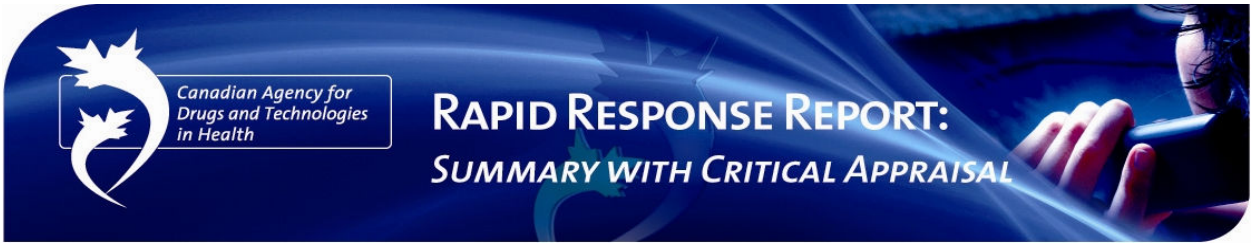


**TITLE: Neurofeedback and Biofeedback for Post-Traumatic Stress Disorder, Generalized Anxiety Disorder, and Depression: A Review of the Clinical Evidence and Guidelines.**

**DATE: 15 June 2012**

## CONTEXT AND POLICY ISSUES

Post-traumatic stress disorder (PTSD), generalized anxiety disorder (GAD), and depression are psychiatric disorders that interfere with daily-life activities and need psychological and pharmacological treatments.[1-3] Approximately, 5.7 % of Canadians 18 years and older are affected by GAD, 6.8% by PTSD, and 4.8% by major depression.[1,4]

Biofeedback therapies are non-pharmacological treatments that use non-invasive techniques with bio-monitoring system and sensors to measure, amplify and feedback information about physiological processes such as respiration, heart rate, heart rate variability (HRV), blood flow and blood pressure, to the individual being monitored, thus assisting the individual to be aware of these processes and to gain voluntary control over body and mind.[5-8] Neurofeedback, also known as brainwave biofeedback, is a subspecialty of biofeedback that monitors brainwave activity from electrodes placed on the scalp. Training with neurofeedback aims to enable the individual to modify patterns of cortical activity and normalize brain activity.[9-11]

This study was conducted to review the clinical effectiveness and guidelines of biofeedback and neurofeedback in the treatment of post-traumatic stress disorder, generalized anxiety disorder, and depression.

## RESEARCH QUESTIONS

1. What is the clinical evidence for the benefits and harms of neurofeedback provided by a health professional for post-traumatic stress disorder, generalized anxiety disorder, or depression?

2. What is the clinical evidence for the benefits and harms of biofeedback provided by a health professional for post-traumatic stress disorder, generalized anxiety disorder, or depression?

3. What is the clinical evidence regarding home use of biofeedback equipment for post-traumatic stress disorder, generalized anxiety disorder, or depression?

4. What are the evidence-based guidelines regarding the use of neurofeedback or biofeedback for the treatment of post-traumatic stress disorder, generalized anxiety disorder, or depression?

## KEY MESSAGE

Evidence from mostly preliminary analyses raised the possibility that biofeedback and neurofeedback may have a potential for the treatment of post-traumatic stress disorder, generalized anxiety disorder, or depression. No relevant evidence-based guidelines were identified.

## METHODS

### Literature search

A limited literature search was conducted on key resources including PubMed, The Cochrane Library (2012, Issue 5), University of York Centre for Reviews and Dissemination (CRD) databases, Canadian and abbreviated lists of major international health technology agencies, as well as a focused Internet search. No filters were applied to limit the retrieval by study type. Where possible, retrieval was limited to the human population. The search was also limited to English language documents published between January 1, 2007 and May 16, 2012.

### Article selection

One reviewer screened the titles and abstracts of the retrieved publications and examined the full-text publications for the final article selection. Selection criteria are outlined in Table 1.

**Table 1: Selection Criteria**

| | |
|---|---|
| **Population** | Adults with post-traumatic stress disorder, generalized anxiety disorder, or depression |
| **Intervention** | Neurofeedback or biofeedback provided by a health professional or patient self-treatment at home |
| **Comparator** | Other treatment for PTSD, GAD or depression (for example, cognitive behaviour therapy, exposure therapy, eye movement desensitization reprocessing)<br>No treatment |
| **Outcomes** | Symptom reduction (for example, reduced stress, anxiety)<br>Safety |
| **Study design** | Health technology assessment, systematic review, meta-analyses, randomized controlled trials (RCTs), non-RCTs, guidelines |

### Exclusion Criteria

Articles were excluded if they did not meet the selection criteria in Table 1, if they did not have a comparator group, if they were published prior to January 2007, if they were duplicate publications of the same study, or if they were referenced in at least one of the selected systematic reviews.

### Critical Appraisal of Individual Studies

The quality of the included studies was assessed using Downs and Black checklist.[12] Numerical scores were not calculated. Instead, the strengths and limitations of individual studies are summarized and presented.

## SUMMARY OF EVIDENCE

### Quantity of Available Evidence

The literature search yielded 963 citations. Nine additional studies were identified by searching the grey literature. After screening of abstracts, 21 potentially relevant studies were selected for full-text review.

Six studies[13-18] were included in the review: two studies on PTSD,[13,16] two on anxiety disorders,[14,17] and two on depression.[15,18] No relevant evidence-based guidelines were identified. The PRISMA flowchart in Appendix 1 details the process of the study selection.

### Summary of Study Characteristics

*Study design*

Included in the review are three randomized controlled trials (RCTs)[13-15] and three prospective observational studies.[16-18] Studies were conducted in the United States,[13,16] Italy,[14] India,[17] Korea,[15] and Germany,[18] published from 2007 to 2011, covering a population from 12[14] to 100 adult patients,[17] and with a follow-up time from two[18] to eight weeks.[13] Detailed characteristics of the included studies are summarized in Appendix 2.

*Population*

Selected studies included patients with PTSD,[13,16] anxiety disorders,[14,17] or depression.[15,18] All patients were adults 18 years old and older, with combat-related PTSD,[13,16] anxiety disorders,[14,17] or depression.[15,18]

*Interventions and comparators*

Interventions included HRV biofeedback (a system that monitors the time interval between heart beats),[13,16,18] galvanic skin response/heart rate biofeedback (the response of the skin to the passage of a small electric current, and the measure of heart rate),[14] and electroencephalographic biofeedback (neurofeedback).[15,17] Comparators included usual treatment,[13,16] mobile phone without biofeedback,[14] anxiolytics treatment,[17] psychotherapy placebo,[15] or healthy volunteers.[18]

*Outcomes*

The primary outcomes of included studies were changes in symptoms of PTSD,[13,16] anxiety,[14,17] and depression,[15,18] based on CAPS score (Clinician-Administered PTSD Scale), PCL-S score (PTSD Checklist-Specific), Zung score, STAI score (State Trait Anxiety Inventory), VAS-A score (Visual Analogue Scale for Anxiety), HAS score (Hamilton Anxiety Scale), TMAS score (Taylor's Manifest Anxiety Scale), BDI-II score (Beck Depression Inventory II), ATQ-P score (Automatic Thought Questionnaire-Positive), ATQ-N score (Automatic Thought Questionnaire-Negative), and HAM-D score (Hamilton Depression Inventory).

**Summary of Critical Appraisal**

A summary of the critical appraisal conducted for selected studies can be found in Appendix 3. Three studies were randomized controlled trials,[13-15] and the remainder were prospective observational studies.[16-18] Hypothesis was not explicit in two studies.[16,18] Most trials were pilot[13,15,18] or exploratory studies[16] with preliminary analyses on small number of participants, with follow-up time ranging from two[18] to eight weeks.[13] The sample size, ranging from 12[14] to 100 patients,[17] may not have had sufficient power to detect a clinically important effect.

**Summary of Findings**

Main study findings and authors' conclusions can be found in Appendix 4.

1. What is the clinical evidence for the benefits and harms of neurofeedback provided by a health professional for post-traumatic stress disorder, generalized anxiety disorder, or depression?

Two studies reported findings on the effect of neurofeedback on patients with anxiety disorders and depression.[15,17] Findings showed that neurofeedback therapy was almost as efficacious as pharmacotherapy in the management of anxiety,[17] and led to alleviation of depressive symptoms.[15]

A prospective study examined the effect of electroencephalographic (EEG) biofeedback (neurofeedback) on 100 adult patients with anxiety disorders.[17] Patients were treated with neurofeedback sessions for eight weeks, five sessions per week (study group) or with anxiolytics (control group). Anxiety level was assessed using Hamilton Anxiety Scale (HAS) and Taylor's Manifest Anxiety Scale (TMAS). In the study group, there was statistically difference between baseline and end of treatment for severity anxiety with HAS score, and for moderate and severe anxiety with TMAS score. There was no statistical difference for mild anxiety with both scores. Despite not reporting data on the pharmacotherapy (control) group, the authors concluded that neurofeedback therapy was almost as efficacious as pharmacotherapy in the treatment of anxiety, but female patients had better response with neurofeedback (data also not shown).

A pilot randomized controlled trial examined the effect of electroencephalographic (EEG) biofeedback (neurofeedback) on 24 adult patients with depressive disorders.[15] Patients were treated with neurofeedback sessions for five weeks, two sessions per week (study group) or with psychotherapy placebo (control group). Depression level was assessed using Hamilton

Depression Inventory (HAM-D). Participants also completed self-report questionnaires, using Beck Depression Inventory II (BDI-II), Automatic Thought Questionnaire-Positive (ATQ-P) and Automatic Thought Questionnaire-Negative (ATQ-N). Side effect during treatment was also examined. Patients in the study group showed significant reduction in depression level using HAM-D, BDI-II and ATQ-N scores while the placebo group did not show a difference. No patients reported significant side effects. The authors concluded that neurofeedback training led to alleviation of depressive symptoms.

2. What is the clinical evidence for the benefits and harms of biofeedback provided by a health professional for post-traumatic stress disorder, generalized anxiety disorder, or depression?

Four studies reported findings on the effect of biofeedback on patients with PTSD, GAD, and depression.[13,14,16,18] Findings showed that biofeedback reduced symptoms of PTSD, but the difference between biofeedback and usual treatment was not statistically significant.[13,16] Biofeedback appeared to reduce anxiety[14] and depression.[18]

A pilot randomized controlled trial examined the effect of HRV biofeedback on 20 veterans with combat-related PTSD.[13] Participants were treated with eight weekly biofeedback sessions plus usual treatment or with usual treatment alone. PTSD symptoms were assessed using the Clinician-Administered PTSD Scale (CAPS) and the PTSD Checklist-Specific (PCL-S). HRV was also compared prior to intervention between the PTSD group and 10 participants without PTSD, by measuring standard deviation of beat-to-beat interval (SDNN). Data showed that prior to intervention, veterans with PTSD had lower HRV than those without PTSD, and the difference was statistically significant. Following intervention, participants in the biofeedback plus usual treatment group showed significant reduction in PTSD symptoms while the differences in the usual treatment group were not statistically significant. However, comparison in symptom reduction between the two groups showed no statistical difference. The authors concluded that participants with combat-related PTSD had significantly depressed HRV as compared to those without PTSD; biofeedback reduced symptoms of PTSD over the course of treatment but the difference between biofeedback plus usual treatment and usual treatment alone was not statistically significant.

A exploratory prospective study examined the effect of HRV biofeedback on 39 active duty service members with PTSD.[16] Participants were treated with three weeks of biofeedback sessions (frequency of interventions not reported) plus usual treatment or with usual treatment alone. PTSD symptoms were assessed using the Post-Traumatic Stress Disorder Checklist (PCL) –Military version and the Zung Self-Rating Depression Scale (Zung score). Analysis of variance (ANOVA) showed there was a statistically significant reduction in PCL and Zung scores for both groups from baseline to three weeks of treatment (main effect for time). However, main effect for group and main effect for group by time was not statistically significant. The authors concluded that the study did not demonstrate a beneficial effect of biofeedback on PTSD symptoms.

A phase-2 randomized controlled trial looked at the effect of biofeedback on 12 adults with GAD.[14] A biofeedback-enhanced virtual reality (VR) system was used together with a mobile phone that allows participants to perform additional daily relaxation homework . Participants were randomly assigned to the VR and mobile phone plus biofeedback group (VRMB) for 8 weekly biofeedback sessions, or the VR and mobile phone without biofeedback group (VRM) or

the waiting list group (WL). Mean changes in State Anxiety Inventory Form Y-1 (STAI-Y1) score, Visual Analogue Scale for Anxiety (VAS-A), score, and heart rate before and after each session were compared between the VRMB and VRM groups. The mean differences in heart rate, STAI-Y1 score and VAS-A score before and after each session were higher in the VRMB group than in the VRM group, but the difference between the groups was not statistically significant. The authors concluded there was some initial evidence for better efficacy in the VRMB group.

A pilot prospective study examined the effect of biofeedback on 14 adults with depression.[18] Participants with depression received 2 weeks of HRV biofeedback, 3 sessions per week and active treatment. Twenty-four healthy volunteers were also randomized to biofeedback plus active treatment or to an active treatment. Heart rate, HRV, Beck Depression Inventory (BDI) score, and State-Trait Anxiety Inventory (STAI) score over the treatment period were reported. Data showed heart rate decreased and HRV increased in depressed patients over the treatment period. BDI score and STAI score also significantly reduced in depressed patients. No mood changes were noted in healthy subjects receiving biofeedback or without (data on healthy group were not reported). The authors concluded that biofeedback appears to be a useful adjunct for depression treatment.

3. What is the clinical evidence regarding home use of biofeedback equipment for post-traumatic stress disorder, generalized anxiety disorder, or depression?

No studies on the clinical evidence regarding home use of biofeedback equipment for post-traumatic stress disorder, generalized anxiety disorder, or depression were identified. Findings from one study on handheld portable biofeedback device[19] that did not meet the inclusion criteria (no comparator group), but could be of interest, are summarized in Appendix 5.

4. What are the evidence-based guidelines regarding the use of neurofeedback or biofeedback for the treatment of post-traumatic stress disorder, generalized anxiety disorder, or depression?

The literature search did not identify any evidence-based guideline regarding the use of neurofeedback or biofeedback for the treatment of post-traumatic stress disorder, generalized anxiety disorder, or depression

**Limitations**

Due to the number of studies identified (n = 6), it is difficult to draw definitive conclusions regarding the clinical evidence of biofeedback and neurofeedback on PTSD, GAD, and depression. Most trials were short-term pilot or exploratory studies with preliminary analyses on small number of participants, which limit the generalizability of the findings to the target populations. No relevant evidence-based guidelines were found.

## CONCLUSIONS AND IMPLICATIONS FOR DECISION OR POLICY MAKING

Evidence regarding the use of biofeedback and neurofeedback from for the treatment of post-traumatic stress disorder, generalized anxiety disorder, or depression came mostly from pilot and exploratory studies with preliminary analyses ranging in size from 12 to 100 participants. Electroencephalographic (EEG) biofeedback (neurofeedback) was associated with statistically significant reduction of symptoms in patients with depressive disorders, but failed to show better

efficacy than pharmacotherapy in patients with anxiety disorders. Biofeedback was not shown to be better than usual treatment in patients with combat-related post-traumatic stress disorder. Biofeedback may have some efficacy in patients with generalized anxiety disorder. Findings from larger size randomized placebo-controlled trials with alternative therapies as the comparator are needed to confirm the potential of biofeedback and neurofeedback, and to develop guidelines regarding the use of these non-pharmacological and non-invasive modalities for the treatment of mood and anxiety disorders.

**PREPARED BY:**

Canadian Agency for Drugs and Technologies in Health
Tel: 1-866-898-8439
www.cadth.ca

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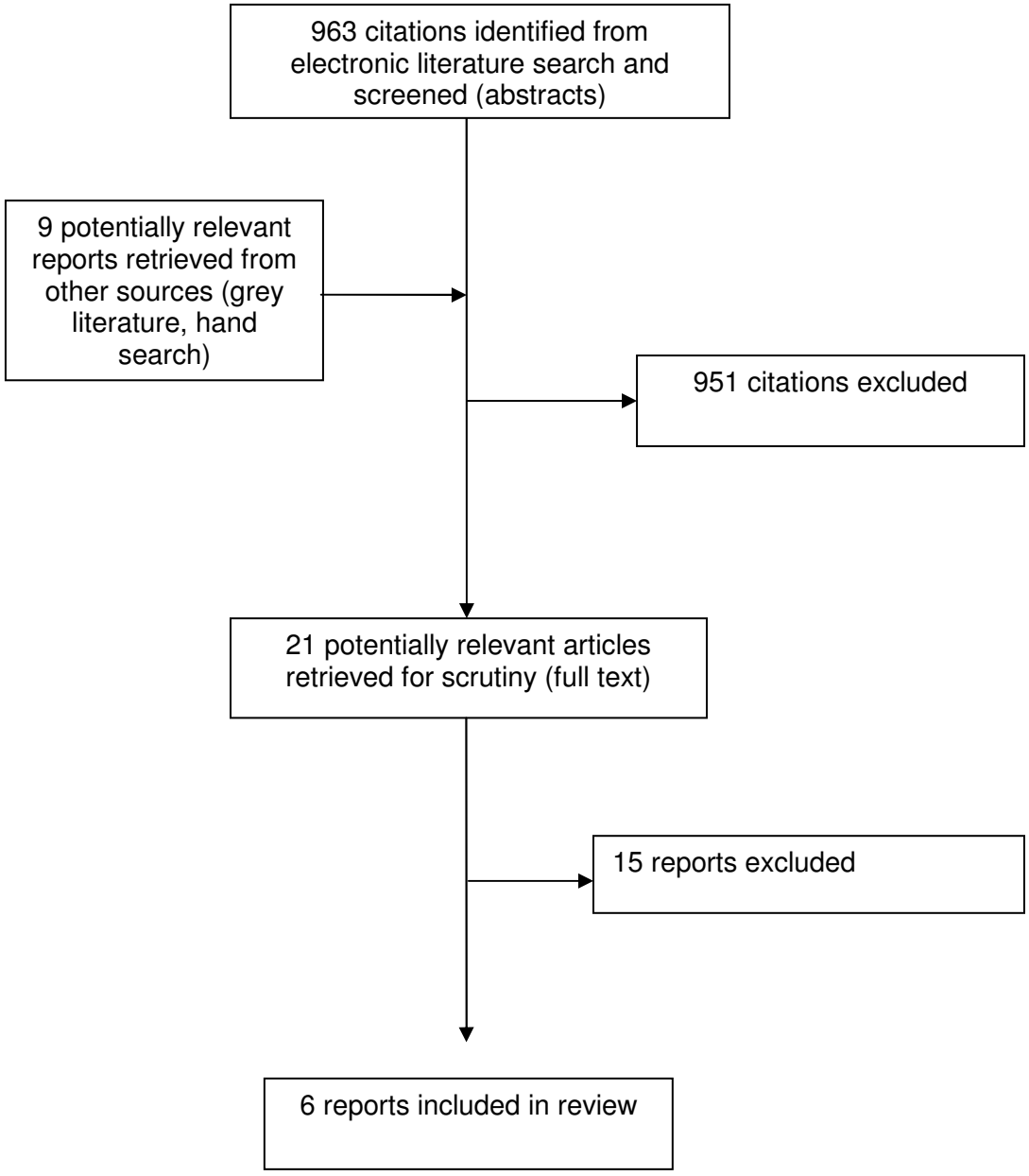
**Appendix 1: Selection of Publications**



## Appendix 2: Characteristics of Included Studies

| Characteristics of Included Trials | | | | | |
|---|---|---|---|---|---|
| **First Author, Publication Year, Country** | **Study Design; Length of Follow-up** | **Patient Characteristics, Sample Size** | **Intervention** | **Comparator(s)** | **Main Outcomes Measured** |
| Tan,[13] 2011, US | Pilot RCT; 8 weekly biofeedback sessions | 20 veterans with combat-related PTSD | HRV biofeedback plus usual treatment | Usual treatment (definition not provided) | Change in symptoms of PTSD (using CAPS, PCL-S scores) |
| Lande,[16] 2010, US | Exploratory prospective observational study; 3 weeks of biofeedback | 39 active duty service members with PTSD | HRV biofeedback plus usual treatment | Usual treatment (trauma specific individual counseling, group therapy, medication management, art therapy and recreation therapy) | Change in symptoms of PTSD (using PCL, Zung scores) |
| Pallavicini,[14] 2009, Italy | Phase-2 RCT; 8 weekly biofeedback sessions | 12 adults with GAD | Virtual Reality and mobile phone plus GSR/HR biofeedback | Virtual Reality and mobile phone without biofeedback | Change in heart rate and symptoms of GAD (using STAI-Y1, VAS-A scores) |
| Bhat,[17] 2010, India | Prospective observational; 8 weeks of biofeedback (5 sessions per week) | 100 adults with anxiety disorders | EEG biofeedback | Anxiolytics treatment | Change in symptom of anxiety (using HAS, TMAS scores) |
| Choi,[15] 2009, Korea | Pilot RCT; 5 weeks biofeedback (2 sessions per week) | 23 adult patients with depressive disorders | EEG biofeedback | Psychotherapy placebo | Change in depressive symptoms (using BDI-II, ATQ-P, ATQ-N, HAM-D scores) |
| Siepman,[18] 2008, Germany | Pilot prospective observational; 2 weeks of biofeedback (3 sessions per week) | 14 adult patients with depression, 24 healthy volunteers | HRV biofeedback | Healthy volunteers with or without biofeedback. No comparator group with depressed patients | Change in depressive symptoms (using BDI, STAI scores), heart rate, HRV |

ATQ-N = Automatic Thought Questionnaire – Negative; ATQ-P = Automatic Thought Questionnaire – Positive; BDI-II = Beck Depression Inventory II; CAPS = Clinician-Administered PTSD Scale; EEG biofeedback = electroencephalography biofeedback; GAD = Generalized Anxiety Disorder; GSR = Galvanic Skin Response; HAM-D = Hamilton Depression Inventory; HAS = Hamilton Anxiety Scale; HR = Heart Rate; HRV = heart rate variability; PCL-S = PTSD Checklist-Specific; PTSD = Post-Traumatic Stress Disorder; RCT = randomized controlled trial; RSA = Respiratory Sinus Arrhythmia biofeedback; STAI-Y1 = State-Trait Anxiety Inventory Form Y1; TMAS = Taylor's Manifest Anxiety Scale; VAS-A = visual analogue Scale for Anxiety

## Appendix 3: Summary of Critical Appraisal of Included Studies

| Summary of Critical Appraisal of Included Studies | | |
|---|---|---|
| **First Author, Publication Year** | **Strengths** | **Limitations** |
| **Systematic Reviews** | | |
| Tan,[13] 2011 | • hypothesis explicit<br>• main outcomes, interventions, patient characteristics, and main findings explicit<br>• estimates of random variability and actual probability values provided<br>• losses to follow-up described<br>• patients randomized | • unable to determine if study power is sufficient to detect a clinically important effect |
| Lande,[16] 2010 | • estimates of random variability and actual probability values provided<br>• losses to follow-up described | • patients not randomized<br>• hypothesis not explicit<br>• main outcomes, interventions, patient characteristics, and main findings not clearly described<br>• unable to determine the frequency of intervention<br>• unable to determine if study power is sufficient to detect a clinically important effect |
| Pallavicini,[14] 2009 | • hypothesis explicit<br>• main outcomes, interventions, patient characteristics, and main findings explicit<br>• estimates of random variability and actual probability values provided<br>• losses to follow-up described<br>• patients randomized | • unable to determine if study power is sufficient to detect a clinically important effect |
| Bhat,[17] 2010 | • hypothesis explicit<br>• estimates of random variability and actual probability values provided<br>• losses to follow-up described | • patients not randomized<br>• data of control group not reported<br>• main outcomes, interventions, patient characteristics, and main findings not clearly described<br>• unable to determine if study power is sufficient to detect a clinically important effect |
| Choi,[15] 2009 | • hypothesis explicit<br>• main outcomes, interventions, patient characteristics, and main findings explicit<br>• estimates of random variability and actual probability values provided<br>• losses to follow-up described<br>• patients randomized | • unable to determine if study power is sufficient to detect a clinically important effect |

| Summary of Critical Appraisal of Included Studies | | |
|---|---|---|
| **First Author, Publication Year** | **Strengths** | **Limitations** |
| Siepman,[18] 2008 | • estimates of random variability and actual probability values provided | • hypothesis not explicit<br>• there was no comparator group with the same condition as the intervention group<br>• patients not randomized<br>• data of control group not reported<br>• main outcomes, interventions, patient characteristics, and main findings not clearly described<br>• unable to determine if study power is sufficient to detect a clinically important effect<br>• losses to follow-up not described |

## Appendix 4: Main Study Findings and Authors' Conclusions

| Main Study Findings and Authors' Conclusions | | |
|---|---|---|
| **First Author** | **Main Study Findings** | **Authors' Conclusions** |
| **Post-traumatic stress disorder** | | |
| Tan,[13] 2011 | **Heart rate variability prior to intervention** (HDNN) (mean (SD)<br>- PTSD: 48.10 (47.87)<br>- No PTSD: 138.70 (47.87)<br>- P < 0.001<br><br>**CAPS score**(mean, SD)<br>Biofeedback group:<br>- baseline 86.4 (19.32)<br>- post baseline: 71.24 (18.51)<br>- p < 0.001<br>Control group:<br>- baseline: 89.13 (24.32)<br>- post baseline: 80.80 (25.23)<br>- p = 0.163<br><br>**PCL-S score** (mean, SD)<br>Biofeedback group:<br>- baseline 64.82 (7.43)<br>- post baseline: 54.43 (11.53)<br>- p = 0.035<br>Control group:<br>- baseline: 62.74 (12.71)<br>- post baseline: 61.74 (10.72)<br>- p = 0.820<br><br>**Change of CAPS score** (mean, SD)<br>- biofeedback group: 15.23 (7.14)<br>- control group: 8.33 (17.34)<br>- p = 0.226<br><br>**Change of PCL-S score** (mean, SD)<br>- biofeedback group: 10.41 (13.32)<br>- control group: 1.01 (13.54)<br>- p = 0.135 | "Veterans with combat-related PTSD displayed significantly depressed HRV as compared to subjects without PTSD" (p 27)<br><br>"although the PTSD biofeedback group showed significant reduction in PTSD symptoms, the comparison in symptom reduction between the PTSD biofeedback group and control group was not statistically significant" (p 34) |
| Lande,[16] 2010 | **Change in PCL score** (ANOVA)<br>Main effect for time: F (1,36): 11.98, p < 0.001<br>Main effect for group: F (1, 36): .1.79, p = ns<br>Group by time interaction: F (1, 36): .2.59, p = ns<br><br>**Change in Zung score** (ANOVA)<br>Main effect for time: F (1,33): 10.26, p < 0.003<br>Main effect for group: F (1, 33): .385, p = ns<br>Group by time interaction: F (1, 33): 3.52, p = ns | "this exploratory study did not demonstrate a reduction in the symptoms of PTSD or depression attributable to the use of biofeedback" (p 258) |
| **Anxiety disorder** | | |
| Pallavicini,[14] 2009 | **Change in STAI-Y1 score** (mean, SD)<br>VRMB group: 6.7917 (2.71)<br>VRM group: 5.2083 (3.26)<br>Difference not statistically significant<br><br>**Change in VAS-A score** (mean, SD)<br>VRMB group: 7.7083 (4.28)<br>VRM group: 6.4583 (3.82)<br>Difference not statistically significant | "the mean differences of heart rate and galvanic skin response before and after each session tended to be higher in the VRMB group than in the VRM group. Nevertheless, the difference between the two experimental groups was not statistically significant" (p 324)<br><br>"the men differences of psychometric variables - STAI-Y1 and VAS-A – before |

| Main Study Findings and Authors' Conclusions | | |
|---|---|---|
| **First Author** | **Main Study Findings** | **Authors' Conclusions** |
| | **Change in HR** (mean, SD)<br>VRMB group: 4.67 (3.32)<br>VRM group: 2.83 (1.16)<br>Difference not statistically significant<br><br>Change in GSR: not reported | and after each session tended to be higher in the VRMB group than in the VRM group. The difference between the two experimental groups was not statistically significant" (p 324) |
| Bhat,[17] 2010 | **Change in HAS score** (mean, SD)<br>Mild anxiety: no statistically difference between baseline and end of treatment (8 weeks): baseline 22.6 (2.67); after 8 weeks 19.6 (1.86); p = 0.069<br><br>Moderate anxiety: no statistically difference between baseline and end of treatment: baseline 27.5 (3.78); after 8 weeks: 26.3 (4.39); p = 0.310<br><br>Severe anxiety: statistically difference between baseline and end of treatment: baseline 45 (4.63); after 8 weeks: 37 (4.29); p = 0.000<br><br>**Change in TMAS score**<br>Mild anxiety: no statistically difference between baseline and end of treatment (8 weeks): baseline 29.7 (3.17); after 8 weeks 26.4 (2.67); p = 0.265<br><br>Moderate anxiety: statistically difference between baseline and end of treatment: baseline 33.9 (2.87); after 8 weeks 31.6 (2.43); p = 0.009<br><br>Severe anxiety: statistically difference between baseline and end of treatment: baseline 44.2 (3.16); after 8 weeks 39.7 (2.95); p = 0.001<br><br>Data on the control group was not reported | Alfa EEG biofeedback reduced severe anxiety (HAS scale) and moderate and severe anxiety (TMAS scale).<br><br>"in the short term, Alfa EEG biofeedback therapy is almost as efficacious as pharmacological intervention in the management of anxiety symptoms" (p 111) |
| **Depression** | | |
| Choi,[15] 2009 | **Change in BDI-II score** (mean, SD)<br>EEG biofeedback group<br>Pre: 22.75 (12.35) Post: 9.08 (6.92)<br>Placebo group<br>Pre: 26.18 (16.21) Post: 21.27 (15.86)<br>p < 0.001<br><br>**Change in ATQ-P** (mean, SD)<br>EEG biofeedback group<br>Pre: 74.83 (14.70) Post: 85.08 (9.31)<br>Placebo group<br>Pre: 76.22 (32.88) Post: 76.11 (31.44)<br>P < 0.05<br><br>**Change in ATQ-N** (mean, SD)<br>EEG biofeedback group<br>Pre: 84.67 (24.13) Post: 59.00 (20.15)<br>Placebo group<br>Pre: 87.44 (33.59) Post: 78.11 (28.83)<br>P < 0.001<br><br>**Change in HAM-D** (mean, SD)<br>EEG biofeedback group<br>Pre: 11.33 (7.52) Post: 4.08 (4.14)<br>Placebo group | "asymmetry neurofeedback training led to alleviation of depressive symptoms" " in contrast to the training group, the placebo group did not show a difference" (p 43) |

| Main Study Findings and Authors' Conclusions | | |
|---|---|---|
| **First Author** | **Main Study Findings** | **Authors' Conclusions** |
| | Pre: 12.36 (7.67) Post: 11.08 (7.91)<br>P < 0.05<br><br>No participants reported significant side effects | |
| Siepman,[18] 2008 | **Change in heart rate**<br>Heart rate was found decreased in depressed patients (p < 0.0001)<br><br>**Change in heart rate variability** (pNN50)<br>Heart rate variability was found increased in depressed patients (p < 0.01)<br><br>**Change in BDI score** (median)<br>Baseline: 21.5<br>Biofeedback: 11.5<br>p < 0.05<br><br>**Change in STAI score** (median)<br>Baseline: 108.0<br>Biofeedback: 85.5<br>p < 0.05<br><br>Data on the healthy volunteer group was not reported | "depressed patients had reduced anxiety, decreased heart rate and increased heart rate variability after conduction of biofeedback" (p 195) |

ANOVA = analysis of variance; ATQ-N = Automatic Thought Questionnaire – Negative; ATQ-P = Automatic Thought Questionnaire – Positive; BDI-II = Beck Depression Inventory II; CAPS = Clinician-Administered PTSD Scale; EEG = Alfa electroencephalography; EEG biofeedback = Electroencephalographic biofeedback; GSR = Galvanic Skin Response; HAM-D = Hamilton Depression Inventory; HAS = Hamilton Anxiety Scale; ns = non-significant; HR = heart rate; PCL-S = PTSD Checklist-Specific; pNN50 = fraction of consecutive normal sinus intervals that differ by more than 50 ms; RSA = Respiratory Sinus Arrhythmia; SD = standard deviation; SDNN = Standard Deviation of normal beat-to-beat intervals; SE = standard error; STAI-Y1 = State-Trait Anxiety Inventory Form Y1; TMAS = Taylor's Manifest Anxiety Scale; VAS-A = visual analogue Scale for Anxiety; VRBM = Virtual Reality and Mobile phone with biofeedback; VRM = virtual reality and mobile phone without biofeedback

**Appendix 5: Summary of findings from a study that did not meet inclusion criteria but could be of interest**

One study reported findings on the clinical effectiveness of home use of biofeedback equipment.[19] The pilot prospective study examined the effect of home use of handheld biofeedback device on 20 adults with anxiety disorders. Participants received three weeks of daily biofeedback sessions, using a Respiratory Sinus Arrhythmia (RSA) handheld portable biofeedback device (Stress Eraser). There was no control group. Changes in State-Trait Anxiety Inventory (STAI-Y) score, State-Trait Anger Expression Inventory (STAEI) score, and Pittsburgh Sleep Quality Index (PSQI) score over the treatment period were reported. Findings showed that there were significant reductions in anger and anxiety symptoms over the course of treatment, as well as a significant increase in total sleep time. Dizziness and sleepiness happened in 15% and 55% of patients, respectively. There were no prolonged adverse events in any participants. Adverse events also did not affect the compliance of the participants. The authors concluded that portable RSA biofeedback may be a promising treatment adjunct for patients with anxiety disorders.