

## Special Issue

# Training for Optimal Performance Biofeedback Program: A Cooperative Program Between East Carolina University and the United States Marine Corps Wounded Warrior Battalion East

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*The signature wounds of the Iraq War are traumatic brain injury and post traumatic stress disorder (PTSD). Due to an emergent need to address the symptoms of these wounds in returning Marines and navy corpsmen, a memorandum of understanding between the U.S. Marine Corps and East Carolina University's Psychophysiology Lab and Biofeedback Clinic was signed and training services were begun in February 2008. The Training for Optimal Performance program involves a biofeedback circuit-training method in which marines and navy corpsmen participate in a graded exposure protocol that includes virtual reality, cognitive retraining, neurofeedback, heart rate variability, and relationship and resiliency training. Preliminary results indicate that this approach is effective in ameliorating symptoms of traumatic brain injury and PTSD.*

### Background

The U.S. Marine Corps is a small, elite fighting force that is prepared to be the first into battle. The statistics regarding those killed or wounded in combat support that this is often the case. A large number of marines were wounded in Iraq and Afghanistan due to traditional warfare as well as improvised explosive devices (IEDs). Injuries in war are devastating and include extreme physical injuries resulting from gunshot and shrapnel wounds, severe concussions from enemy IEDs and mortars as well as backblasts from in-close fighting. Concussions from multiple sources are a major cause of traumatic brain injury and are prevalent among marine Wounded Warriors.

On the battlefield, medical care is provided to marines by navy corpsmen. These "field doctors" are inseparable from marines, for they are truly embedded into marine infantry (grunt) squads. Their main duty is to keep marines alive and healthy. In combat, corpsmen continually risk their lives as they move into harm's way to stabilize marines who have



been wounded. In the course of their duty they too get injured by bullets, shrapnel, and blasts, as well as by war exposure injuries like post traumatic stress disorder (PTSD).

Marines and navy corpsmen consider one another brothers. As part of the pact, they all commit to never, ever leave a wounded or dead marine or corpsman on the battlefield. Many marines and corpsmen have sacrificed their lives upholding this pact. The resulting deep bond that is formed among marines and corpsmen is lifelong. Recognizing the importance of this bond in healing, and noticing that injured marines and corpsmen were spread out in a number of facilities and couldn't share their healing experiences, Lt. Col. Tim Maxwell proposed the idea of having a Wounded Warrior Barracks where injured marines and corpsmen could recover together (Maxwell, 2008). Lt. Col. Maxwell, who received the Purple Heart for a severe head trauma after his brain was penetrated with shrapnel during a mortar attack on Camp Kalsu south of Baghdad, said he felt lonely and lost during his rehabilitation, longing for the companionship of his brothers. Upon the recommendation of Lt. Col. Maxwell and with the support of Lt. Gen. James Amos, the first-of-its-kind Wounded Warrior Barracks was created at Camp Lejeune in eastern North Carolina in the

spring of 2005. By June of that year, six men had moved into the facility.

The Wounded Warrior Battalion (WWB) is now a comprehensive program that supports and maintains awareness of all ill and/or injured marines and/or sailors who are in residence east of the Mississippi River. The mission of WWB-East is to provide assistance to those service personnel and their families until they: (a) have been returned to duty, (b) have been medically discharged, (c) or have successfully readjusted to civilian life. Currently there are 147 marines at Maxwell Hall, suffering from a variety of physical disabilities ranging from amputations to head trauma, which are all too often coupled with PTSD, depression, and other emotional disorders.

### Traumatic Brain Injury and PTSD

Traumatic brain injury (TBI) frequently is accompanied by psychiatric disturbances and concurrent alterations in behavior, personality, and emotional regulation, which have a deleterious effect on recovery and rehabilitation outcomes (Warriner & Velikonja, 2006). Survivors of TBI are particularly susceptible to major depression, generalized anxiety disorder, and post-traumatic stress disorder. Premorbid personality traits and postinjury psychological reactions to disability and trauma are important factors in the generation and maintenance of post-TBI psychiatric disorder (Rogers & Read, 2007). More than 46% of blast patients and 55% of amputees at Walter Reed Army Medical Center have sustained comorbid brain injury. Moreover, it is estimated that up to 90% of these Wounded Warriors with bodily injury seen at the National Naval Medical Center, Walter Reed, and the Center for the Intrepid at Brook Army Medical Center also suffer from subthreshold or full PTSD.

When a person is exposed to the extreme stress of war, clinically significant symptoms often emerge (American Psychiatric Association, 2000). The existence, frequency, intensity, and duration of these symptoms are dependent upon many factors, including, gender, age, and ethnic background of the person exposed to the stressor as well as the person's social environment and ability to employ coping strategies (Russoniello et al., 2002; Vernberg, LaGreca, Silverman, & Prinstein, 1996). The long-term effects of chronic stress can effect anatomical change with devastating consequences, as demonstrated by some Vietnam veterans with PTSD who have shown significant shrinkage in the hippocampus area of the brain (Sapolski, 1998). Chronic stress also is associated with risk for depression, anxiety, and alcohol or substance abuse as well as for other diseases of the cardiovascular, digestive, musculoskeletal, endocrine, respiratory, and nervous systems (Davidson, 2001).



Specific emotional and behavioral responses to stress have been observed and studied over time by mental health professionals in multiple settings, under different circumstances (American Psychiatric Association, 2000). These symptoms have become the clinical indicators used for identifying the stress-related disorder known as PTSD. Although this classification system is somewhat helpful in clinical practice, it has some noted limitations such as the exclusion of some less common cognitive, emotional, behavioral, and physiological-somatic symptoms (Armstrong & Holaday, 1993).

Given the multifaceted nature of comingling conditions and the lack of diagnostic specificity, it has been next to impossible to determine what condition causes which symptoms. For example, in one recent study researchers found that symptoms normally associated with concussions (e.g., headaches, dizziness, irritability, and memory problems) actually were related to PTSD or depression. In order to address this conundrum, a biofeedback program that combined central nervous system (CNS) and autonomic nervous system (ANS) biofeedback training seemed appropriate to the symptoms regardless of the etiology. The goal is to help Wounded Warriors simultaneously train both nervous systems, combining the benefits of each training approach to reset the Central Autonomic Network (CAN) or the communication system between the CNS and ANS (Thayer & Broschott, 2005).

The Training for Optimal Performance (TOP) program was started in February 2008 with the goal of providing a continuum of services for marines and navy personnel (Wounded Warriors) returning from war, with the ultimate goal of assisting them in adjusting to their disabilities and/or helping them with life transition. The TOP program teaches Wounded Warriors methods to improve physical and psychological control of ANS and CNS functioning, to build positive relationship skills, and to process traumatic experiences.

Wounded Warriors who are referred to the program receive individualized training plans (ITPs). Each ITP



includes an assessment of contributing behaviors, establishment of physiological and psychological baselines, and the training and practice of biofeedback techniques that have demonstrated efficacy. TOP program interventions for PTSD and TBI follow standard training protocols and involve sessions both at our designated office in Camp Lejeune and at the Psychophysiology Lab and Biofeedback Clinic at East Carolina University.

Currently, the TOP program is improving individual Wounded Warrior performance by using several biofeedback training methods, which are combined in a circuit-training format to produce similar outcomes: improved control of the central and autonomic nervous systems using operant conditioning techniques. Biofeedback is the process of recording physiological signals (such as muscle tension or brain waves) and displaying them in real time to the person being recorded. This information is used to help a person learn to gain additional control over his or her physiology (Association for Applied Psychophysiology and Biofeedback, 2008). Biofeedback treatments work by teaching people to recognize how their bodies are functioning and to control patterns of physiological functioning (i.e., arousal control).

One biofeedback method used in the TOP program is called heart rate variability (HRV) training. HRV is measured by photoplethysmography (PPG) technology and is designed to teach Wounded Warriors how to synchronize respiratory and cardiac functioning as a method to control the body's reaction to stress and to increase cardiorespiratory efficiency. Another biofeedback modality is neurofeedback, a training technique in which brain waves are fed back in real time and the Wounded Warriors learn to gain control of them. Changes in brain waves at different amplitudes and in different parts of the brain are highly correlated with improved memory, attention, and decreases in impulsive behaviors and seizure activity. Often biofeedback takes place

while Wounded Warriors are engaged in activities such as video games, where success is contingent upon successful control of the central and autonomic systems.

Once Wounded Warriors are evaluated and learn how to control physiological reactions with mild stressors (e.g., math, continuous performance testing, or talking about a stressful experience), they are exposed to progressively more stressful situations (graded exposure) that eventually involves immersive virtual reality (e.g., virtual Iraq and virtual combat medic). Wounded Warriors can now practice controlling their physiological responses as the stressor becomes more relevant to the trauma. Data on outcome variables are collected pre-post each intervention and statistical analysis conducted. Changes in HRV and electroencephalogram patterns, psychological tests, and functional outcomes are the main endpoints on which treatment efficacy is being evaluated.

The TOP program for Wounded Warriors with TBI and PTSD consists of four training components and pre- and posttraining evaluations: (a) cognitive retraining; (b) HRV training; (c) neurofeedback training; and (d) relationship and resiliency training.

An outline of the TOP program and its components follows.

### **Initial Evaluation**

The stress test comprises a 5-minute baseline, a 20-minute continuous performance test (TOVA), a 5-minute recovery, a 5-minute traumatic memory recall, a 5-minute recovery, a 1-minute orthostatic hypertension test, and a 5-minute recovery. Measurements include electroencephalography, HRV, skin conductance, respiration, and skin temperature.

### **Cognitive Training**

Successful amelioration of PTSD and TBI symptoms is contingent upon cognitive retraining as well biofeedback training exercises. Cognitive therapy provides an effective method of helping Wounded Warriors identify dysfunctional thought patterns and their associated emotions by seeing their physiological impact. Wounded Warriors practice methods designed to change negative thoughts into neutral or positive ones, reducing their contribution to symptom development and maintenance. Based on meta-analyses of studies, cognitive therapy (CT) is highly effective in treating unipolar depression and is as effective as interpersonal or brief psychodynamic therapy (Beck, 1976). Moreover, a meta-analysis of studies, including one conducted by the National Institute of Mental Health (1989) that compared CT with medications, found similar effects versus placebo. These findings led reviewers to conclude that CT is a valid



alternative to medications when treating mild to moderate depression. Due to the preponderance of evidence supporting CT efficacy, a recent article in *American Family Physician* recommended that family practice physicians consider CT as a frontline treatment for mild, moderate, and severe depression (Rupke, Blecke, & Renfrow, 2006).

According to the Beck Institute on Cognitive Therapy (2008), CT is a form of psychotherapy proven in numerous clinical trials and is effective for a wide variety of disorders. The therapist and client work as a team to identify and solve problems. Therapists help clients to overcome their difficulties by changing their thinking, behavior, and emotional responses (Beck Institute for Cognitive Therapy, 2008). The TOP program utilizes cognitive therapy to help Wounded Warriors correct negative self-beliefs that lead to changes in mood and behavior (Greenberger & Padesky, 1995). The TOP program CT involves connecting thoughts to emotion, identifying autonomic thoughts and their underlying beliefs, and practicing techniques to increase balanced thinking.

### Heart Rate Variability Biofeedback Training

Respiratory sinus arrhythmia (RSA) is an important physiological construct that represents a rhythmic coherence between the cardiovascular and respiratory systems. When a person achieves RSA, the individual facilitates an improved cardiorespiratory balance. ANS imbalance has been associated with a number of medical conditions and may in fact contribute to chronic conditions such as diabetes, cardiovascular disease, anxiety, and depression (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996).

RSA involves centrally modulated cardiac vagal and sympathetic efferent activities, which are mediated by respiration. For example a person's pulse increases on inhalation and decreases in the same fashion on exhalation.

RSA is therefore a pattern directly connected to the state of the respiration (Axelrod et al., 1981). According to current theory, improving RSA will likely improve an ANS-related condition, and the loss of RSA that occurs in illness is a consequence of uncoupling of important biological oscillators. It is therefore recommended that interventions be developed that restore or enhance coupling (Wilkinson et al., 1998). One research team suggests that baroreflex stimulation occurs as a result of RSA training and may produce effects that are similar to electrical vagus nerve stimulation (Vaschillo, Lehrer, Rishe, & Konstantinov, 2002). This in turns impacts conditions such as clinical depression at reduced cost and minimal risk (Mussleman, Evans, & Nemeroff, 1998).

In a recent study (Karavidas et al., 2007), RSA training, also known as HRV training, was used as an intervention technique and demonstrated that the ANS could be trained when participants breathed at individual resonant frequencies. The results of the training indicated a reduction of depression symptoms. Data showed that participants had learned to increase their HRV using this procedure and were able to breathe at or close to their resonant frequency across sessions, maintaining positive HRV changes even when controlled for respiration.

### Neurofeedback Training

The neurofeedback training (NFT) training regimen follows a modified version of neurofeedback protocols used for the treatment of TBI and PTSD symptoms (Byers, 1995; Keller, 2001). Eight sessions of NFT include:

- Four sessions enhancing beta 15–18 Hz at T9-C3 or T4-C4 (two sessions at each location) and suppressing the lower theta (4–7 Hz) activity. Progress is evaluated at the end of Session 4.
- Four sessions of sensorimotor (SMR) NFT designed to enhance the sensorimotor rhythm (12–15 Hz) and the



beta (15–18 Hz) frequency bands while at the same time suppressing theta (4–7 Hz).

Preliminary results from Wounded Warriors seen in the East Carolina University biofeedback clinic suggests that the TOP program training approach that combines cognitive behavioral therapy, interpersonal therapy, personal reflection, biofeedback, and virtual reality is effective in reducing symptoms of PTSD. Preliminary data show consistent neurofeedback changes across treatment sessions, indicating a shift from a more vigilant, more agitated state to a more stable, relaxed state. In addition, HRV data show less “fight or flight response” or physical stress.

### Relationship and Resilience Training

In addition to the important training mentioned above, the TOP program includes an overarching recreational therapy philosophy that encourages participation in activities designed to help Wounded Warriors practice building and maintaining supportive relationships. Interactions between East Carolina University students, faculty, and the Wounded Warriors have contributed to the development of a therapeutic milieu where everyone is learning about relationships and diversity from one another. Another important benefit of this approach is that it exposes Wounded Warriors to activities they can participate in regardless of their injuries, demonstrating that injury does not have to prevent participation in fun activities. These resiliency-building activities, which are needed for health promotion and disease prevention, have included wheelchair basketball, quad rugby, and disc golf. They have been well received. Wounded Warriors often relay stories from past games to Wounded Warriors new to the program, touting the good times they had. Relationships between Wounded Warriors and their spouses are enhanced by activities designed to improve intimacy as well. A TOP companion program beginning at Camp Lejeune in January 2009 will address improving intimacy and reducing symptoms of PTSD by using ballroom dancing.

The TOP program also has helped marines get engaged in university activities that are consistent with their career desires. One Wounded Warrior has become very adept at Second Life, an online virtual world, and has built a number of structures including the new (Second Life) Wounded Warrior Barracks (in process) that will facilitate communications among Wounded Warriors all over the world—furthering Lt. Col. Maxwell’s request for Wounded Warrior companionship. Remarkably, this same Wounded Warrior stated recently that his cognitive functioning had improved, based on neuropsychology testing. When he was asked why he thought this was the case, he attributed the



improvement to working in Second Life using shapes to build houses and so forth. He may have serendipitously found a new modality for cognitive retraining. Another Wounded Warrior is assisting East Carolina University students with design of the real Wounded Warrior Barracks and still another will be shadowing emergency room doctors.

In summary, the TOP program has recorded increases in positive mood and interpersonal skills; decreases in agitation, anxiety, and panic; and better control of anger. Subjective reports from Wounded Warriors convey the positive effects of the intervention (see <http://www.newsobserver.com/102/story/1139240.html>). The TOP program staff continues to hone this unique biofeedback circuit-training program based upon emerging data with a goal of creating a best practice to assist Wounded Warriors experiencing the untoward effects of war such as PTSD and TBI.

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The Fall 2008 issue of *Biofeedback* included an article, “Early-Generation Biofeedback Instruments and Modern Computers,” (p. 117) by author Michael Wong, PT, MS. Mr. Wong has established a website to provide additional information on the use of early generation biofeedback instruments: <http://www.geocities.com/myotrac>.