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FEATURE ARTICLE

Implementing Heart Rate Variability Biofeedback Groups for Veterans with Posttraumatic Stress Disorder

Frances J. Reyes

Evaluation Department, Volunteers of America Greater Los Angeles, Los Angeles, CA

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This article describes the administration of a heart rate variability (HRV) biofeedback intervention designed to reduce posttraumatic stress disorder (PTSD) severity in post-9/11 service members. The study recruited 33 male OEF/OIF/OND combat veterans in a Los Angeles transitional housing program. Twenty-seven veterans completed the study. Participants attended eight once-weekly HRV biofeedback group sessions. For the first four weeks, veterans learned to use biofeedback to regulate physiological stress responses. The latter four weeks consisted of real-life biofeedback application and coaching. Results suggest that consistent HRV biofeedback practice was essential for HRV improvement, which may help alleviate PTSD.

Advances in military technology and medicine mean reduced casualty rates for post-9/11 military, yet increases in the likelihood of living through traumatic combat experiences and acquiring psychiatric disorders (Okie, 2005; Warden, 2006). Roughly one-third of Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF)/Operation New Dawn (OND) veterans experience symptoms of mental health or cognitive conditions (Tanielian & Jaycox, 2008). Posttraumatic stress disorder (PTSD), one such malady, afflicts nearly 20% of Iraq and Afghanistan veterans (Ramchand et al., 2010). Besides dealing with debilitating symptoms, those with PTSD are prone to endure poorer overall health, functioning, relationships, living conditions, and life-satisfaction (Schnurr, Lunney, Bovin, & Marx, 2009). Meanwhile, the estimated two-year cost of PTSD and major depression associated with medical treatment, suicide, and lost productivity ranges between $4.0 and $6.2 billion (Tanielian & Jaycox, 2008). The toll taken on the well-being of veterans, their families, and society renders PTSD a major public health concern.

Unfortunately, veteran characteristics make treatment less effective for them than other populations (Creamer & Forbes, 2004). Veterans with PTSD are subject to a host of symptoms and comorbid conditions including traumatic brain injury (TBI) or substance use disorder (SUD). Furthermore, recent research suggests that one-fourth of U.S. soldiers experience mental health issues before enlistment and nearly half of internalizing disorders (e.g., PTSD, major depression) and 80% of behavioral disorders (e.g., SUD, ADHD) predate deployment (Harvard Medical School, 2014, March 5). Psychiatric complications may be more prevalent for returning OIF/OEF/OND service members who typically experience more frequent, longer deployments than older counterparts (Hosek, Kavanagh, & Miller, 2006). Multifaceted treatment plans evince PTSD's complexity (van der Kolk, 2001). Nevertheless, researchers suggest the key to recovery lies in addressing the body's ability to self-regulate (Ford, 2013; Gevirtz & Dalenberg, 2008).

Biofeedback therapy facilitates self-regulation by assisting individuals in harnessing the body's involuntary functions. Heart rate variability (HRV) biofeedback monitoring beat-to-beat heart rate fluctuations may be an advantageous adjunct to PTSD treatment given the condition's physiological basis. Heightened reactions characterizing PTSD reflect autonomic nervous system (ANS) dysfunction signified by low HRV (Bedi & Arora, 2007). Conversely, high HRV indicates parasympathetic–sympathetic balance and response flexibility (Lagos et al., 2008; Prinsloo, Derman, Lambert, & Laurie Rauch, 2013). Research suggests increasing baseline HRV via biofeedback may help alleviate PTSD symptoms for the general population (Gevirtz & Dalenberg, 2008; Zucker, Samuelson, Muench, Greenberg, & Gevirtz, 2009) and veterans alike (Tan, Dao, Farmer, Sutherland, & Gevirtz, 2011).

Although research indicates potential benefits of HRV biofeedback for PTSD management, there is a relative dearth of information substantiating the intervention's real-world feasibility. This paucity is detrimental given that treatment providers face challenges including limited

budgets, time, or staffing. One way of capitalizing on limited resources is through group intervention (Sloan, Bovin, & Schnurr, 2012). Such groups may also promote the establishment of safe environments, normalization of experiences, or creation of support networks (Knight, 2006; Sloan et al., 2012).

The current study's objective was to assess effectiveness of a biofeedback therapy group designed to improve HRV in OEF/OIF/OND veterans with PTSD partaking in a residential treatment program. Participants learned to use biofeedback alongside emotion-regulation techniques to enhance HRV. Progress was signified by increased cardiac coherence (CC), a heart rate index believed to gauge the degree of synchronization between ANS systems (Ginsberg, Berry, & Powell, 2010; McCraty, 2011). Researchers suggest that CC, operationally defined below, occurs when heart rate and blood pressure oscillate out of phase while heart rate and respiration oscillate in phase at a resonant frequency of about 10 seconds prompting increased sympathetic–parasympathetic efficiency (Vaschillo, Vaschillo, & Lehrer, 2006). Studies link enhanced CC to psychological benefits involving cognitive functioning and psychosocial outcomes (Ginsberg et al., 2010; McCraty, 2011).

Intervention consisted of two phases: (a) HRV biofeedback instruction, and (b) once-weekly support groups accompanied by daily biofeedback practice. Analysis of overall results assessed HRV improvement (represented by CC gained) and decreases in PTSD symptom severity throughout participation in eight once-weekly group sessions. Three case studies illustrate challenges and success. The intention of the second phase was to provide group support reinforcing daily biofeedback practice and encouraging emotion-regulation mastery. Therefore, CC improvements were expected to persist into the second phase. Accordingly, reductions in PTSD severity were predicted to accompany increased coherence.

Methods

Study Setting

HRV biofeedback groups were conducted at a Los Angeles transitional residence for OEF/OIF/OND veterans experiencing difficulty reintegrating into civilian life. The facility featured a holistic case management program offering group therapy, individual counseling, and resource referrals.

Participants

OEF/OIF/OND veterans with combat experience (33 men, $M_{age} = 31$, age range: 22–50) were recruited through flyers, house meeting presentations, and case manager referrals. Exclusion criteria included psychotic symptoms or previous HRV biofeedback experience. Participants received credit towards the program's mandatory group requirements and $50 gift cards following successful study completion. Six of 33 veterans who began attending groups were discharged from the program early and were unable to complete all eight sessions. Thus, the final sample used for analyses was 27 veterans. About 19% of these individuals reportedly developed PTSD before deployment. Percentages of veterans who had known pre-enlistment histories of depression or substance abuse were 33% and 48%, respectively. Finally, 15% of the sample experienced TBI.

Three case studies illustrate achievements and pitfalls of group biofeedback intervention for PTSD. Case selection was based on level of CC improvement compared to the group mean and presence of PTSD as indicated by a PTSD Checklist score above the 50-point cutoff. Case 1 achieved a CC increase substantially larger than the average increase (2,622% vs. 229%, respectively). Case 2 demonstrated an 8% decrease rather than increase in CC from preintervention to postcoaching. Case 3 gained CC at postcoaching, albeit at a lower degree (140%) than average.

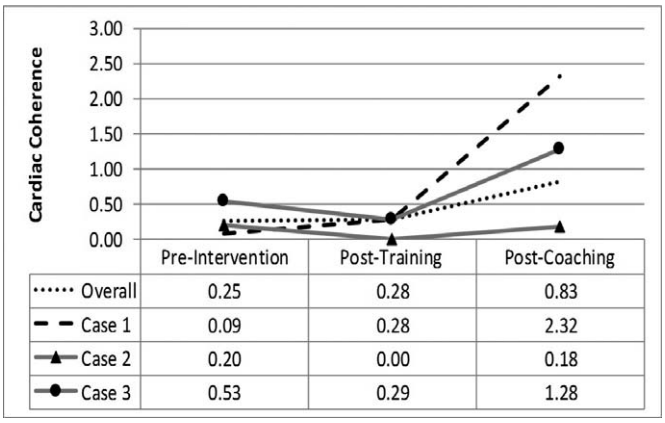
Biofeedback Devices

The emWave Desktop (HeartMath, Boulder Creek, CA), a heart rhythm monitoring system, was installed on laptops assigned to participants during group sessions. The program includes an infrared photoplethysmography sensor and software displaying real-time HRV patterns and coherence levels. Supplementary features include a breath pacer, pulse monitor, and games designed to assist participants in reaching CC. During Week 3 of training, participants received the emWave2, a portable HRV monitor, to practice biofeedback outside of groups. Veterans kept the device for their personal use after successful study completion.

Measures

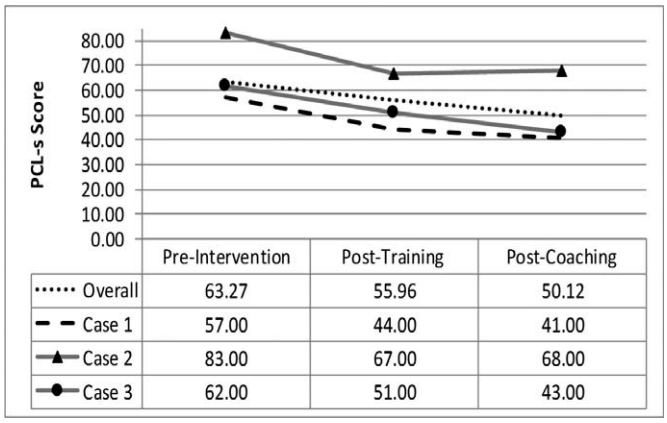
HRV and PTSD severity were measured at three points: prior to biofeedback training commencement (preintervention), after the 4-week biofeedback training groups (posttraining), and after the 4-week biofeedback coaching groups (postcoaching).

PTSD severity. The self-administered 17-item PTSD Checklist Stressor-Specific version for Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) (PCL-S; Weathers, Litz, Herman, Huska, & Kean, 1993) measured PTSD severity. Individuals rated items from 1 ("not at all")



	Pre-Intervention	Post-Training	Post-Coaching
Overall	0.25	0.28	0.83
Case 1	0.09	0.28	2.32
Case 2	0.20	0.00	0.18
Case 3	0.53	0.29	1.28

Figure 1. Preintervention, posttraining, and postcoaching CC.



	Pre-Intervention	Post-Training	Post-Coaching
Overall	63.27	55.96	50.12
Case 1	57.00	44.00	41.00
Case 2	83.00	67.00	68.00
Case 3	62.00	51.00	43.00

Figure 2. Preintervention, posttraining, and postcoaching PTSD severity.

to 5 ("extremely"), indicating the frequency with which respondents have been bothered by DSM-IV defined PTSD symptoms (i.e., avoidance numbing, hypervigilance, intrusive recollection). Following recommendations by Weathers et al. (1993), a score over 50 indicated probable PTSD.

Cardiac coherence. Coherence, operationally defined as a narrow peak falling within the low frequency band of the HRV power spectrum, is quantified using the ratio: Peak Power / (Total Power − Peak Power) (McCraty, 2011). Computation requires identifying the maximum peak falling between 0.04 Hz and 0.26 Hz, calculating the integral within a 0.03 Hz window centered on this peak, and calculating total spectrum power.

Heart rate data were recorded with the emWave Desktop system using procedures adapted from Ginsberg et al. (2010). Participants turned away from the computer screen to avoid viewing visual feedback and refrained from moving or speaking during 10 minutes of recording. Data exported from emWave was analyzed using Kubios software (University of Eastern Finland, Kuopio, Finland).

Intervention

Phase 1. The first phase of groups followed preintervention testing and consisted of once-weekly biofeedback training sessions facilitated by a life skills teacher (LST) who introduced participants to concepts of biofeedback, HRV, CC, and physiological stress responses. Additionally, the LST instructed on biofeedback use and an emotion-regulation technique coupling positive thoughts or imagery with deep, controlled breathing.

Phase 2. Following posttraining testing, participants embarked on the second phase consisting of once-weekly HRV biofeedback coaching groups. The objective was to support veterans through usage of newly learned emotion-regulation techniques during real-life situations. The LST encouraged daily exercise of emotion-regulation techniques paired with use of personal biofeedback devices. Group members discussed personal progress and biofeedback-usage issues during sessions. To facilitate discussion, participants noted experiences in weekly journal forms that included prompts for reflection on emotions and physical sensations.

Results

Average CC, calculated using data from the final sample, increased by 229%. A one-way repeated measures ANOVA with a Greenhouse-Geisser correction indicated significantly different means between time points, $F(1.128, 29.329) = 9.25$, $p < .01$. Post hoc tests using the Bonferroni adjustment revealed a nonsignificant increase in CC from preintervention ($M = .25$, $SD = .38$) to posttraining ($M = .28$, $SD = .22$), $p > .05$. However, the mean postcoaching CC ($M = .83$, $SD = .98$) was significantly higher than CC preintervention ($p < .05$) and posttraining ($p < .05$). Figure 1 depicts average CC at each time point. Results suggest that real-life biofeedback practice and support offered in Phase 2 is essential for CC improvement.

Results indicated a drop in PTSD severity from preintervention through study completion. A one-way repeated measures ANOVA showed significant decreases in PTSD severity between time points, $F(2, 50) = 17.16$, $p < .001$. Post hoc tests using the Bonferroni adjustment revealed that PCL-s scores decreased significantly from preintervention ($M = 63.27$, $SD = 13.89$) to posttraining ($M = 55.96$, $SD = 16.81$), $p \leq .001$. PTSD severity continued to decrease postcoaching ($M = 50.12$, $SD = 16.34$) and was significantly lower than preintervention scores, $p < .001$. Figure 2 depicts changes in mean PCL-s scores.

Case Studies

Case 1. Rupert, a 25-year old male, had a predeployment history of PTSD, depression, and substance use disorder. He attended individual and group therapy and Narcotics Anonymous meetings. Rupert's preintervention CC (.09) was lower than the group average and his PCL-s score was 57. He began HRV biofeedback training with five other veterans immediately following program intake. The LST noted Rupert who displayed a quiet, focused countenance during sessions, was exceptionally dedicated to learning about biofeedback. The LST also mused on Rupert's penchant for encouraging others to remain focused during group exercises. Posttraining, Rupert's PCL-s score (44) dropped below the 50-point cutoff as CC (.28) increased by 10%.

Rupert's commitment to biofeedback and group attendance continued into Phase 2. Rupert practiced with his portable device, which he likened to a challenging videogame, daily. In journals, Rupert often noted shifts towards mental and physical balance, calm, or focus following biofeedback practice. Rupert's final PCL-s score of 41 demonstrated reduced PTSD severity through the second phase. Meanwhile, his postcoaching CC of 2.32 evidenced a keen ability to self-regulate. This score was substantially higher (2622%) than his pre- and posttraining scores and the overall average.

Case 2. Arthur was a 34-year-old male who acquired PTSD and moderately severe TBI during military service. Treatment included individual and group therapy and regular visits to a VA psychiatrist. Arthur began HRV biofeedback groups alongside two other veterans less than 2 weeks after program intake. Preintervention, his CC (.20) was on par with the overall mean, yet his PTSD severity was well above average at 83 points. Unfortunately, Arthur experienced difficulty making scheduled group sessions and, after two weekly training sessions, opted out of participation until his schedule permitted for consistent attendance.

Arthur restarted HRV biofeedback training about 1 month later, in a four-veteran cohort. To capture Arthur's true preintervention baseline, analyses used his initial PCL-s and CC scores. Unfortunately, his difficulty attending persisted and he often scheduled one-on-one makeup sessions. While Arthur was comfortable during group discussions, the LST noted he did not appear to buy into HRV biofeedback or emotion-regulation techniques and seemingly lacked focus during group exercises. Arthur reasoned that training would not make a difference due to his naturally calm, hard-to-aggravate demeanor. Lack of buy-in likely resulted in only a minor CC increase from pre- to posttraining (.20 vs. .23). PTSD severity did decrease by 19% (PCL-s = 67), yet remained above the cutoff point.

Arthur continued participation through Phase 2. In journal entries, he discussed practicing biofeedback to shift from negative emotions (e.g., anger, frustration) to balanced, calm states. Furthermore, he asserted that practice afforded reprieve from daily stressors. Still, the LST's observations contradicted Arthur's self-reports and his behaviors and dialogues evidenced little commitment to practice. Arthur's final CC (.18) was not much higher from preintervention and his postcoaching PTSD severity (PCL-s = 68) showed no substantial departure from posttraining.

Case 3. Bradley was a 29-year-old veteran who experienced moderately severe TBI and had a predeployment history of PTSD, depression, and SUD. In-house treatment included individual and group therapy along with psychoeducation. Bradley's HRV biofeedback group participation commenced two months following program intake in a group alongside five other veterans including Case 1 (Rupert). Bradley demonstrated dedication to group sessions often arriving early to get extra practice and assist with setup. During group, Bradley appeared energetic and positive with an infectious jovial attitude. However, his mood often shifted depending on life issues. Despite enthusiasm for HRV biofeedback, Bradley's CC decreased from .53 to .29 after Phase 1. Fortunately, Bradley's PTSD severity did decrease by 18% from pre-intervention to posttraining (62 to 51 points, respectively).

During coaching sessions, Bradley admitted failing to use biofeedback daily. Rather, he often used emotion-regulation techniques without biofeedback. Bradley's journals detailed instances of using newly learned self-regulation skills to feel less anxious, overwhelmed, or energetic during daily activities and stressful situations. The result would be calm, focus, or simply contentment. Although his practice was not as frequent as recommended, Bradley declared satisfaction with the device for aiding mindfulness and wrote, "It's great to have a visual of what is going on when I practice." Brad's coherence levels increased during coaching, albeit at a lower degree than average (140% vs. 229%, respectively). Still, his postcoaching CC of 1.28 demonstrates a strong ability to maintain physiological balance. Lastly, Brad's final PCL-S score (43) was a 44% decrease from preintervention and below the 50-point cutoff.

Discussion

This research adds to the body of research linking enhanced HRV to reduced PTSD severity. As expected, overall results

show that the average group CC increased after the 8-week group series. Furthermore, improvement was most salient following coaching. This suggests that practice, reinforced during group sessions, is critical in order to bolster baseline CC. Analyses also demonstrate reduced PTSD severity beginning at posttraining and continuing through to postcoaching. This is unsurprising considering the physiological source of the psychiatric symptoms. Taken together, study outcomes suggest that the group protocol was able to effect a change in veterans' baseline CC that, in turn, may have aided in alleviating PTSD symptoms.

The aforementioned cases provide additional evidence and helps pinpoint key factors for intervention success. Rupert and Bradley, two participants highly dedicated to mastering HRV biofeedback, achieved substantial CC gains by the end of the study. Bradley exercised emotion-regulation skills frequently, but did not pair this with biofeedback as often as recommended. This likely resulted in some difficulty attaining CC during posttests. Conversely, Rupert demonstrated extreme focus and dedication to daily practice during the second phase attaining a higher than average increase in coherence. Both Rupert and Bradley reported decreased PTSD symptomatology at posttraining that continued to decrease through coaching. Their results evidence the importance of consistently employing biofeedback as an emotion-regulation aid. Arthur, meanwhile, did not put as much effort into groups or practice. As can be expected, his CC levels remained stagnant throughout the study. Moreover, his decreases in PTSD severity seemingly plateaued after training. It seems that to improve coherence, solely learning to use biofeedback is insufficient. Consistent, daily practice is crucial for improving baseline CC and maximizing decreases in PTSD symptomatology.

Conclusion

This study shows promise for HRV biofeedback interventions focused on treating trauma and stress-related disorders and suggests the necessary ingredient for effectiveness is practice. Daily implementation helps incorporate biofeedback into an individual's routine. A group protocol, meanwhile, fosters continued practice by offering support through mastery of everyday self-regulation skills. These results warrant further investigation on the use of biofeedback group therapy as an intervention not only for veterans, but also for other trauma-affected populations.

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Frances J. Reyes

Correspondence: Frances J. Reyes, Evaluation Department, Volunteers of America Greater Los Angeles, Los Angeles, CA 90010, email: freyes@voala.org.