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# Biofeedback-Assisted Relaxation Therapy on Women with Breast Cancer after Mastectomy: Effects of EMG-HRV Biofeedback on Psychological Symptoms

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## Abstract

**Introduction:** Breast cancer patients usually react to mastectomy surgery by increased levels of stress, anxiety and depression which requires effective interventions. The aim of present research was to investigate the effects of an Electromyography (EMG) and heart rate variability (HRV) biofeedback-assisted relaxation training to alleviate the psychological symptoms of mastectomy breast cancer women.
**Method:** In a randomized controlled trial design about 14 mastectomy women were randomly chosen and divided into two groups and measures of Depression Anxiety Stress Scale were gathered for them. The experimental group received biofeedback-assisted relaxation training, whereas no intervention administered on the control group. All subjects again completed the DASS scales afterwards. Indices of smooth artifact free surface Electromyography (sEMG) and HRV biofeedback recorded using a *Biofeedback 2000 x-pert system Version 4*. Data were analyzed by a General Linear Model: Multivariate Analysis of Variance statistical analysis.
**Results:** Depression, anxiety, and stress average scores showed a significant difference after biofeedback intervention. Significant differences were observed in the sEMG and Heart Rate Variability-Index (HRV-Index) measures of the two groups with better results for the experimental subjects as well.
**Conclusion:** The biofeedback-assisted relaxation training could effectively decrease negative psychological symptoms of the mastectomy breast cancer patients due to sEMG and HRV positive changes and is then recommended for these patients in the course of their treatment.

**Keywords:** Biofeedback, Relaxation, Anxiety, Depression, Stress, Breast Cancer, Mastectomy

## Introduction

Breast cancer is one of the most common non-skin cancers and the second leading cause of cancer death among women [1, 2]. The incidence of breast cancer in the United States has doubled in the last two decades [3, 4]. It is estimated that one-seventh of women are diagnosed with breast cancer during their lifetime and the risk of illness increases with age [1]. Surgery has been very common [5] in the form of breast conservation surgery, lymph node dissection, and removal of the breast or mastectomy [6]. However, emotional disturbances such as increased levels of anxiety and depression symptoms following mastectomy [7, 8] are not uncommon, and may lead to psychotherapy and/or psychiatric interventions [9].

Mastectomy refers to the complete removal of the breast tissue including the skin of the breast, nipple, and areola [10]. The mastectomy procedure could be useful and the only solution in some cases but the subsequent psychological effects seems inevitable, and may eventually lead to the reoccurrence of the disease. Indeed, emotional reactions such as increased levels of depression and anxiety symptoms are not uncommon in women undergoing mastectomy [7]. Thus, breast cancer surgery, including mastectomy, requires adjunct psychological treatments such as distraction, hypnosis, visualization, logotherapy, self-regulation, physical exercise, relaxation, and biofeedback [9-12]. Among researchers in this field there are some who consider increased levels of anxiety and stress symptoms as immunosuppressive agents in breast cancer patients that increases the risk for growth of cancer cells [13]. Generally, high levels of depression, anxiety, and stress symptoms can increase the blood concentration of corticosteroids, particularly cortisol and catecholamine (e.g., epinephrine), subsequently leading to a blockage of the immune system or can even cause metabolic malfunctions [14-16].

On the other hand, biofeedback and relaxation training are known to be effective treatments for a wide range of anxiety and stress related problems. Biofeedback provides individuals with useful information about the bodily processes which play important roles in the control of physiological functioning [17, 18]. Biofeedback is a common clinical modality used to provide real time information regarding a physiological event or series of events that would typically not be perceived by the user [19-21].

Among the different modalities, the sEMG externally focuses the user's attention away from the exclusive attempt to contract the intended muscle, and towards an outward cue representing the underlying muscle activation [22, 23]. Shifting an individual's focus away from the muscle contraction towards an external cue is hypothesized to improve the acquisition and retention of the motor skills [24]. However, findings about the effectiveness of electromyography biofeedback were controversial in some studies. For example, in one study researchers [25] failed to find any positive effect for isolated biofeedback training in work with breast cancer mastectomy patients under chemotherapy.

Otherwise, HRV measures has recently gained the independent value in scientific research. The immensity of HRV indicate the ability to adapt to physiological changes, and low HRV increases vulnerability to stress and disease. Indeed, several systems should work together to maintain a minimum level of cardiovascular activity and impediment of these systems lead to a more severe or temporally extended stress response by individuals which may even lead to physical or psychological illnesses including depression, and anxiety [26].

Accordingly, HRV optimization could equip individuals to better manage stress and reduce risk and/or severity of stress-related disease factors. The likely prognostic value of HRV has recently been in the focus of attention due to relations between low HRV and/or baroreflex sensitivity and psychological problems including depression [27] and anxiety [28].There are consensus that low HRV and baroreflex sensitivity permeate several unwelcome physical and mental health illnesses. Low HRV may play a significant role in carrying risk for perseveration of symptoms, morbidity and mortality due to decreased autonomic health in people. Therefore, attempts to identify effective interventions to improve the HRV and baroreflex function, as well as, feasibility of such interventions as adjuncts to standard medical treatments are warranted. Biofeedback has been recently applied as a method for improving HRV parameters and/or baroreflex functioning [29].

Further, a number of studies showed usefulness of the enhanced HRV following HRV biofeedback trainings in different settings and for different participants. For example, Ratanasiripong et al. [30] showed a positive impact of the HRV emWave biofeedback intervention programme on nursing students' levels of stress and anxiety symptoms during their first clinical training. In another research [31], college students learned to produce heart rhythms associated with positive emotions, which reduced their stress level and improved their overall well-being using the emWave unit. Frank et al. [18] believed that biological feedback training could also help patients become aware of their thoughts, feelings, and behaviours in relation to their disease, enabling them to bring about change. Peira et al. [32] recently showed in a study that accurate online heart rate biofeedback provided an efficient way to down-regulate autonomic physiological reactions when encountering negative stimuli. Finally, research scientists believe that heart rate variability biofeedback increases HRV indices and baroreflex gain [33] and can be used with Coronary Artery Disease patients to decrease their expressive and suppressive hostility.

Given the above mentioned effects of sEMG and HRV on the aspects of different diseases and the necessity of adjunct psychological therapies beside medical interventions for breast cancer women, in this study, it was aimed to investigate the effectiveness of sEMG and HRV biofeedback-assisted relaxation therapy on the alleviation of the physiological and psychological symptoms of breast cancer patients after mastectomy.

In the current study, the attenuated muscle tension was hypothesized and heart rate variability measures were enhanced in women with breast cancer after the sEMG-HRV biofeedback-assisted relaxation therapy reinforced by daily home relaxation practices. More importantly, by using these interventions, researchers expect the positive physiological changes to attenuate the emotional disturbances such as depression, anxiety, and stress symptoms in breast-cancer patients with a mastectomy decision.

## Method

The society of this randomized controlled trial design constituted of women who had undergone surgery after being diagnosed with breast cancer in a Tehran hospital during the year 2018. A sample of 14 women was selected and were divided into experimental and control groups on a randomly basis. The selection criteria included: 1- an age range of 31 to 51 years 2- premenopausal state and 3- a recent history of modified radical mastectomy. The exclusion criteria included: 1- patients undergoing chemotherapy and/or radiation therapy 2- chronic and/or acute psychiatric and other physical illnesses.

The tools used in this study are as follows:

**Biofeedback Device:** A modular and portable biofeedback 2000 $^{x\text{-}pert}$ system Version 4 made by Schuhfried was used. The EMG and HRV modules were applied to record a participant's physiological parameters in the baseline and eight treatment sessions. The exchange of data between the radio modules and the computer was administered via a cordless Bluetooth connection.

**Depression, Anxiety& Stress Scale (DASS):** The DASS scale [34] includes 42 phrases related to negative emotions with every subscale consisting of 14 items. The cut-off point for the total score and depression, anxiety, and stress subscales are 33, 10, 8, and 15 respectively. The internal consistency coefficients of the mentioned subscales respectively were reported to be 0.95, 0.90, and 0.93 for a normal population [35] 0.96, 0.89, and 0.93 for a clinical population [36] and 0.93, 0.85 and 0.87 for a normal Iranian population [37].

**Surface Electromyography Biofeedback (sEMG):** Dry sensors were linked to the patient's arm (biceps bruchii) in the mastectomy side of the body. The two electrodes were kept at a distance of 3 cm from each other. The reference electrode was attached to the body ground in the elbow joint. The room temperature for biofeedback training was maintained at 23 ±1° C. Using this bodily feedback together with relaxation training the patient was instructed to remove tension in the mastectomy region and was asked to free her mind of any negative emotions and thoughts as well [38].

**Heart Rate Variability Biofeedback (HRV):** In this research, acquiring from the manualized HRV BF protocol [39] along with the instructions provided in the BF device, information on respiratory movements was visually fed back to the patients. The respiratory movement made a picture of a natural place on the monitor bigger or smaller. The more the patient took a deep and slow breath, the bigger the part of picture was shown to them.

**sEMG-HRV Protocol**

The protocol of the study for sEMG and HRV sessions is presented in Table 1:

**Table 1.** sEMG-HRV Protocol

| | |
|---|---|
| Baseline | ✓ Informed consent and general instructions + sEMG recording on biceps brachii for 10 minutes with the 3 cm electrode distance in mastectomy side of the body and elbow joint as reference electrode without any relaxation or biofeedback.<br>✓ 10 minutes HRV recording without any respiration instruction+ searching for the resonant frequency in each subject using the HRV measures and heart rate diagram<br>✓ Filling DASS Questionnaire |
| 1st session | ✓ Instruction for contracting and releasing all 16 muscles progressively + Learning to get feedback from BF device and creating music and natural scene on the monitor.<br>✓ Instruction to breathe as deeply as possible with the target of reaching to her unique determined target and to + get feedback from monitor |
| 2nd session | ✓ Skip contraction phase and release all 16 muscles progressively + get feedback from BF device and creating music and natural scene on the monitor.<br>✓ HRV training and feedback by the aim of reaching the target and creating coherence in the diagram |
| 3rd session | ✓ Focussing on the mastectomy part of the body and releasing contractions using learned techniques and receiving feedback from BF device.<br>✓ HRV training and feedback by the aim of creating coherence |
| 4th session | ✓ Relaxation exercises + getting feedback from BF device + sEMG recording on biceps brachii at the end for 10 minutes.<br>✓ HRV training and feedback by the aim of reaching the target and creating coherence in the diagram + HRV recording for 10 minutes. |
| 5th session | ✓ Relaxation exercises + getting feedback from BF device.<br>✓ HRV training and feedback by the aim of reaching the target and creating coherence in the diagram |
| 6th session | ✓ Relaxation exercises + getting feedback from BF device.<br>✓ HRV training and feedback by the aim of reaching the target and creating coherence in the diagram |
| 7th session | ✓ Relaxation exercises + getting feedback from BF device.<br>✓ HRV training and feedback by the aim of reaching the target and creating coherence in the diagram |
| 8th session | ✓ Relaxation exercises + getting feedback from BF device + sEMG recording on biceps brachii at the end for 10 minutes.<br>✓ HRV recording for 10 minutes. |

Data extracted from biofeedback device in 3 phases (initial, middle and termination) in which the FFT measures for the sEMG and HRV-index data were entered into a SPSS.18 program for a Manova statistical analysis. Indices of DASS scale were also provided in two pre-post stages and were analysed by the same procedure.

## Results

sEMG and HRV Analysis:

Mean and standard deviation for the collected data is presented for both groups in different stages (Table 2).

No significant Box's M and Leven's Test for the extracted data were found that validated administration of a Manova analysis. Results indicated significant differences for time and time× groups effects (P<0.01) for both indices of sEMG and HRV. Robust significant declining trend in sEMG indices was visible and the difference between two groups increased towards the termination phase of the therapy (P<0.01). The HRV-Index measures had also significantly increased in the experimental subjects. A mild rise had occurred at the middle phase of the research and reached to its peak in the termination phase with small changes for the control subjects. (Table 3).

In the second line of the research, three subscales of the DASS scale in two pretest-posttest occasions were analyzed by a Manova analysis. A significant group effect was evident for subscales as well (P<0.01). A significant between-subjects effects was found for depression, anxiety, and stress in the post-test states. Estimated partial eta squared was 0.543, 0.403, and 0.539 respectively for depression, anxiety and stress which was quiet lower than physiological modes (Table 4).

Finally, the total score of DASS and its three subscales were compared to their corresponding cut-off points using a one-sample T-test at pretest and posttest states in both groups. A reduced gap was detected for the total DASS score. Examining subscales also showed reduced stress and anxiety compared to depression (not reported).

**Table 2.** Descriptive Statistics

| Group | sEMG | Mean | Std. Deviation | HRV | Mean | Std. Deviation | Posttest-DASS | Mean | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| *Experimental* | EMG 0 | 23.39 | 2.55 | HRV0 | 2.95 | 0.60 | Depression | 13 | 2.44 |
| *Control* | | 20.50 | 3.84 | | 3.78 | 0.91 | | 19.42 | 3.77 |
| *Experimental* | EMG 4 | 12 | 2.42 | HRV4 | 3.79 | 0.58 | Anxiety | 10.85 | 2.73 |
| *Control* | | 17.73 | 4.26 | | 3.46 | 0.77 | | 15.42 | 3.25 |
| *Experimental* | EMG 8 | 5.56 | 1.45 | HRV8 | 5.12 | 0.73 | Stress | 16 | 2.51 |
| *Control* | | 16.49 | 3.91 | | 3.38 | 0.78 | | 23.14 | 4.37 |

**Table 3.** Tests of Between-Subjects Effects

| Source | Dependent Variable | df | Mean Square | F | Sig. | (ή2) |
|---|---|---|---|---|---|---|
| Group | EMG | 1 | 221.169 | 21.133 | 0.001 | 0.370 |
| | HRV | 1 | 1.781 | 3.241 | 0.080 | 0.083 |
| Time | EMG | 2 | 429.310 | 41.022 | 0.001 | 0.695 |
| | HRV | 2 | 2.883 | 5.245 | 0.010 | 0.226 |
| Group * Time | EMG | 2 | 170.585 | 16.300 | 0.001 | 0.475 |
| | HRV | 2 | 5.800 | 10.553 | 0.001 | 0.370 |
| Error | EMG | 36 | 10.465 | | | |
| | HRV | 36 | 0.550 | | | |

**Table 4.** Tests of Between Subjects Effects

| Source | Dependent Variable | df | Mean Square | F | Sig. | (ή2) |
|---|---|---|---|---|---|---|
| *Group* | Post-Depression | 1 | 144.643 | 14.261 | 0.003* | 0.543 |
| | Post-Anxiety | 1 | 73.143 | 8.084 | 0.015* | 0.403 |
| | Post-Stress | 1 | 178.571 | 14.019 | 0.003* | 0.539 |
| *Error* | Post-Depression | 12 | 10.143 | | | |
| | Post-Anxiety | 12 | 9.048 | | | |
| | Post-Stress | 12 | 12.738 | | **P<0.01* | |
| | Post-Anxiety | 12 | 9.048 | | | |
| | Post-Stress | 12 | 12.738 | | | |

## Discussion

The aim of this research was to examine the effectiveness of a surface electromyography and the heart rate variability biofeedback-assisted relaxation on alleviation of the physiological and psychological symptoms of breast cancer patients after mastectomy.

Firstly, the psychophysiological findings in this research suggests promising impact for biofeedback-assisted relaxation therapy on breast cancer patients with mastectomy experience. The sEMG findings indicate that the biofeedback-assisted relaxation therapy together with a home relaxation schedule attenuates the muscular tension of the breast cancer mastectomy patients recorded in the biceps brachii. Indeed, a significant sEMG reduction was evident in the patients after treatment. The treatment effects were detected in the middle phase and trend of the improvement continued until the termination phase of the biofeedback therapy. The HRV-Index data also show that the biofeedback-assisted relaxation therapy and home relaxation practices could improve the

HRV of the breast cancer mastectomy women. An increasing trend was observed during the course of treatment particularly in the termination phase of the therapy.

Secondly, the biofeedback-assisted relaxation therapy could considerably alleviate three important psychological symptoms of depression, anxiety and stress in the breast cancer patients. The results of the present study revealed a higher than cut-off point in the total score of the scale at the beginning of the research, whereas the symptoms decreased considerably after eight therapy sessions.

Indeed, the elevated symptoms of depression, anxiety, and stress in both groups at the beginning of the study was obvious, and the biofeedback-assisted relaxation therapy considerably reduced these symptoms in the experimental group rather than the control. For depression, however, the residual symptoms continued to be above the cut-off point (mean difference: 6.43). Further, a moderate effect size was observed (Eta Squared: 0.54), which was quite smaller than the sEMG and HRV physiological modes. In contrast, the observed anxiety, and stress symptoms of the patients were markedly reduced in the experimental group compared to the control (anxiety = mean difference: 4.57; stress = mean difference: 7.43) with no significant residual symptoms at the end of the biofeedback therapy. This is while the small effect size measures were obtained again for anxiety and stress (Eta Squared: 0.40 and 0.53) which restrict generalizability of the results. The results of self-report psychological symptoms suggests greater effectiveness in case of anxiety and stress than depressive symptoms of the mastectomy breast cancer patients.

These findings were in part compatible with Gruber et al. [40]. They used EMG biofeedback and relaxation training to find immune system and psychological changes in Stage 1 breast cancer patients. Thirteen breast cancer patients had been recruited. All patients had undergone a modified radical mastectomy and were lymph node negative. Their study showed significant effects in Natural Killer (NK) cell activity, mixed lymphocyte responsiveness. Positive reductions were also seen in the psychological inventory scales measuring anxiety.

These results were also compatible with those studies [41] who showed reduced anxiety symptoms of in-patient breast cancer women during three periods of chemotherapy. In their study, similar to this research, 14 women with anxiety were divided into experimental and control groups with biofeedback and relaxation training being given to experimental-group patients. The therapeutic intervention could effectively decrease the state of anxiety estimated by Spilberger's Anxiety Test.

In regards to the HRV biofeedback, no research, to the knowledge of the researchers of this study, has yet examined the therapeutic effects on mastectomy breast cancer women. However, in line with the positive HRV results on mastectomy women in a different population [42], a short-term HRV were used as an indicator of autonomic response to stressors in 32 school children. The results indicated a significant autonomic activation in response to stressors but children were able to self-regulate after learning breathing techniques. The self-regulatory enhancement was evident in high coherence scores and a sine wave pattern displayed on the output device. Results were also consistent with Ratanasiripong et al.'s [30] attempts as reported earlier. They showed that, an HRV emWave biofeedback intervention program could successfully reduce the nursing students' levels of stress and anxiety during their first clinical training. Arguelles et al. [43] believe that, during experiences of stress, the heart rhythms take on a jagged and erratic appearance, reflecting an imbalance between sympathetic and parasympathetic branches of the autonomic nervous system. According to McCraty et al. [42] HRV biofeedback indeed reflects the autonomic regulation of the heart and could be considered as an important indicator of changes induced by emotional stress. The HRV biofeedback is also described as the non-invasive measure of neurocardiac function reflecting the mind-body interactions and autonomic nervous system fluctuations. It seems that the HRV optimization could equip the mastectomy breast cancer women to better manage their stress and reduce their anxious and/or depressive states of minds.

In another compatible recent biofeedback study, I-Mei et al., [33] revealed that six weeks' HRV biofeedback could effectively restore cardiac autonomic balance and decrease hostility among patients with Cardiac Artery Disease (CAD). In fact, expressive hostility, suppressive hostility, and total hostility score at post-intervention and one-month follow-up after HRV biofeedback were significantly lower than at pre-intervention. They concluded that HRV biofeedback could increase HRV, and decrease expressive and suppressive hostility behavior in patients. Similarly, Peira, et al. [32] tested whether heart rate biofeedback could help normal participants reduce physiological reactions in response to negative and neutral pictures , and found that accurate online heart rate biofeedback provides an efficient way to down-regulate autonomic physiological reactions when encountering negative stimuli.

Considering the limitation of the small sample size and having no control of the isolated relaxation effect in the study, a more representative sample, as well as, isolating the variable of relaxation training is recommended for future research in this field which perhaps fosters a kind of freedom and independence that might accelerate reductions of DASS scores. Also investigating the effects of these trainings relating to other psychological variables such as self-regulation and attachment styles in breast cancer patients are recommended [44, 45].

## Conclusion

In summary, biofeedback-assisted relaxation therapy together with daily relaxation home practices could effectively improve the muscle tension (sEMG) of breast cancer mastectomy patients. Interventions could also enhance the Heart Rate Variability (HRV) of the patients. Beside these physiological changes, an alleviated depression, anxiety, and stress symptoms were evident in the mastectomy patients as well. Therapeutic effects were robustly recognized on anxiety and stress symptoms of the mastectomy women than depressive symptoms. As a result, it is worth noting that applying the EMG-HRV biofeedback-assisted relaxation as a helpful complementary treatment is highly recommended for breast cancer women with mastectomy surgery decision.

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