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ORIGINAL ARTICLE

A pilot study of heart rate variability biofeedback therapy in the treatment of perinatal depression on a specialized perinatal psychiatry inpatient unit

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Abstract Heart rate variability biofeedback (HRVB) therapy may be useful in treating the prominent anxiety features of perinatal depression. We investigated the use of this non-pharmacologic therapy among women hospitalized with severe perinatal depression. Three questionnaires, the State Trait Anxiety Inventory (STAI), Warwick–Edinburgh Mental Well-Being Scale, and Linear Analog Self Assessment, were administered to 15 women in a specialized inpatient perinatal psychiatry unit. Participants were also contacted by telephone after discharge to assess continued use of HRVB techniques. The use of HRVB was associated with an improvement in all three scales. The greatest improvement (−13.867, $p<0.001$ and −11.533, $p<0.001$) was among STAI scores. A majority (81.9 %, $n=9$) of women surveyed by telephone also reported continued frequent use at least once per week, and over half (54.6 %, $n=6$) described the use of HRVB techniques as very or extremely beneficial. The use of HRVB was associated with statistically significant improvement on all instrument scores, the greatest of which was STAI scores, and most women reported frequent continued use of HRVB techniques after discharge. These results suggest that HRVB may be particularly beneficial in the treatment of the prominent anxiety features of perinatal depression, both in inpatient and outpatient settings.

Keywords Depression · Pregnancy · Perinatal depression · Postpartum depression · Biofeedback · Complementary and alternative medicine

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Introduction

Perinatal depression is defined as the occurrence of a major and/or minor depressive episode either during pregnancy or within a period of up to 12 months following delivery (Gavin et al. 2005; Gaynes et al. 2005; O'Hara and Swain 1996; Yonkers et al. 2001). Prevalence estimates for major and minor depression includes ranges of 8.5–11.0 % during pregnancy and 6.5–12.9 % during the first 12 months postpartum (Gaynes et al. 2005). Risk factors for perinatal depression include depression before or during pregnancy (Beck 2001; Milgrom et al. 2008; O'Hara and Swain 1996; Robertson et al. 2004), marital discord (Beck 2001; O'Hara and Swain 1996), poor social support (Beck 2001; Milgrom et al. 2008; O'Hara and Swain 1996; Robertson et al. 2004), anxiety during pregnancy, life stress, and unplanned or unwanted pregnancy (Beck 2001; Robertson et al. 2004). Depressed mothers have been shown to be more likely to discontinue breastfeeding (Dennis and McQueen 2007; Field 2010; McLearn et al. 2006a), have infants with problematic sleep experiences (Field 2010; Hiscock and Wake 2001), and be less likely to engage with or nurture their infant (Lovejoy et al. 2000; McLearn et al. 2006a, b; Stein et al. 1991) which can further

result in impaired neurodevelopment and increased risk for long-term psychiatric disorders in their offspring (Campbell et al. 2004; Paulson et al. 2006).

Treatment of perinatal depression is particularly challenging due to a lack of definitive evidence related to drug therapies during pregnancy and/or breastfeeding. Women have expressed apprehension about potential side effects related to use of antidepressants, and these concerns may greatly influence medication compliance or willingness to accept pharmacologic treatment (Dennis and Chung-Lee 2006). While there is limited evidence of teratogenic effects or adverse postnatal effects from the use of antidepressants during pregnancy or breastfeeding, respectively, physicians and mothers alike may be hesitant to initiate or continue pharmacologic treatments (Einarson and Einarson 2005; Malm et al. 2005; Wen et al. 2006).

Concerns about pharmacotherapy coupled with the risk of potential adverse effects of inadequately treated illness serves as a unique motivation for this patient population to seek treatment for depression in modalities other than standard medications, despite the fact that complementary and alternative medicine (CAM) therapies have often been less rigorously studied. Heart rate variability biofeedback (HRVB) is a form of CAM therapy that has shown promise in the treatment of major depressive disorder (Karavidas et al. 2007) and can also be used in the treatment of perinatal depression. It also has demonstrated efficacy in the treatment of attention-deficit disorder, headaches, hypertension, temporomandibular disorders, urinary incontinence, and fibromyalgia (Hassett et al. 2007; Horowitz 2006). HRVB refers to a process that utilizes instruments that measure and "feed back" information about physiological activity, therefore enabling an individual to interpret and respond to these signals for the purposes of improving their own health and well-being (Association for Applied Psychophysiology and Biofeedback Inc. 2011; Barragan Loayza et al. 2011).

Heart rate variability (HRV) refers to oscillations of heart rate around a mean value, variations in which are due to changes in the autonomic activity (Friedman 2007), and a growing body of research suggests that depression is associated with alterations in autonomic function, such as impaired baroreflex sensitivity, changes in heart rate, and reduced heart rate variability (HRV) (Karavidas et al. 2007). Increases in HRV have been demonstrated to occur in patients successfully treated with antidepressants (Balogh et al. 1993), and a review of over 20 studies revealed an association between abnormalities of HRV and the presence of anxiety (Cohen and Benjamin 2006).

HRVB may therefore be suited to treat the prominent anxiety features of perinatal depression. Bernstein et al. (2008) demonstrated that, compared to non-postpartum depressed patients, patients with postpartum depression displayed more prominent anxiety-related symptoms, such as psychomotor restlessness and agitation as well as impaired concentration and decision making. Beck and Indman (2005) also revealed that among women diagnosed with major postpartum depression, one of the top three elevated dimensions of the Postpartum Depression Screening Scale was anxiety. A Cochrane Review, published in 2011, showed that there is some evidence that mind–body interventions, such as autogenic training, biofeedback, hypnotherapy, imagery, meditation, prayer, auto-suggestion, tai-chi, and yoga, may be beneficial in the treatment of anxiety during pregnancy (Marc et al. 2011). We therefore hypothesized that among inpatient perinatal psychiatry patients, the use of adjunctive HRVB treatments would result in a decrease in the prominent anxiety symptoms that are known to be a central feature of perinatal depression.

Materials and methods

Participants

Patients were recruited from the UNC Hospitals Perinatal Inpatient Psychiatry Unit (PPIU) from January 31, 2012 to June 1, 2012. Eligible participants were female, over age 18, English-speaking, currently pregnant or within 1 year of delivery, and admitted to the PPIU for treatment of severe depression and/or anxiety. All patients admitted to the PPIU are offered the opportunity to participate in HRVB therapy with a recreational therapist who is trained and certified in biofeedback techniques.

Thirty-six patients were admitted to the PPIU during the course of the study, and 31 (86.1 %) were eligible for participation. Nine (29 %) of the 31 patients refused and seven (22.5 %) were admitted for short stays on the unit, which precluded their involvement in biofeedback therapy. A total of 15 patients were enrolled. This study had full approval from the UNC Institutional Review Board, and all subjects gave informed written consent for study participation.

Equipment and technical procedures

HRVB was administered using the emWave® Desktop (HeartMath®, Boulder Creek, Colorado) heart-monitoring system (Childre and Martin 1999). The system functions by using a pulse sensor that is placed on the patient's earlobe and then connected to the program. The sensor collects information and translates it into graphics that are displayed on a computer screen. These graphics are used to display heart rhythm patterns in real time, which allows patients to receive immediate feedback on their performance.

Patients participating in HRVB therapy were taken to a private room where the instruction and participation in

HRVB therapy was conducted individually. Patients completed two HRVB therapy sessions, ranging in length from 30 min to 1 h. The initial session consisted of educating the patient about biofeedback, the science behind the technique, and potential benefits and outcomes of its use. The patient was then provided with a demonstration and given time to practice using the skills of biofeedback. Specifically, patients were trained to use deep, abdominal, or diaphragmatic breathing techniques to disengage from anxious and/or stressful thoughts and emotions. The second session consisted of administration and practice of HRVB and strategies for utilizing biofeedback after discharge from the hospital.

Assessment measures

Patients were asked to complete a set of three self-report questionnaires, the State Trait Anxiety Inventory: State Anxiety Scale, the Linear Analog Self-Assessment (LASA), and the Warwick–Edinburgh Mental Well-Being Scale (WEMWBS) just prior to participation in their first biofeedback session and again immediately following the session (time point A). Participants again completed the questionnaires according to the same protocol at the time of the second biofeedback session (time point B), for a total of four completed sets of assessments. Additionally, all patients admitted to the inpatient unit are asked to complete an Edinburgh Postnatal Depression Scale (EPDS) at the time of admission and again prior to discharge. Lastly, participants were contacted by telephone after discharge to assess continued usage of HRVB techniques outside of the hospital setting.

Instruments

State trait anxiety inventory: state anxiety scale

The Spielberger State Anxiety Inventory (STAI) is a widely used, validated 20-item psychological inventory based on a four-point Likert scale that measures anxiety in the present moment (Spielberger 1983). Possible scores range from 20 to 80, and higher scores are correlated with higher levels of anxiety.

Linear analog self-assessment

The LASA is a survey instrument that contains six simple items that assess patients' state of anxiety and feelings about specific domains of quality of life based on a Likert scale (Locke et al. 2007). On this scale, scores range from 6 to 30, and higher scores are correlated with better quality of life.

Warwick–Edinburgh mental well-being scale

The WEMWBS is a 14-item scale with five potential response categories for each item (Tennant et al. 2007). It assesses patients' thoughts and feelings over the past 2 weeks. Similar to the LASA instrument, higher scores are associated with better well-being. The lowest possible score is 14 and the highest possible is 70.

Edinburgh postnatal depression scale

The EPDS is one of the most commonly used and validated instruments for assessing perinatal depression (Brouwers et al. 2001; Cox et al. 1987). A cutoff of score of ≥12 on the EPDS has been consistently shown to be associated with major depression, when compared to a structured clinical interview (Cox et al. 1987). EPDS scores of 10–12 have been associated with an accurate diagnosis of minor depression.

Post-discharge follow-up assessment

Participants were also contacted by telephone approximately 6 weeks after discharge to assess continued use of biofeedback techniques. Using a multiple choice, Likert scale survey developed by the authors, participants were asked how frequently they had used HRVB techniques since their discharge and how beneficial they found the techniques to be. Lastly, participants were asked if they had purchased the HeartMath® machine for personal use.

Coherence scores

The emWave® machine measures coherence, which correlates with improved order and correspondence between an individual's psychological and physiological processes. Physiologically, this state of coherence is reflected in the presence of a smooth, sine-wave-like pattern in the HRV tracing. There are three levels of coherence scores that can be attained using the emWave machine—low, medium, and high. Low coherence reflects the percentage of time in which there is no wave-like activity, medium coherence indicates the percentage of time in which there is some wave-like activity, and high coherence reflects the percentage of time in which there is a great deal of wave-like activity in the HRV tracing (HeartMath 2011).

Data analysis

Our hypothesis for this study was that exposure to HRVB therapy would be associated with improvements in scores on the three instruments assessing anxiety, quality of life and mental well-being. Primary outcome measures were

differences in pre- versus post-treatment instrument scores. Statistical analysis was performed using SPSS software, version 19.0 (SPSS, Inc., Chicago, IL, USA). Paired samples *t* tests were conducted to compare the difference in scores of all three instruments used, the STAI, LASA, and WEMWBS, between pre- and post-HRVB therapy sessions. This analysis was conducted for each of the two time points (A and B) at which participants completed HRVB therapy and the pre- and post-treatment surveys. The EPDS score, as a potential confounder, was analyzed using fixed effects regression analysis, in order to determine whether admission EPDS scores had a significant effect on the size of score difference on each of the three instruments used. A p value of less than 0.05 was considered statistically significant for all tests.

Results

Demographic characteristics of participants are displayed in Table 1. The average age of participants was 31, and the majority of participants was Caucasian (86.7 %, N=13), married (80 %, N=12), and in the postpartum period (73.3 %, N=11). Additionally, coherence score data are included in Table 2. The data demonstrate that the proportion of coherence scores in the medium (M=42.00–55.00) to high (62.73–65.29) range increased when participants were actively using HRV techniques compared to the medium (M=28.30–25.58) to high (M=6.00–16.25) scores at baseline when not using the techniques. This suggests that participants were correctly utilizing the HRV techniques and achieving a greater state of physiologic coherence.

Table 1 Demographic characteristics of participants

Characteristics	Overall mean (range) or frequency (percent)
Age	30.8 (19–42)
Race (n=15)	
White/Caucasian	13 (86.7 %)
African American	2 (13.3 %)
Hispanic	0
Marital status (n=15)	
Single	0
In a relationship	3 (20 %)
Married	12 (80 %)
Separated/divorced	0
Widowed	0
Highest level of education completed (n=15)	
Some high school	1 (6.7 %)
High school diploma	1 (6.7 %)
Some college	3 (20 %)
2-year college program	3 (20 %)
4-year college/Bachelor's degree	2 (13.3 %)
Graduate school	5 (33.3 %)
Pregnancy status	
Currently pregnant	4 (26.7 %)
Postpartum	11 (73.3 %)

Table 2 Mean coherence scores at baseline and during active use of HRV techniques

	Coherence scores		
	Low	Medium	High
Time point A			
Baseline	80.73	28.30	6.00
Active	23.33	55	65.29
Time point B			
Baseline	75.2	25.58	16.25
Active	34.75	42	62.73

The mean time difference between time point A and time point B was 2.2 days, and survey instruments at both time points showed statistically significant mean differences in pre- versus post-HRVB treatment scores. There was a significant difference in the scores for the STAI survey, when comparing pre- versus post-HRVB treatment, at time both point A (M=−13.867, p<0.001) and at time point B (M=−11.533, p<0.001). Similarly, there was also a significant difference in the sum scores achieved on the WEMWBS survey at both time point A (M=6.143, p<0.001) and time point B (M=5.333, p<0.001). Lastly, the difference in scores on the LASA surveys was also significant, both at time point A (M=1.933, p=0.024) and time point B (M=2.867, p<0.001). These results suggest that biofeedback treatment sessions had a positive effect on the sum scores on each of the three surveys completed by participants, as there was a statistically significant improvement across all instruments in pre- versus post-therapy scores at both time points. Given that a higher score on the STAI instrument is associated with increased levels of anxiety, a score decrease is therefore associated with reduced levels of anxiety. Conversely, the WEMWBS and LASA instrument scores are proportional to levels of mental well-being and quality of life, respectively. Therefore, a positive change in these scores likely reflects an improvement in these two measures. Further details of this analysis are included in Table 3.

The admission EPDS score had no statistically significant effect on STAI scores at time point A (p=0.106) or at time point B (p=0.185), nor did it significantly affect the difference in WEMWBS scores at time point B (p=0.104). The EPDS scores did have a statistically significant effect on LASA scores at both time points A (p=0.003) and B (p=0.029) as well as on WEMWBS scores at time point A

Table 3 Paired samples *t* test analysis of differences in scores at time points A and B

Score difference	Time point	Mean difference	SD	*df*	*t*	*p* value (2-tailed)
STAI	A	−13.867	5.436	14	9.879	<0.001
	B	−11.533	9.680	14	4.615	<0.001
WEMWBS	A	6.143	3.527	13	−6.517	<0.001
	B	5.333	5.563	14	−3.713	0.002
LASA	A	1.933	2.963	14	−2.527	0.024
	B	2.867	2.134	14	−5.204	<0.001

(p=0.002). These results suggest that each one point increase in EPDS score corresponds to a 0.440706 (point A) and 0.327996 (point B) point decrease in the LASA score differences. Similarly, each one-point increase in EPDS score also corresponds to a 1.377832 decrease in the WEMWBS score difference at time point A. These results are summarized in Table 4.

Of the 15 participants enrolled in the study, 11 (73.3 %) completed the continued use phone survey, the results of which are displayed in Table 5. A majority of respondents (81.9 %, N=9) reported using the techniques at least once per week, if not more frequently, and more than half (54.6 %, N=6) rated biofeedback techniques as either very or extremely beneficial. None of the participants surveyed had purchased the HeartMath® machine for home use.

Discussion

This study demonstrates that among our participants, scores on all three instruments improved after women were exposed to HRVB therapy. While all three scores improved, the largest differences were observed among the STAI scores, with mean differences of 11.533 and 13.867, compared to mean differences in WEMWBS scores of 6.143 and 5.333 and in LASA scores of 1.933 and 2.867. Biofeedback techniques have previously been demonstrated to improve STAI scores in work done by Siepmann et al. (2008), which showed a median 20-point reduction in STAI scores among male and female participants undergoing biofeedback therapy for the treatment of depression.

Table 4 Fixed effects regression analysis of admission EPDS scores and survey score differences

Score difference	Time point	Estimate	*p* value
STAI	A	0.70491	0.106
	B	0.630786	0.185
WEMWBS	A	−1.377832	0.002
	B	−0.654241	0.104
LASA	A	−0.440706	0.003
	B	−0.327996	0.029

The greatest difference was seen in comparing pre- versus post-treatment STAI scores, and therefore, our results suggest that HRVB was most beneficial in targeting the acute anxiety symptoms of perinatal depression. Given that all patients hospitalized on the PPIU receive a full range of traditional treatments, including medications and psychotherapy, as well as the use of other CAM therapies such as yoga, we did not attempt to analyze improvements in instrument scores over the course of the inpatient stay, as it would be difficult to isolate the individual effects of the various treatments that the patients receive.

Our results suggest that admission EPDS scores did have some effect on the mean differences in pre- and post-treatment LASA scores at both time points and WEMWBS scores at time point A. This suggests that women with more severe depression may have experienced a slightly reduced benefit from participating in HRVB therapy. While these effects were statistically significant, they were small in magnitude, all resulting in less than a 1.5-point decrease in mean score difference in these two instruments. Additionally, admission EPDS scores, and therefore depression

Table 5 Continued use phone survey results

Question	Overall frequency (percent)	Overall mean (range)
Frequency of use (n=11)		
Not at all	1 (9.1 %)	3.36 (1–6)
Once per month	1 (9.1 %)	
Once per week	4 (36.4 %)	
More than once per week	4 (36.4 %)	
Once per day	0 (0.0 %)	
More than once per day	1 (9.1 %)	
Benefit of use (n=10)		
Not at all beneficial	0 (0.0 %)	3.55 (2–5)
Somewhat beneficial	1 (9.1 %)	
Moderately beneficial	4 (36.4 %)	
Very beneficial	5 (45.5 %)	
Extremely beneficial	1 (9.1 %)	
Purchase of HeartMath machine for home use		
Yes	0 (0.0 %)	2.00 (2–2)
No	11 (100.0 %)	

severity, did not seem to have a significant effect on mean differences in STAI scores at either time point.

Improvement in anxiety symptoms is of great importance in the treatment of this patient population, given that anxiety seems to be a prominent feature of their illness. As previously noted, there is evidence to suggest that anxiety may play an even greater role among women with postpartum depression. Hendrick et al. (2000) showed that among women seeking treatment for major depression, postpartum depressed women were more likely to present with anxious features compared with depressed women not in the postpartum period. Similarly, Ross et al. (2003) showed that among pregnant and postpartum women who screened positive for depression on the EPDS, the three-item anxiety subscale accounted for 47 % of the total score among women in pregnancy and 38 % of the total score among postpartum women.

Furthermore, the patients included in this study were particularly ill, with depression severity requiring hospital admission. The literature documents that perinatal depression presents with prominent anxiety features (Bernstein et al. 2008), and therefore, an intervention that focuses on management of anxiety is particularly important in those patients who require inpatient hospitalization. HRVB seems to, therefore, have a promising role in both inpatient as well as outpatient management of perinatal depression, the potential of which is further emphasized by the results of the follow-up telephone survey.

In addition to the demonstrated improvements in scores on the standardized instruments, participants in the study seemed to also perceive a benefit from utilizing biofeedback techniques, even outside of the hospital setting. A majority of participants (81.9 %) who were surveyed about continued use reported using biofeedback techniques at least once per week, and a majority (54.6 %) of participants also rated the use of biofeedback as either very or extremely beneficial to them in the outpatient setting. These results were obtained in the setting of none of the respondents having purchased the HeartMath® machine for personal use, indicating that they were able to practice HRVB techniques without the use of additional equipment.

While the results of this study are promising, it nevertheless is not without limitations. First of all, this study is limited by the absence of a control group against which to compare outcomes. Without a control group, it is difficult to say with certainty that the improvements in instrument scores are attributable to the usage of HRVB rather than regression to the mean or effects of passage of time. The study also includes a small, somewhat homogeneous sample size of 15, mostly Caucasian participants. Although HRVB treatment sessions were conducted in a similar manner and led by a single therapist, variations in participants' abilities and performance were not accounted for in this study. While the results suggest that the use of HRVB may have more immediate, short-term benefits for women with perinatal depression, this study did not assess potential long-term effects of it use. Lastly, while participants generally reported frequent use and significant perceived benefit from using HRVB techniques after discharge, it is possible that because this survey was conducted via telephone, that responses were affected by social desirability bias, causing participants to report increased frequency or benefit of use.

Conclusion

Biofeedback may have a promising role as a complementary treatment for perinatal depression. While it may be effective in treating all forms of major depression, it seems to be particularly useful among this patient population. Given the heightened concern about potential adverse effects of pharmacologic treatments on a developing fetus or a newborn that is breastfeeding, additional non-pharmacologic treatments are greatly needed for pregnant and postpartum women with depression. Our study demonstrated that HRVB may be particularly effective in treating the prominent anxiety symptoms of perinatal depression, as evidenced by the significant reduction in STAI scores. This effect may be greatly useful among pregnant and postpartum women, whose depression tends to be associated with significant anxiety features. Lastly, the utility of HRVB techniques seems to also be valuable to patients in the outpatient setting, as evidenced by their reported continued use and perceived benefits of doing so. While this study shows promising results, further research is needed among a larger, more diverse population and in comparison with a control group to better assess the use of biofeedback in the treatment of perinatal depression.

Conflict of interest The authors declare that they have no conflict of interest.

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