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Biofeedback to Treat Anxiety in Young People at Clinical High Risk for Developing Psychosis

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Abstract

Aim—Anxiety is a common presenting concern for individuals at clinical high risk (CHR) for psychosis. Treatment for CHR is still in the early stages and has focused on transition to psychosis and positive symptom reduction but little is known about what may be effective in reducing anxiety for these young people. One treatment that may be effective for anxiety is heart rate variability (HRV) biofeedback. The aim of this study was to test the efficacy and feasibility of using HRV biofeedback to reduce anxiety and distress in those at CHR.

Methods—Twenty participants who met minimum scores for anxiety and distress completed four weeks of a HRV biofeedback intervention and received pre and post intervention assessments. Repeated measures were used to examine changes in scores over time.

Results—There was a significant decrease over time in impaired ability to tolerate normal stressors ($p \leq .001$) and dysphoric mood ($p \leq .001$). There was no change on self-report measures of anxiety and distress. However, when two outliers were removed there was a trend towards improvement in self-reported anxiety ($p = .07$). These results were not impacted by usage time as a covariate. Feedback and adherence were generally good.

Conclusions—HRV biofeedback may be a feasible treatment option for individuals at CHR who have concerns with impaired stress tolerance and dysphoric mood. Future studies with a randomized controlled trial design will be necessary to further determine efficacy.

Keywords

Anxiety; Biofeedback; Clinical High Risk; Heart Rate Variability; Psychosis

Introduction

Anxiety has been identified as a frequent concern in schizophrenia.[1-3] It can contribute to distress and negatively impacts functioning and quality of life.[1,4] Similarly, a substantial number of individuals at Clinical High Risk (CHR) for psychosis present with anxiety disorders[5] and distress.[6] In fact, in CHR anxiety and depression are most frequently endorsed as the first noticed symptoms[7] and are often of more concern to these individuals than their sub-threshold psychotic symptoms.[8] Up to half of CHR individuals meet

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diagnostic criteria for an anxiety disorder[9] and they frequently have an impaired ability to tolerate normal stress.[10]

There are several interventions used for anxiety, such as pharmacological approaches, Cognitive Behavioral Therapy (CBT),[11] biofeedback,[12] exposure-based interventions,[13] exercise,[14] progressive muscle relaxation, yoga, mindfulness, hypnotherapy, meditation and nutritional changes.[15] Treatments demonstrating efficacy in schizophrenia include CBT,[16] second generation antipsychotics and SSRIs, exposure-based therapies, progressive muscle relaxation, yoga, and mindfulness.[1,17] Several treatment approaches for individuals at CHR are being explored including CBT,[18-22] antipsychotic medication,[23-25] and omega-3 supplements[26] for reduction of transition rates and positive symptoms. However, anxiety reduction has not been a primary outcome. Studies that did report on anxiety did not observe reduced anxiety with CBT versus the control condition,[20, 22] although one study found that improvement in anxiety was observed in both their CBT and supportive therapy groups.[18] As one of the most common presenting concerns for young people at CHR, anxiety is a valuable treatment objective. One treatment that has not been explored in this population is heart rate variability (HRV) biofeedback.

The heart is dually innervated by the sympathetic and parasympathetic nervous systems,[27] allowing for processes of the heart to provide an index for autonomic functioning. HRV reflects beat-to-beat changes in heart rate and provides a measure of neurological ability to function adaptively within changing environments.[28] Thus, higher variation indicates an increased ability to respond to external demands and changes. Low HRV indicates increased sympathetic nervous system activity[29] and is characteristic of many psychiatric and general medical conditions.[12] There is evidence for autonomic system dysfunction as evaluated by low HRV, low vagal activity, and poor autonomic adaptability and reactivity in people with schizophrenia.[30-33] This is similarly observed in anxiety disorders, though more pronounced in psychosis.[34] A simple and noninvasive way to impact autonomic activity is with HRV biofeedback, a tool that can increase HRV, mainly through the regulation of breathing in response to external feedback to influence associated autonomic reactions.[35] There is evidence for reduced symptomatology in a variety of illnesses, including anxiety disorders, through increasing HRV with biofeedback.[12]

In summary, treatments are needed not only to prevent or delay the development of psychosis but also to address the significant associated symptomatology, such as anxiety, experienced by young people at CHR. The aim of this study is to examine the efficacy and feasibility of a HRV biofeedback intervention to target anxiety and distress in young people at CHR. It is hypothesized that CHR individuals with repeated exposure to HRV biofeedback will demonstrate improvements in 1) measures of anxiety; 2) distress scores; and 3) the symptoms of Impaired Tolerance to Normal Stress and Dysphoric Mood on the SOPS.

Methods

Study Design

This study was an open four-week trial using a single group pre-test post-test design to evaluate HRV biofeedback. An open-trial design was chosen since this was a pilot study to inform feasibility, possible efficacy, and effect sizes for a larger study.

Sample

Twenty participants (6 male, 14 female) were recruited for this study. All participants met CHR for psychosis criteria according to the Criteria of Prodromal Syndromes (COPS), which is based on the Structured Interview for Prodromal Syndromes (SIPS).[36] Gold standard post-training agreement on determining the prodromal diagnoses was excellent (kappa=0.90).[37]

All participants either a) had a raw score of 36 or higher on the Self-Rating Anxiety Scale (SAS),[38] and/or b) scored 20 or higher on the Kessler Psychological Distress Scale (K10).[39] Participants were excluded if there was a known history of a cardiac illness, known hypo/hyperthyroidism, or an initiation or change in dose of psychiatric medication within the month prior to baseline assessment. Exclusion criteria also having a current or lifetime Axis I psychotic disorder, impaired intellectual functioning (IQ<70), past or current clinically significant central nervous system disorder, substance dependence in the past 6 months, or if the diagnostic prodromal symptoms were clearly caused by an Axis 1 disorder, including substance use disorders, in the judgment of the evaluating clinician.

Measures

The Structured Clinical Interview for DSM-IV Disorders[40] was used to determine the presence of major DSM-IV axis I disorders and to rule out any psychotic disorders and the *SIPS* and the *Scale of Prodromal Symptoms (SOPS)*[36] to determine COPS criteria and symptom severity. The items “Dysphoric Mood” and “Impaired Tolerance to Normal Stress” from the General Symptoms of the SOPS were outcome measures for this study. *The Kessler Psychological Distress Scale (K10)*[39] measured distress related to anxiety and depressive symptoms. A score of 20 or above may indicate between a mild to severe mental disorder. *The Social Interaction Anxiety Scale (SIAS)*[41] measures anxiety in social situations and *The Zung Self-Rating Anxiety Scale (SAS)*[38] measured general anxiety. A raw score of 20-36 is considered to be within the normal range and higher scores indicate between mild to extreme anxiety. *Social & Global Functioning Scales (GF:S & GF:R)*[42] were specifically designed for use with those at CHR.

Procedures

Raters were experienced research clinicians who demonstrated good reliability at routine reliability checks. The study protocols and informed consents were approved by the local ethics committee. All participants provided informed consent or assent prior to completing study measures and parental or guardian consent was also obtained for participants under age 18.

After completing the baseline assessment, participants received anxiety education to provide a rationale for the intervention and to help compliance. They were then given the biofeedback device and instructions for use. Biofeedback was achieved using emWave®2 technology developed by the Institute of HeartMath (Boulder Creek, CA). Participants received both a handheld biofeedback device and computer software and were taught to pace their breathing in accordance with the light and sound feedback from the device. The small, portable device can be used alone, or with the computer software that provided interactive games. This technology provides an on-line platform that uploads session data, so that actual usage can be determined. Participants were directed to use the biofeedback intervention a minimum of one hour per week for four weeks. Exposure time was based on averages taken from previous studies, which were variable.[43-48] Participants were contacted weekly to check on usage, questions or concerns. Every effort was made to ensure that each participant received the same amount of contact.

At the end of the four-week intervention, participants returned the biofeedback device and completed the outcome measures. Participants then completed a follow-up four weeks after the end of intervention visit. In order to protect against sources of bias, those responsible for monitoring and supervising the treatment were not involved in follow-up assessments.

Statistical Analysis

All outcome variables were examined prior to analysis for distribution and all variables were normally distributed on measures of skewness and kurtosis except for the item Grandiose Ideas. Repeated measures with Sidak post-hoc tests were used, as Mauchley's test of sphericity was not significant, to examine changes in Impaired Tolerance to Normal Stress, Dysphoric Mood, SAS, K10, SIAS, SOPS and functioning scores over the three visits; baseline, week 4 and end of study follow-up. Biofeedback usage time was then added as a covariate to the repeated measures to control for a dose response.

Results

Recruitment

Out of 20 participants enrolled in the study, 12 met entry criteria on both the SAS and K10 and eight participants met only K10 criteria. One participant was lost to follow-up and was unable to be contacted after baseline. An additional two participants declined to complete the end of study follow-up assessment. See Figure 1.

Participant Characteristics

Mean age of participants was 16.70 years (SD = 2.30, range 13-22). The majority of participants were female, Caucasian, never married, living with their family, and currently enrolled as a student. Out of the 20 participants enrolled in the study, 18 met CHR criteria based on attenuated positive symptoms and two met for genetic risk and deterioration. The majority of participants met criteria for an anxiety and/or a depressive disorder. See Table 1.

Mean scores of SOPS symptoms and functioning are presented in Table 2. Repeated measures were conducted to determine if there was any change over time. There were

significant decreases in Unusual Thought Content, Grandiose Ideas, and total positive symptom scores.

Other Treatment

At study entry, several participants were receiving concurrent pharmacological or psychological treatment. Details are presented in Table 3. One participant was an in-patient on a psychiatric unit at study entry and received passes to complete study assessments. Another participant was hospitalized after their week 4 assessment due to suicidal ideation and depression and was discharged prior to end of study follow-up.

Adherence

Participants were instructed to use the biofeedback for a minimum of one hour per week, or 240 minutes total. Adherence was variable and ranged from 5-486 minutes. The mean amount of usage time was 142 minutes. Twenty percent of participants used the biofeedback for four hours or more, an additional 25% used it for more than two hours, 25% used it for between one to two hours, and 30% used it for less than one hour. Average use was 48 minutes during week 1, which steadily decreased to 23 minutes by week 4. Several participants reported that they wished they had used it more and cited avolition as a barrier.

Outcome

There was a significant change over time on Impaired Tolerance to Normal Stress and Dysphoric Mood. There was no significant change over time on the K10, SAS or SIAS self-report measures. See Table 4. Usage time was added as a covariate to the repeated measures. However, this had no impact on these results.

Two participants had a noticeable worsening in SAS scores. One of these participants had increasing depression with suicidal ideation and was hospitalized during the study. The other used the biofeedback a total of seven minutes and was five weeks late for their week 4 assessment. When these outliers were removed, there was a trend for improvement in SAS scores ($F = 2.86$, $p = .07$).

Participant Feedback

Participant feedback was positive with 85% of participants reporting they were moderately to very satisfied with the study. No participants reported dissatisfaction. Participants reported that the biofeedback was moderately to very easy to use and somewhat to moderately helpful with anxiety. A few participants reported finding it most useful for panic attacks, stressful situations or anger.

Discussion

This pilot study examined the utility of a HRV biofeedback intervention for young people at CHR for psychosis who reported experiencing anxiety and distress. Our first two hypotheses, that there would be improvements in anxiety scores and distress scores, were not supported as there were no significant changes on the SAS, SIAS or K10 measures of

anxiety and distress. However, there was support for the third hypothesis as the two SOPS items, impaired stress tolerance and dysphoria, significantly improved.

There are several possibilities for the lack of change on the self-report measures. First, the study was underpowered and the sample size was too small to detect a difference or to handle outliers. Secondly, it is possible that four weeks was not a sufficient length of time, although several studies in non-CHR anxiety populations did observe an effect with this duration of time or less.[44,46,47,49] However, increasing duration may not be advantageous as participants were most adherent during the first week with a steady decline through the subsequent three weeks. Despite our observation that there was no dose effect, only 20% of participants used the biofeedback for the recommended amount of time and as a result exposure time may have been inadequate. Thirdly, HRV biofeedback primarily targets autonomic responses but it may be difficult to impact anxiety and distress if other factors are not addressed, such as underlying thoughts. Thus, it may be more effective to add HRV biofeedback as an adjunctive therapy. The potential for increased treatment efficacy by using combination therapy for anxiety is supported in the literature, such as CBT plus an SSRI.[50] Although many individuals were receiving concurrent treatments in this study, these varied widely. Thus, it would be useful to examine HRV biofeedback as an adjunct to other treatments where these treatments are administered consistently for all participants.

Fourthly, it may have been problematic using the SIAS which measures social anxiety and was included because social phobia is one of the most prominent anxiety disorders in CHR. However, it has been suggested that social anxiety may not respond well to “generic” anxiety disorder treatment in children and adolescents and may need intervention specific to social interactions, such as social skills training or increasing opportunity for peer interaction.[11] Other studies have found CBT and pharmacological approaches to be the most efficacious in treating social anxiety.[51-52] To the best of our knowledge, HRV biofeedback has not been examined for the treatment of social phobia. Furthermore, since participants did not use the intervention in social situations, an impact on the behavioral and cognitive items of the SIAS is unlikely since these are not the target mechanisms of change from HRV biofeedback.

There was however both clinically and statistically significant decreases in both Impaired Tolerance to Normal Stress and Dysphoric Mood. Impaired Tolerance to Normal Stress averaged moderate-moderately severe at baseline, indicating increasing difficulty with daily experiences that previously were easily dealt with but are currently becoming very challenging. By week four this item was on average rated at a mild level and remained stable until the end of study. Dysphoric Mood averaged moderately severe at baseline, indicating recurring periods of anxiety, sadness, irritability, and depression. This item decreased to a moderate level by week four and even more to mild-moderate by the end of study. These reductions may indicate that participants’ ability to cope and the degree to which they are impacted by anxiety and distress significantly improved during the intervention.

There was a significant reduction in positive symptoms on the SOPS. Symptoms decreased an average of one point for overall positive symptom scores and Unusual Thought Content. However, the mean average at baseline was slightly below a level of three, which is below

the threshold for COPS criteria. Therefore, although this decrease is statistically significant it may not be clinically significant.

Although there was variation in levels of adherence to the required usage time, the majority of participants had at least one hour of exposure to the HRV biofeedback intervention. Adherence was not found to impact changes in scores but overall the adherence does suggest that participants were willing to use the intervention on a repeated basis. Participant feedback was also positive with the majority reporting high levels of satisfaction with their study experience. Taken together, observed improvements in scores, adherence, and participant feedback indicate that this type of intervention is well-tolerated and may be a feasible option for individuals at CHR who are experiencing anxiety and distress.

There are several limitations to this study. First, the use of a single group pre and post-test design, rather than a randomized controlled trial design, limits the ability to determine if any effects observed were due to the intervention. Secondly, the study was likely underpowered as the sample was small. Sample size was based on the fact that individual devices had to be purchased and this first trial was intended to be a feasibility study. Thirdly, many individuals were receiving concurrent treatment during this study that may have impacted scores of anxiety and distress. However, we attempted to reduce the impact of psychotropic medications as a confounding variable by excluding those who had changes in their treatment within the last month from this study, though several participants had treatment changes after beginning the study. This study did not control for substances such as alcohol, caffeine or nicotine. Fourthly, the use of self-report measures increases the possibility of reporting biases, although rater-completed measures were also used for outcome. Fifthly, participants used the biofeedback on their own time and this may have impacted adherence, although this was done in order to provide a more real-world understanding of usage and to reduce additional beneficial effects of repeated therapeutic contact. Furthermore, HRV data was not measured in this study so it is not possible to determine if the biofeedback impacted HRV. Finally, it is possible that the treatment was not efficacious, although the lack of power also impacts this conclusion.

This study has clinical implications for the treatment of individuals at CHR for psychosis. Anxiety is a common concern for these young people and HRV biofeedback may be a useful tool to alleviate impaired stress tolerance and dysphoria. It may be best utilized as an adjunct to other interventions with well-established efficacy for anxiety, such as CBT. HRV biofeedback could be useful in situations where other relaxation or stress reduction techniques, such as mindfulness, meditation, and physical activity, are often recommended.[53] HRV biofeedback may be specifically advantageous in certain situations, such as where the use of an interactive technology may be more engaging with younger people than other relaxation techniques. Next steps for determining the efficacy of HRV biofeedback for anxiety in the CHR population would be a randomized controlled trial with an adequately powered sample controlling for confounding variables, such as concurrent treatment and including pre and post measures of HRV. A larger sample would allow for the comparison of completers versus non-completers.

In conclusion, this pilot study demonstrated that HRV biofeedback is a well-tolerated intervention that may be useful in reducing some presenting symptoms of concern, such as impaired stress tolerance and dysphoric mood, in individuals at CHR experiencing anxiety and distress. Thus, HRV biofeedback may be a feasible treatment option for young people at CHR for psychosis.

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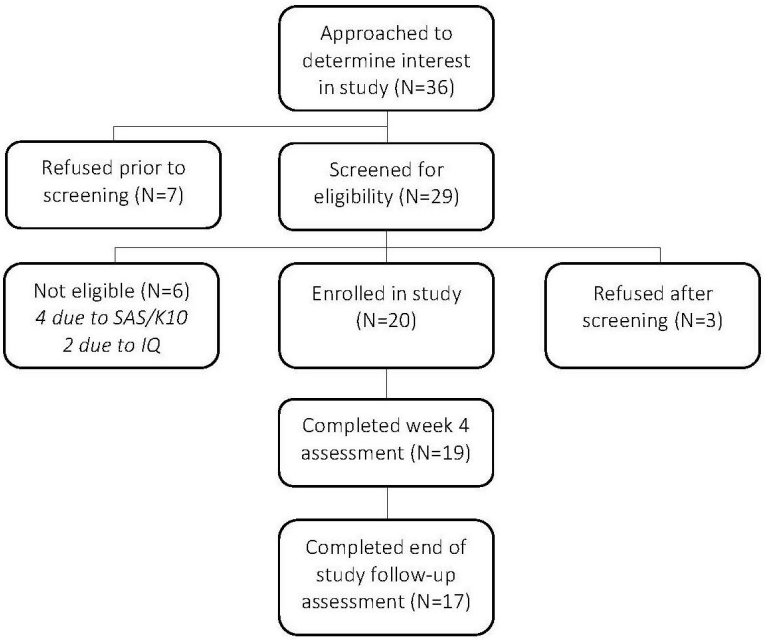

Figure 1.
Consort diagram

Table 1

Prevalence of DSM-IV Axis I disorders

DSM-IV Axis I diagnosis	Study participant (*N*=20)
	***N* (%)**
Any anxiety disorder	12 (60.0)
Generalized anxiety disorder	5 (25.0)
Panic disorder	4 (20.0)
Social phobia	4 (20.0)
Specific phobia	1 (5.0)
Obsessive-compulsive disorder	1 (5.0)
Anxiety disorder not otherwise specified	0 (0.0)
Posttraumatic stress disorder	0 (0.0)
Agoraphobia	0 (0.0)
Any depressive disorder	12 (60.0)
Major depressive disorder, recurrent	6 (30.0)
Major depressive disorder, single episode	5 (25.0)
Depressive disorder NOS	1 (5.0)
Attention-deficit/hyperactivity disorder	2 (10.0)
Substance use disorder	1 (5.0)

Table 2

Scale of Prodromal Symptoms and functioning repeated measures

Measure	Baseline (N = 20)	Week 4 (N = 19)	Follow-up (N = 17)	*F*
	***M* (SD)**	***M (SD)***	***M (SD)***	
Scale of Prodromal Symptoms				
Unusual Thought Content	2.95 (1.34)	2.11 (1.49)	1.82 (1.55)†	6.56**
Suspiciousness	2.00 (1.81)	1.74 (1.63)	1.65 (1.41)	0.85
Grandiose Ideas	0.45 (0.83)	0.16 (0.50)	0.18 (0.53)	5.76*
Perceptual Abnormalities	2.65 (1.57)	2.84 (1.34)	2.71 (1.36)	0.40
Disorganized Communication	0.55 (0.69)	0.63 (0.64)	0.82 (0.14)	1.80
Overall Positive Symptoms	8.60 (3.80)	7.05 (4.01)	7.44 (3.73)	3.23*
Overall Negative Symptoms	7.35 (4.59)	5.58 (5.59)	6.24 (6.08)	1.48
Functioning				
Global Assessment of Functioning	49.50 (14.01)	58.21 (13.76)	57.35 (14.10)	2.66
Global Functioning: Social	7.50 (1.40)	7.68 (1.83)	7.18 (2.19)	0.71
Global Functioning: Role	6.15 (2.01)	6.16 (2.17)	6.24 (2.56)	0.33

† significantly different from baseline

* $p \leq .05$,

** $p \leq .01$

Table 3

Concurrent treatment

Type of Treatment	Baseline	Week 4	Follow-up
	N (%)	*N (%)*	*N (%)*
Pharmacological			
Antipsychotic	7 (35.0)	6 (30.0)	5 (25.0)
Benzodiazepine	1 (5.0)	2 (10.0)	1 (5.0)
Lithium	1 (5.0)	1 (5.0)	1 (5.0)
Selective Serotonin Reuptake Inhibitor	3 (15.0)	5 (25.0)	4 (20.0)
Serotonin-Norepinephrine Reuptake Inhibitor	0 (0.0)	1 (5.0)	1 (5.0)
Stimulant	2 (10.0)	2 (10.0)	2 (10.0)
Tricyclic Antidepressant	0 (0.0)	0 (0.0)	1 (5.0)
Psychological			
Case Management	8 (40.0)	10 (50.0)	5 (25.0)
Cognitive Behavioral Therapy	1 (5.0)	0 (0.0)	0 (0.0)
Family Therapy	0 (0.0)	1 (5.0)	1 (5.0)
School Counselling	1 (5.0)	1 (5.0)	2 (10.0)
Supportive Therapy	9 (45.0)	10 (50.0)	9 (45.0)
In-patient Hospitalization	1 (5.0)	1 (5.0)	0 (0.0)

Table 4

Outcome repeated measures

Measure	Baseline (N = 20)	Week 4 (N = 19)	Follow-up (N = 17)	*F*
	***M* (SD)**	***M (SD)***	***M (SD)***	
Impaired Stress Tolerance	3.80 (2.21)	2.05 (2.09)†	2.35 (2.15)†	8.75***
Dysphoric Mood	4.35 (1.73)	2.95 (2.32)†	2.65 (2.21)†	8.16***
Self-Rating Anxiety Scale	42.90 (11.88)	40.16 (13.00)	44.56 (15.23)	2.07
Social Interaction Anxiety Scale	35.00 (18.01)	29.16 (18.23)	33.81 (17.93)	1.36
Kessler Distress Scale	29.80 (7.97)	26.95 (9.85)	30.25 (10.54)	0.89

† significantly different from baseline

*** $p \leq .001$