

# The Effectiveness of Neurofeedback Training on Reducing Symptoms of War Veterans with Posttraumatic Stress Disorder

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## ABSTRACT

**Objective:** Current study aimed to determine the effectiveness of neurofeedback training on decreasing posttraumatic stress disorder (PTSD) in veterans.

**Methods:** The present study is an experimental research with pretest, posttest, and control group design. Patients with PTSD were randomly selected by purposive sampling method and assigned in experimental (15 persons) and control groups (15 persons). Data were collected by the posttraumatic stress disorder checklist (PCL). After the pretest, experimental group received neurofeedback training for 20 sessions, 3 days per week. Groups were evaluated for intensity of symptoms by PCL questionnaire at the beginning and end of the study. Data were analyzed using analysis of covariance (ANCOVA) by SPSS version 22.

**Results:** The results of covariance test showed that there are differences between adjusted mean of PTSD symptoms in groups in posttest by removing the impact of pretest scores.

**Conclusion:** Our findings showed that neurofeedback training has significantly decreased the score of total symptoms ( $F=22.506$ ,  $P<0.001$ ).

## 1. Introduction

Posttraumatic Stress Disorder (PTSD) is one of the stress disorders which is chronic and complex. Its symptoms include re-experiencing memories which relate to injuries the patient experienced, fear and distress, avoidance of situations reminiscent of the trauma, and emotional numbness. Also, the patient constantly reviews events in his mind, but at the same time avoids them. And finally, the patient feels hyperarousal states such as irritability, poor concentration, and exaggerated reactions (Dobie et al., 2002).

PTSD usually accompany with other disorders such as anxiety disorders, mood disorders, depression, and addiction (Panagioti, Gooding, & Tarrier, 2009; Trichey et al., 2012). The symptoms have significant effect on patient's

life, job, social relations, and education (Chossegros et al., 2011; Panagioti, Gooding, & Tarrier, 2009). In addition to the main symptoms, there are other problems such as difficulty in interpersonal relationships; Disability in emotional control; Drug and alcohol abuse; Aggressiveness and violence; Poor control of impulse; Feeling of helplessness, inferiority, guilt, shame, and severe anger; irritability; divorce; separation; and a variety of physical and medical complaints (Panagioti, Gooding, & Tarrier, 2009). Sexual assault, war and other forms of violence probably lead to PTSD more than other injuries (Dobie et al., 2002; Panagioti, Gooding, & Tarrier, 2009).

Eight years of war between Iran and Iraq imposed multiple damages such as mental injuries of martyrs and missing families, and injured people on Iranian people and its adverse effects still persists. Because of the 8 year war, Iranian people have experienced a lot of physical

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and mental problems and most of the soldiers suffer from PTSD. Nourbala (1993) studied PTSD prevalence in Tehran City and reported that 29.1% of veterans, 18.1% of soldiers, and 5.7% of general population (which were not in war) suffer from PTSD.

Khodaei Ardekani and Karami (2007) reported the PTSD prevalence as 40% among veterans. According to a research in 2001 on records and files of mental veterans and related interviews, more than 80% of mental veterans suffer from PTSD with different levels and all of them needed professional treatments (Donyavi & Amiri, 2008).

When an illness appears, the most important thing is choosing an on time and suitable treatment which is more necessary in mental disorders due to complexity of human behaviors and increasing mental disorders (Dibajinia, Zahiroddin, & Ghidar, 2011).

Psychological interventions and medications are used to treat PTSD signs and symptoms. Also some research has been done on the effect of the methods such as immunization in reducing stress syndrome of PTSD (Ahmadzade Aghdam et al., 2012), desensitization by eye movements and reprocessing (BMDR) of PTSD (Niroumandi, 2008), and the cognitive behavioral treatment on symptoms of PTSD and depression (Bakhtavar, 2007). However, due to biological basis and abnormal patterns of brain function in these patients, the improvement of PTSD symptoms was not observed in Iran or abroad.

Recent studies have recognized brain function abnormalities in stress disorders such as PTSD (Brown, Scheflin, & Hammond, 1998). In this regard, neurofeedback instruction is one of modern techniques which are used to treat many such disorders (Rozelle & Budzyneski, 1995).

Based on this technique, brain learns to correct itself by observing abnormalities in its waves. This treatment process is done according to learning principles (Gunkelman & Johnstone, 2005). In order to justify the symptoms of PTSD, modern neuropsychological studies show that people who suffer from PTSD confront with disability in executive functions (Hull et al., 2003; Twamley, Hamia, & Steina, 2004). Different studies confirmed biological bases for PTSD (Mellman et al., 1997). Also, a few studies used quantitative electroencephalography in PTSD patients (Jokic-Begic & Begic, 2003). Ahmadi, Bakhtshipour, and Vahedi (2009) observed significant decrease in  $\alpha$  wave function in the patient against control group in frontal and central regions by comparing quantitative electroencephalogram in PTSD patients. The result of Jeong-Ho et al. research (2004) showed that

PTSD patients generally have less complexity in their EEG waves. Jokic-Begic and Begic (2003) reported that soldiers who suffered from PTSD showed a decrease in  $\alpha$  waves and increase of  $\beta$  waves. Lubomir and Pavlov (2004) findings showed that low level hyperarousal state (with closed eyes) in subjects with high stress associates with increasing in right hand function of  $\theta 1$  and  $\beta 1$  waves in parietal-temporal cortex. Metzger et al. (2004) found that PTSD hyperarousal symptoms relate to increase in right parietal lobe function.

On the whole, these findings refer to the abnormality in information processing of patients with PTSD (Jeong-Ho et al., 2004). Peniston and Kulkosky (1999) studied the effect of neurofeedback training on veterans who suffered from PTSD or alcoholism. They showed that neurofeedback had positive effects on PTSD symptoms. Also, Skott et al. found the same results in their research. They showed that although some patients needed to repress  $\alpha$  function, others needed to reinforce  $\alpha$  function. White and Richards (2009) also showed that  $\alpha/\theta$  treatment can be suitable in people who suffer from trauma; Furthermore, same research confirms that neurofeedback training has positive effects on stress disorders. Naeini-an et al. (2009) studied the effect of neurofeedback on decreasing comprehensive stress disorders symptoms and the quality of life. They showed that neurofeedback training results in increasing  $\alpha$  waves and decreasing symptoms of generalized anxiety disorder in the treatment group. Mahini (2010) also showed that neurofeedback had positive effects on attention competitive trait anxiety and heartbeat. Singer (2004) showed that neurofeedback training adjusted neuron system function by regulating sleep pattern and decreasing anxiety and tension. Study of Agnihorti et al. (2007) shows the effect of neurofeedback on decreasing trait and state anxieties.

According to above findings, neurofeedback training can be used as a therapeutic method for stress disorders. However, most of studies are case studies which cannot be generalized and need field study by researchers. Therefore, we aimed to study the neurofeedback effectiveness on decreasing PTSD symptoms in veterans.

## 2. Methods

This research is a semi-experimental with pre-test, post-test, and control group. In this research, PTSD symptoms are considered as dependent variables and neurofeedback training as independent variable.

The statistical population includes all veterans who suffer from PTSD and hospitalized in psychiatric cen-

ters and hospitals. Purposive sampling was done among patients who hospitalized in spring, summer, and fall of 2014 in Sadr, Delaram and Parsa Psychiatric centers. A total of 30 patients were selected by considering inclusion criteria consisting of suffering from PTSD according to posttraumatic stress disorder checklist (PCL), clinical interview done by the psychologist and psychiatrist, being male, 40-60 years old, having under constant medication, attendance in neurofeedback treatment, and having the least ability in reading and writing. Exclusion criteria were being psychotic, drug abused, getting score higher than 29 in Beck depression inventory II, and having the experience of neurofeedback treatment. They were randomly assigned in experimental group (n=15) and control group (n=15). Cohen method was used to determine the sample size. In this method,  $\alpha$  and the effect size was determined as 0.50. In this case, with statistical power of 0.76, a total of 15 people were selected for each group.

The posttraumatic stress disorder checklist (PCL) is a self-report list to evaluate the disorder and screen normal people. It is a short list and limited to military forces. The list is provided based on DSM-IV criteria by Weathers, Herman, Huska and Keane (1993). It includes 17 items. Of them, 5 items are related to re-experiencing symptoms of PTSD, 7 items are related to symptoms of numbness and avoidance, and 5 items are related to hyperarousal symptoms. Total scores range between 17 and 85 scores which is calculated by summing 17 items according to Likert-type scale. Cut-off point is determined at 50 in samples who were related to military forces in patients with PTSD. The validity and reliability of the list was calculated by Goudarzi (2003) in Shiraz University in Iran by collecting data from 117 subjects and using the Cronbach  $\alpha$  coefficient.

The coefficient was 93% which indicates its good reliability. Also coefficient reliability was 87% by split-half method which indicates list reliability. In order to provide validity index, its correlation was determined by life event list. Correlation coefficient refers to the synchronicity of index validity. In PCL list, items of 1 to 5 evaluate re-experiencing, items of 6 to 12 evaluate numbness and avoidance and items of 13 to 17 determine hyperarousal. Each item is scored from 1 to 5. Mirzaei et al. (2004) showed that the strongest symptoms belonged to constant irritability and re-experiencing and the mildest symptoms with the avoidance of memory in PTSD patients in the interview. The interview is consistent with total sleep deprivation (TSD) clinical psychiatric interviews. Mirzaei and Imani (2011) implemented PTSD list on 475 veterans who suffered from mental disorders to determine its validity. Fifty of them reevaluated 2 weeks

later. Pearson correlation coefficient was 0.866 in retest which validates its reliability. The Cronbach  $\alpha$  was 0.851 in PCL-M and PTSD-I in 20 people.

Sampling was started by obtaining necessary permissions from managers of Sadr, Parsa, and Delaram hospitals and coordinating with mental centers administrator and talking with therapists and consulting with psychiatrists. A total of 30 male veterans, aged 40-60 years, were selected by clinical interview according to DSM-IV-TR criteria, PCL questionnaire, and Beck depression inventory (BDI-II). The subjects obtained scores of upper than 50 in PCL questionnaire and lower than 29 in BDI-II questionnaire (17 people from Delaram center, 10 people from Parsa hospital and 3 people from Sadr hospital). Then, they were randomly assigned into two groups of experimental and control groups. The experimental group members were trained by neurofeedback in 20 sessions of each 45 minutes according to  $\alpha/\theta$  protocol. Control group were under conventional treatment. Meanwhile 2 subjects dropped from the experimental group and 2 other patients replaced them (one of them died due to heart attack at home and other was released from hospital due to hepatitis C).

The method of neurofeedback was as follow. At first, electrodes were set on desired location with special gels in 10-20 standard points according to international system. All subjects were trained  $\alpha/\theta$  protocol for 45 minutes in Pz point. In  $\alpha/\theta$  protocol, there is an auditory feedback with river and ocean sounds. River sound is a feedback from  $\alpha$  wave prepotency and ocean sound is a feedback from  $\theta$  wave prepotency. All of them are optimal. The subjects most hear ocean sounds more than others and think about bad memories and ideals and the solutions of his problems. This task has no reinforcement or suppression, but it needs justifying (make harmony) between  $\alpha/\theta$  waves by the subject. The subject must think about the solution of bad experiences. However, delta axis alerts by wave controlling when patients are approaching to the state of drowsiness. Therefore, they must be conscious during the process. Analysis of Covariance (ANCOVA) were done by SPSS version 22. There are several key assumptions that underlie the use of ANCOVA and affect interpretation of the results. There are five standard assumptions that include linearity of regression, homogeneity of error variances, independence of error terms, normality of error terms and homogeneity of regression slopes.

### 3. Results

The study subjects were 30 patients (15 patients in the control group and 15 in the experimental group). Aver-

**Table 1.** Descriptive findings of pretest and posttest scores of PTSD symptoms in experimental and control group.

Variable	Experimental group				Control group			
	Pre-test		Post-test		Pre-test		Post-test	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
PTSD Symptoms	68.6667	6.30948	60.9333	5.68792	67.5333	6.62103	66.3333	7.10801

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age age of the experimental group members was 48.20 years and its range was 43-60 years. Average age of the control group was 48.73 years and its range was 41-60 years old. There is no significant difference between two groups ( $P=0.739$ ,  $t=0.336$ ). Also, in terms of marital status there is no meaningful difference between two groups ( $P=0.699$ ,  $X^2=715$ . and also regarding educational level ( $P=0.649$ ,  $X^2=1.644$ ). Therefore, two groups had no significant differences in terms of age, marital status, and educational level. In Table 1, descriptive data related to pre-test and post-test and dependent variables of control and experimental groups are shown. As you can see in Table 1, the average of all values in the post-test of experimental group is less than those in the pre-test.

One-way analysis of covariance was used to study the effect of neurofeedback in decreasing PTSD symptoms in veterans according to 2 level independent variable (experimental and control group) and continuous dependent variable (post-test scores in PTSD symptoms) and variable changes (pre-test scores in PTSD symptoms). This analysis shows the difference between total scores average in experimental group (neurofeedback training) and control group after adjusting scores. The results are shown in Table 2.

As you can see in Table 2, there is a significant difference between 2 groups with regard to total score of PTSD symptom. A significant difference exists between adjusted averages of total score of PTSD symptoms in posttest by omitting pretest score effect. On the whole, according to the finding, neurofeedback training decreased total square of PTSD symptoms. This decrease is significant. Neuro-

feedback training resulted in 45% difference between experimental group and control in terms of PTSD symptoms.

#### 4. Discussion

Our study results show that PTSD symptom's average scores of 2 groups had significant difference which was due to neurofeedback treatment (45% difference). The results are consistent with the findings of Peniston and Kalkusky (1991), Scott et al. (2002), Naeinian et al. (2009), Mahini (2010), Hardt (1973), Singer (2004), Agnihory, Poul, & Sandho (2007), Wight and Richards (2009).

The effectiveness of neurofeedback treatment according to  $\alpha/\theta$  waves can be attributed to some factors. In these patients, there are reports of their brain waves damage, so it can be helpful to emphasize on the treatment of the waves. Evidence showed that depression and stress are related to unequal pattern of brain functions. Researchers examined a relationship between PTSD, stress, depression symptoms and  $\alpha$  wave asymmetry in frontal, temporal, and parietal brain areas of female nurses who served at war. The result showed that PTSD hyperarousal symptoms were associated with increased activity of right parietal area (Margze et al., 2004). Begic et al. (2001) also showed that there were significant changes in  $\alpha/\theta$  functions in PTSD patients. In PTSD patients,  $\theta$  function increases in central area. The increase of  $\beta$  functions are seen in frontal, central, and left occipital areas. Jokic-Begic (2003) reported that in PTSD soldiers,  $\alpha$  waves decreased and  $\beta$  wave increased. Therefore, brain waves are disordered in patients with PTSD and neurofeedback treatments are effective by repairing the waves.

**Table 2.** Analysis of covariance on overall test score of PTSD symptoms in the experimental group and the control group with pre-test control.

Dependent variable	Source	Total squares	df	Mean squares	F	Sig. level	Level of effect
Total square of PTSD symptoms	Pre-test	801.8	1	801.8	60.392	0.000	0.691
	Group	298.798	1	298.798	22.506	0.000	0.455
	Error	358.467	27	13.277			
	Total	122855	30				

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Theta waves may be detected in some lobes. It is believed that  $\theta$  wave reflects limbic system function which has an important role in memory and emotion (Geev et al., 2005; cited in Ali Mirzaei, 2013). With increasing  $\theta$  wave, we can create trace by neurofeedback training which decreases hyperarousal. In normal adults with closed eyes,  $\alpha$  wave activity is seen, especially in occipital area. These waves indicate relaxation. With especial sensory excitations and open eyes, the waves function stops and  $\beta$  waves replaced them (Schwartz & Andrasick, 2003). Alpha function is increased in hypnotism and meditation (Anand et al., 1961; cited in Schwartz & Andrasick, 2003). It was reported that  $\alpha$  waves are emitted from thalamus-cortical circuit during the waking state and are related to relaxing and awareness status (Giyo et al., 2005; cited in Ali Mirzaei, 2003). The effect of neurofeedback training on  $\alpha$  waves results in relaxation mode (Demos, 2005). Therefore, focus on both  $\alpha$  and  $\theta$  waves can result in relaxation in patients with PTSD, then they feel less hyperarousal and do everything with less stress and more relaxation. Often  $\alpha$  and  $\theta$  waves work synchronically in brain which named  $\alpha/\theta$  waves function which makes it the most effective method to treat stress disorders. Theta waves with sensory motor relaxation and  $\alpha$  waves with mental states and positive emotions decrease hyperarousal state in patients with PTSD.

In addition, treatment based on  $\alpha/\theta$  neurofeedback decreases symptoms by effecting memory and attention in PTSD patients. Also, studies show that there is a disability to control and adjust the memory of PTSD patients (Yehuda & McFarlane, 1995). There are abnormalities in information processing in PTSD patients (Jeong-Ho et al., 2004). Also Peniston and Kalkusky (1999) believed that there are problems in attention, concentration, and active memory in PTSD patients.

On the other hand, evidence shows that neurofeedback can increase memory ability (Hanslmayr et al., 2005; Egner & Gruzelier, 2001; Damasio, 1994; Vernon, 2005; Hong & Lee, 2012), attention, and concentration (Gevenselben et al., 2010; Mahini, 2010; Doppelmayr & Weber, 2011; Arns, Drinkenburg, & Kenemans, 2012). Regarding the attention and memory disorders in patients with PTSD, we can conclude the effectiveness of neurofeedback training on memory and attention symptoms of PTSD.

According to treatment protocol in this study,  $\alpha/\theta$  wave restoration improves personal imagination and memory (Green, Walter, & Green 1970). During neurofeedback training and treatment based on  $\alpha/\theta$ , the patient learns to increase  $\alpha/\theta$  pattern of brain waves and create a new state in brain waves experiencing less stress and more happiness.

As you can see, this training is done on Pz area that could explain our results. Evidence shows that patients with PTSD have problems in parietal lobe (Weber et al., 2005). Also, patients with PTSD who suffer from severe anxiety have problems in parietal part (Ljubomir & Pavlov, 2004). As a result,  $\alpha/\theta$  brain waves adjustment in Pz area can be helpful. By  $\alpha/\theta$  waves adjustment in Pz area, we can restore the imbalance between two waves and decrease symptoms arising from poor performance.

The  $\alpha/\theta$  waves have direct effects on neurotransmitters that can decrease stress. Evidence confirms that brain waves, especially  $\alpha/\theta$  waves have relaxation and anti-stress effects through neurotransmitters such as  $\beta$ -endorphin, serotonin, and dopamine. Jemmer (2009) believed that brain waves stimulation with  $\beta$  and  $\gamma$  frequencies result in increasing dopamine and  $\alpha$  and  $\theta$  frequencies result in increasing serotonin in brain. Calabrese and Zwickey (2007) confirmed that synchronization of brain waves in  $\theta$  frequency would result in decreasing nerve transporter dopamine.

Peniston research (1998) also shows that  $\alpha/\theta$  protocol results in  $\beta$ -endorphin in brain. The mechanism of this effect becomes apparent, when we notice the role of  $\beta$ -endorphin and serotonin in relaxation and stress control and also the role of dopamine in stress. Thus, stress decrease due to brain wave synchronization can be caused by neurotransmitters changes. According to Kienast et al. (2008), the release of dopamine due to stress, results in saving neurotransmitters in amygdale and the increase of amygdale dopamine level results in stress in people. On the other hand, the decrease of dopamine level due to brain wave synchronization will result in decreasing of dopamine level, tension, and hyperarousal in patients.

Because of the positive effect of neurofeedback training in PTSD symptoms, we suggest that the number of treatment sessions increases to obtain better results. Neurofeedback training is necessary for other types of PTSD too. The comparative studies show that the effectiveness of neurofeedback is more than other types of treatments. Furthermore, it is necessary to hold instruction programs for patients and their family about PTSD symptoms.

### Limitations of the study

This research like all other studies has some limitations that are related to terms and conditions of scientific research. All of these limitations can be considered in future studies in order to be eliminated. We mention the most important ones below:

One limitation which is relevant to the questionnaire investigation is that patients, especially with PTSD, show disinterest and reluctance in responding. Also the possibility of error increased because of existence of self-reporting bias in this kind of research. In addition, neurofeedback placebo effect was not controlled due to time and financial constraints. Also, we could not draw conclusion about the impact of long-term treatment due to the lack of follow-up research. Primarily, the follow-up tests offer better and extensible results to assess long-term effects of interventions.

Furthermore, this study is based on non-random selection of participants which limits the generalization of our findings. Another limitation of this study is using a small sample.

### Ethical considerations

Subjects were included in neurofeedback training after assuring the confidentiality of their personal information and taking written consents from them. Also in this study, subjects were allowed to refrain from participating at any time they were reluctant to continue cooperation. Research methods did not violate legal, cultural, and Islamic principles.

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