in a large group of active-duty Marines and relationship to posttraumatic stress. Psychosom Med 2014; 76: 292–301.
8. Lee EA, Theus SA: Lower heart rate variablity assoicated with military sexual trauma rape and posttraumatic stress disorder. Biol Res Nurs 2012; 14: 412–8.
9. Agorastos A, Boel JA, Heppner PS, et al: Diminished vagal activity and blunted diurnal variation of heart rate dynamics in post-traumatic stress disorder. Stress 2013; 16: 300–10.
10. Shah AJ, Lampert R, Goldberg, Veledar E, Bremner JD, Vaccarino V: Post-traumatic stress disorder and impaired autonomic modulation in male twins. Biol Psychiatry 2013; 73: 1103–10.
11. Wahbeh H, Oken BS: Peak high-frequency and peak alpha frequency higher in PTSD. Appl Psycyophysiol Biofeedback 2013; 38: 57–69.
12. Thayer JF, Ahs F, Fredrikson M, Sollers JJ, Wager TD: A meta-analysis of heart rate variability and neuroimaging studies: implications for heart rate variability as a marker of stress and health. Neurosci Biobehav Rev 2012; 36: 747–756.
13. Hauschildt M, Peterws MJV, Moritz S, Jelinek L: Heart rate variability in response to affective scenes in post-traumatic stress disorder. Biol Psychiatry 2011; 88: 215–22.
14. Berntson GG, Cacioppo JT: Heart rate variability: stress and psychiatric conditions. In: Dynamic Electrocardiography. Edited by Malik M, Camm AJ. New York, Blackwell/Futura, 2004.
15. Friedman BH, Thayer JF, Tyrrell RA: Spectral characteristics of heart period variablity during cold face stress and shock avoidance in normal subjects. Clin Auton Res 1996; 62: 796–803.
16. Delaney JP, Brodie DA: Effects of short-term psychological stress on the time and frequency domains of heart-rate variabilty. Percept Mot Skills 2000; 91: 515–24.
17. Lehrer PM, Woolfolk RL: Research on clinical issues in stress management. In: Priniciples and Practice of Stress Management, Chapter 26, Ed. 3. Edited by Lehree PM, Wiikfikj RL, Sime WE. New York, Gilford, 2007.
18. Reiner R: Integrating a portable biofeedback device into clinical practice for patients with anxiety disorders: results of a pilot study. Appl Psychophysiol Biofeedback 2008; 33: 55–61.
19. Zucker TL, Samuelson KW, Muench F, Greenberg MA, Gevirtz RN: The effects of respiratory sinus arrhythmia biofeedback on heart rate variability and post-traumatic stress disorder symptoms: a pilot study. Appl Psychophysiol Biofeedback 2009; 34(2): 135–43.
20. Ozer EJ, Best SR, Lipsey TL, Weiss D: Predictors of post-traumatic stress disorder and symptoms in adults: a meta-analysis. Psychol Bull 2003; 129(1): 52–73.
21. Tharion E, Samuel P, Rajalakshmi R, Gnanasenthil G, Subramanian RK: Influence of deep breathing exercise on spontaneous respiratory rate and heart rate variability: a randomised controlled trial in healthy subjects. Indian J Physiol Pharmacol 2012; 56(1): 80–7.
22. Schipke JD, Arnold G, Pelzer M: Effect of respiration rate on short-term heart rate variability. J Clinical Basic Cardiology 1999; 2: 92–5.
23. Strauss-Blasche G, Moser M, Voica M, McLeod DR, Klammer N, Marktl W: Relative timing of inspiration and expiration affects respiratory sinus arrhythmia. Clin Exp Pharmacol Physiol 2000; 27: 601–6.
24. Tripathi KK: Respiration and heart rate variability: a review with special reference to its application in aerospace medicine. Indian J Aerospace Medicine 2004; 48: 64–75.
25. Stetz MC, Kaloi-Chen JY, Turner DD, Bouchard S, Riva G, Wiederhold BK: The effectiveness of technology-enhanced relaxation techniques for military medical warriors. Mil Med 2011; 176(9): 1065–70.
26. McKibben E, Britt T, Hoge C, et al: Receipt and rated adequacy of stress management training is related to PTSD and other outcomes among Operation Iraqi Freedom veterans. Mil Psychol 2009; 21(2): S68–81.
27. Watson CG, Tuorila JR, Vickers KS, Gearhart LP, Mendez CM: The efficacies of three relaxation regimens in the treatment of PTSD in Vietnam War veterans. J Clin Psychol 1997; 53(8): 917–23.
28. Baker MS, Armfield F: Preventing post-traumatic stress disorders in military medical personnel. Mil Med 1996; 161(5): 262–4.
29. Deahl M, Srinivasan M, Jones N, Thomas J, Neblett C, Jolly A: Preventing psychological trauma in soldiers: the role of operational stress training and psychological debriefing. Br J Med Psychol 2000; 73(Pt 1): 77–85.
30. Meichenbaum D, Cameron R: Stress inoculation training. In: Stress Reduction and Prevention. Edited by Meichenbaum D, Jaremko M. New York, Plenum Press, 1983.
31. Flanagan SC, Kotwal RS, Forsten RD: Preparing soldiers for the stress of combat. J Spec Oper Med 2012; 12(2): 33–41.
32. Hourani LL, Council CL, Hubal RC, Strange LB: Approaches to the primary prevention of posttraumatic stress disorder in the military: a review of the stress control literature. Mil Med 2011; 176(7): 721–30.
33. Ćosić K, Popović S, Kostović I, Judas M: Virtual reality adaptive stimulation of limbic networks in the mental readiness training. Stud Health Technol Inform 2010; 154: 14–9.
34. Hubal R, Kizakevich P, McLean A, Hourani L: A multimedia environment for stressing warfighters before they deploy. Interservice/Industry Training, Simulation, and Education Conference 2010, pp 1688–96. Available at http://www.rvht.net/pubs/10129.pdf; accessed April 28, 2015.
35. Bouchard S, Baus O, Bernier F, McCreary DR: Selection of key stressors to develop virtual environments for practicing stress management skills with military personnel prior to deployment. Cyberpsychol Behav Soc Netw 2010; 13(1): 83–94.
36. Hubal R, Kizakevich P, Furberg R: Synthetic characters in health-related applications. Stud Comp Intell 2007; 65: 5–26.
37. Whitmore R, Kizakevich PN: Data collection platforms for integrated longitudinal surveys of human exposure-related behavior. Final Report on U.S. EPA STAR Grant RD-83154101 submitted to U.S. Environmental Protection Agency, Washington, DC, 2010. https://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/7434/report/F; accessed April 28, 2015.
38. Berntson GG, Quigley KS, Jang JF, Boysen ST: An approach to artifact identification: application to heart period data. Psychophysiology 1990; 27(5): 586–98.

Downloaded from publications.amsus.org: AMSUS - Association of Military Surgeons of the U.S. IP: 152.130.006.006 on Sep 27, 2016.
Copyright (c) Association of Military Surgeons of the U.S. All rights reserved.

39. Blanchard EB, Jones-Alexander J, Buckley TC, Forneris CA: Psychometric properties of the PTSD Checklist (PCL). Behav Res Ther 1996; 34(8): 669–73.
40. Cohen S, Kamarck T, Mermelstein R: A global measure of perceived stress. J Health Soc Behav 1983; 24(4): 385–96.
41. King D, King L, Vogt D: Manual for the Deployment Risk and Resilience Inventory (DRRI): Boston, MA, 2003. Available at http://www.ptsd.va.gov/PTSD/professional/assessment/deployment/index.asp; accessed April 28, 2015.
42. Radloff L: The CES-D scale: a self-report depression scale for research in the general population. Appl Psychological Measurement 1977; 1(3): 385–401.
43. Spitzer RL, Kroenke K, Williams JB: Validation and utility of a self-report version of PRIME-MD: the PHQ primary care study. Primary care evaluation of mental disorders. Patient Health Questionnaire. JAMA 1999 10; 282(18): 1737–44.
44. Lakusic N, Fuckar K, Mahovic D, Cerovec D, Majsec M, Stancin N: Characteristics of heart rate variability in war veterans with post-traumatic stress disorder after myocardial infarction. Mil Med 2007; 172(11): 1190–3.
45. Frank DL, Khorshid L, Kiffer JF, Moravec CS, McKee MG: Biofeedback in medicine: who, when, why and how? Ment Health Fam Med 2010; 7(2): 85–91.
46. Bouchard S, Bernier F, Boivin E, Morin B, Robillard G: Using biofeedback while immersed in a stressful videogame increases the effectiveness of stress management skills in soldiers. PLoS One 2012; 7(4): e36169.
47. Rizzo A, Parsons TD, Lange B, et al: Virtual reality goes to war: a brief review of the future of military behavioral healthcare. J Clin Psychol Med Settings 2011; 18(2): 176–87.
48. Foran HM, Adler AB, McGurk D, Bliese PD: Soldiers' perceptions of resilience training and postdeployment adjustment: validation of a measure of resilience training content and training process. Psychol Serv 2012; 9(4): 390–403.
49. Adler AB, Bliese PD, McGurk D, Hoge CW, Castro CA: Battlemind debriefing and battlemind training as early interventions with soldiers returning from Iraq: randomization by platoon. J Consult Clin Psychol 2009; 77(5): 928–40.
50. Roemer L, Litz BT, Orsillo SM, Ehlich PJ, Friedman MJ: Increases in retrospective accounts of war-zone exposure over time: the role of PTSD symptom severity. J Trauma Stress 1998; 11(3): 597–605.

Downloaded from publications.amsus.org: AMSUS - Association of Military Surgeons of the U.S. IP: 152.130.006.006 on Sep 27, 2016.
Copyright (c) Association of Military Surgeons of the U.S. All rights reserved.