Mental Health in Family Medicine 2011;8:195–203

Article

Game-based biofeedback for paediatric anxiety and depression

M Knox
Associate Professor, Department of Psychiatry

J Lentini
Resident, Department of Psychiatry, Child and Adolescent Division

TS Cummings
Chief Resident, Department of Psychiatry, Child and Adolescent Division

A McGrady
Professor, Department of Psychiatry

K Whearty
Research Assistant, Department of Psychiatry

University of Toledo College of Medicine, Toledo, OH, USA

L Sancrant
Licensed Clinical Counselor, University of Toledo Physicians, Toledo, OH, USA

ABSTRACT

Twenty-four children and adolescents aged 9–17 who were referred for treatment for anxiety were assigned to either a game-based biofeedback group or a waiting list comparison group. The eight-session biofeedback intervention included psychoeducation, identification of triggers and signs of anxiety, and in vivo practice. The intervention used computer-based gaming technology to teach and practise relaxation. Analyses using ANCOVA revealed significant differences in post-test scores of anxiety and depression measures between the two groups. The intervention group reduced anxiety and depression scores on standardised tests. Findings suggest that biofeedback-assisted relaxation training can be useful in decreasing anxiety and depressive symptoms in anxious youths.

Keywords: anxiety, biofeedback, children/adolescents, depression, relaxation

Introduction

Anxiety disorders are among the most frequent psychological problems in childhood and adolescence and show moderate stability over time,[1] often lasting into adulthood. In addition to intense or persistent fear, worry or avoidance, anxiety in children and adolescents is frequently manifested in physiological reactivity and physical responses such as headaches, stomach aches, toileting accidents and sleep disturbances.[2–5] Research on the treatment of anxiety disorders has identified cognitive–behavioural therapy (CBT) as an effective treatment for paediatric anxiety.[6,7] However, evidence-based treatments such as CBT are often not accessible to children who need them and 20–50% of children treated with CBT do not show an adequate treatment response,[8] suggesting the need to improve on current treatment strategies.

Possibly because of the physical and somatic components of paediatric anxiety, relaxation training has been identified as a key component of treat-

ment.[9–12] Positive results from traditional relaxation training for children are time-limited, perhaps due to the lack of continued practise of the techniques.[13] Biofeedback-based treatments have been developed to further help children and youths with anxiety and stress-related medical conditions to learn to relax and control physiological reactivity. Biofeedback is a technique in which information about a physiological function, such as breathing rate, finger temperature or skin conductance is provided to the child/adolescent with the goal of learned control over time. Awareness of changes in the physiological variables associated with stressful thoughts or relaxation facilitates learning in an operant conditioning paradigm. Association between symptoms and stress responses forms the foundation for the effects of biofeedback-assisted relaxation on symptom reduction.[14] In one study, a biofeedback intervention was shown to reduce both state and trait anxiety for a sample of teenagers with anxiety.[15] A non-clinical adolescent sample experienced reduced state and test anxiety following a combination of CBT and biofeedback.[16] In another study, children and adolescents with headache and high anxiety showed significant improvements following biofeedback and imagery training.[17] Similarly, a sample of adolescents using biofeedback exhibited reduced test anxiety, reduced negative affect and improved test performance.[18] Culbert *et al*[19] used a paediatric biofeedback programme with 24 youths, approximately half of whom presented with medical disorders such as migraine headaches, abdominal pain or sleep disturbance, and the other 12 participants presented with anxiety and stress-related symptoms. Results indicated youths enjoyed the training and experienced greater control over their mind and/or body. All participants experienced either partial or complete remission of symptoms, supporting the potential effectiveness of this method with anxious children, and suggesting that biofeedback training may be useful as an adjunctive treatment in the care provided to youths with anxiety and stress-related medical disorders.[19]

Anxiety and depressive disorders have been shown to be highly comorbid in up to 50% of children and youths.[20–24] As with anxiety, CBT has been identified as an evidence-based treatment for depression in children and youths.[25] Furthermore, a recent study indicated that both anxious and depressed teenage girls show evidence of relatively decreased heart rate variability.[26] The commonalities between youth anxiety and depression are so profound that some researchers are suggesting a unified treatment for these disorders.[27] Thus, strategies such as biofeedback, which can be useful with anxious children, may also hold promise as an effective treatment strategy for children and youths with depression. Recent research suggests that biofeedback for heart rate variability may be useful in treatment of depression in adults,[28] but similar evidence is not yet available for paediatric depression.

Game-based biofeedback

In recent years, technology has been developed that makes use of video-game-like technology and graphics to increase interest and engagement in biofeedback and to facilitate learning of deep breathing, imagery and relaxation. Although there is not yet ample empirical evidence demonstrating the efficacy of these new programmes, it stands to reason that such technology may be useful for work with children and youths, in part because children and adolescents are often avid users of video games. School-age children in the USA spend an average of seven hours per week playing video games, and eighth and ninth grade students average about nine hours per week.[29,30] Given their prevalence in youth culture, video-game-based programmes may be enjoyable and motivating media for treatments intended for children and adolescents. Video game technology has been used successfully to aid in the treatment of several childhood illnesses such as asthma, cancer, diabetes[31] and even post-traumatic stress disorder (PTSD).[32] Use of such technology may improve on the relatively short-term outcomes reported in some prior research on relaxation training with children and youths.[13]

To date, very little research exists about the use of biofeedback-assisted relaxation training using gaming technology with children and youths. Recently, Pop-Jordanova and Gucev[33] found that game-based biofeedback may be useful for stress mediation for children. In a study of the efficacy of a computer-based 'active feedback' game called *The Journey to Wild Divine*[34] with 24 children diagnosed with attention-deficit/hyperactivity disorder (ADHD),[35] children were taught to manipulate their heart rate using breathing techniques taught during the game. The experimental group demonstrated significant reductions in ADHD symptoms. Researchers also noted that children took great interest in the study and were stimulated and motivated by the use of technology and video game format.

This study examined changes in anxiety and depression in a sample of children and youths referred for treatment for anxiety. It was hypothesised that participants who receive biofeedback-assisted relaxation training in combination with CBT would experience reduced symptoms of:

- overall anxiety, assessed by total scores on the Multidimensional Anxiety Scale for Children (MASC)[36]

- somatic/autonomic symptoms, indicated by MASC Somatic/Autonomic subscale
- perceived tenseness, determined by MASC Tense/Restless subscale
- trait anxiety, measured by the (State–Trait Anxiety Inventory for Children (STAIC)[37] and
- depression, indicated by total scores on the Children's Depression Inventory (CDI).[38]

Methods

Participants

Prior to recruitment of participants, the research study was reviewed and approved by the primary investigator's institutional review board. Referrals for the study were made by nurse practitioners, physicians and mental healthcare providers of children aged 9–17 years who reported symptoms of anxiety such as excessive worry and fear or carried a diagnosis of an anxiety disorder such as generalised anxiety disorder. Thirty individuals were referred and enrolled in the study. Each participant's legal guardian gave informed consent, and each child or adolescent completed an informed assent form. Participants were assigned to intervention and comparison groups sequentially, with the first 15 assigned to the intervention group, and the next 15 assigned to a waiting list comparison group. The sequential assignment was necessitated by staffing issues. Of the original 30, six participants dropped out prematurely (three from each group), leaving 12 participants in each group. Twenty-four children/adolescents (nine females, 15 males), aged 9–17 (M = 12.88, SD = 2.42) fully completed the study. Of these, 22 (91.7%) were white, one (4.2%) was African American and one (4.2%) was Latina. The sample's mean socio-economic score (based on Total Based SEI)[39] was 62.96 (SD = 18.11), and ranged from 34 to 95. None of the participants received therapy addressing anxiety or depression during the study. Six of the intervention participants and seven of the control participants were on medications that could address anxiety or depression. None of the participants started or changed medications during the course of the study.

Materials

The MASC[36] assesses anxiety symptoms in children. It is used in children aged 8–19 and is a self-report measure. The MASC has several scales that address physical symptoms, social anxiety, harm avoidance, separation/panic, anxiety disorders and total anxiety. The physical symptoms scale has items addressing physical signs of anxiety such as tenseness, dizziness and feeling sick, sweaty or shaky. It has two subscales: Tense/Restless and Somatic/Autonomic. The Tense/Restless subscale assesses tension symptoms with items such as 'I feel restless and on edge' and 'My hands shake'. The Somatic/Autonomic subscale assesses somatic symptoms with items such as 'My heart races or skips a beat' and 'I feel sick to my stomach'. The test takes about 10 minutes to complete and consists of 39 items. Items are rated on a four-point Likert scale ranging from 'Never true about me' to 'Often true about me'. The MASC has a fourth grade reading level. The scale has good internal consistency and test–retest reliability.[34,40] There is also evidence indicating sound convergent and discriminant validity of the scale.[36]

The CDI[38] is used with children aged 7–17. It has 27 items and generally takes 15 minutes to complete. Each question has three statements to choose from; the respondent chooses the statement that best describes him/her over the past two weeks. For example, the respondent can choose from 'Things bother me all the time', 'Things bother me many times' and 'Things bother me once in awhile'. Scores from this measure can be used to suggest, but not prove, the absence/presence of depression. The scale has a first grade reading level and has been found to have excellent internal consistency, and satisfactory (two weeks to one month) test–retest reliability. The scale discriminates between depressed and non-depressed children and has adequate concurrent validity.[38]

The STAIC[37] is used to distinguish between anxiety that is a fleeting emotion versus more stable anxiety or anxiety-proneness. The test has two parts; one asks respondents about how they feel at certain moments in time (state anxiety), the second asks them about how they usually feel (trait anxiety). On the trait subscale of this instrument, items such as 'I worry about making mistakes' are rated as either 'hardly ever', 'sometimes' or 'often' true. It takes about 20 minutes to complete. The scale has a reading level appropriate for children 9 years of age and older. It is considered a reliable and valid measure of anxiety in children.[41]

Procedures

Informed consent was obtained from parents, and informed assent from youths, prior to their participation in the study. The biofeedback (intervention) condition was based on a session-by-session protocol combining relaxation training and practise with psychoeducation about how stress can affect children,

how relaxation can relieve or prevent stress and when and how to use relaxation techniques in real life. Participants were also helped to identify signs of anxiety as well as events and thoughts that trigger anxiety. Participants were assigned behavioural practice that was designed to help them most effectively incorporate the use of relaxation into their daily lives. Appendix 1 shows the session-by-session protocol that was used.

All aspects of the study were conducted in an outpatient mental health agency for children, adolescents and families. The agency is located on the campus of a large metropolitan university in the Midwestern USA. Intervention group participants completed the STAIC, the MASC and the CDI just prior to and immediately after completion of the eight sessions. Comparison participants were given the same measures eight weeks apart. Biofeedback was offered without charge to the waiting list comparison group after the completion of the study.

Freeze-Framer 2.0[42] and Journey to the Wild Divine: The Passage software[34] programs were utilised in this study. These programs use one to three small skin electrodes that record moment by moment changes in heart rate variability (HRV) and skin conductance level (SCL). These changes can be plotted on graph or modulated through a game. As a person becomes more relaxed, his/her HRV increases, SCL decreases and he/she experiences physiological coherence. HRV and SCL are secondary measures of the autonomic nervous system (ANS). HRV is the amount of difference between heart beats. Low variability is usually indicative of stress. SCL is a calculation of the activity of the sweat glands (usually at the fingertips). An increase in perspiration implies an increase in ANS activity, which occurs with both anxiety and excitement. Physiological coherence is associated with increased sense of well-being and relaxation, and an assessable change in brain activity from erratic beta waves to steady alpha waves.[43]

The Freeze-Framer program allows the player to engage in activities such as colouring a meadow, making a rainbow or floating in a hot air balloon that appear on the computer screen. The Journey to the Wild Divine program involves an assortment of experiences (e.g. making a fire, building a wall and shooting a bow and arrow) in a fantasy land. The games use imagery and sound to aid in relaxation. As an example, in The Journey to the Wild Divine, a tree moves rhythmically in the breeze (to help the user to slow breathing) to soft music. The user has a goal of building a bridge across a valley. As the person's breathing slows and tension decreases, the bridge is built. If the user experiences frustration or anxiety, the bridge disappears. After a continuous amount of relaxation, the bridge is completed and the user may 'cross' to the next activity. Other more challenging tasks require reducing tension during a stressful event, for example, retrieving a ball within striking distance of a snake. This change in difficulty is useful for patients to practise remaining calm in outside, 'real-world', stress-inducing events.

Results

The participants who dropped out did not differ significantly from the study completers on any of demographic (age, socio-economic status, gender, ethnicity) or pre-test variables (MASC pre-test score, CDI pre-test score) suggesting that there was no identifiable pattern of attrition. In addition, the intervention and comparison group participants did not differ on the demographic variables (participant age, treatment status, socio-economic status, gender or ethnicity). However, the intervention and comparison groups did differ on pre-test total scores on the MASC [$t(1,22) = -2.44$; $P = 0.021$], with the intervention group having significantly lower mean total scores than the comparison group (M = 59.08, SD = 13.94; and M = 72.09, SD = 11.35, respectively). In order to account for pre-test group differences, ANCOVA was used in subsequent analyses, with pre-test scores as the covariate. Table 1 lists characteristics of the total sample and each group.

ANCOVA was used with pre-test MASC total *T*-scores as the covariate, and MASC total post-test *T*-scores as the dependent variable. This analysis revealed significant differences between the intervention and comparison groups at post-test [$F(2,23) = 12.18$, $P = .000$; partial $\chi^2 = 0.54$] favouring the intervention group. ANCOVA was used with pre-test MASC Somatic/Autonomic scale *T*-scores as the covariate, and post-test MASC Somatic/Autonomic scale *T*-scores as the dependent variable. This analysis revealed significant differences between the intervention and comparison groups at post test [$F(2,23) = 6.74$, $P = 0.005$; partial $\chi^2 = 0.39$] favouring the intervention group. ANCOVA was used with pre-test MASC Tense/Restless scale *T*-scores as the covariate, and post-test MASC Tense/Restless scale *T*-scores as the dependent variable. This analysis revealed significant differences between the intervention and comparison groups at post test [$F(2,23) = 5.31$, $P = 0.014$; partial $\chi^2 = 0.34$] favouring the intervention group. ANCOVA was also used with STAIC Trait Anxiety subscale post-test scores as the dependent variable, and STAIC Trait Anxiety subscale pre-test scores as the covariate. This analysis resulted in significant differences between the intervention and comparison groups at post test

Table 1 Intervention group, comparison group and total sample: mean scores and standard deviations on pre and post measures

	Intervention group				Comparison group				Total sample			
	Pre		Post		Pre		Post		Pre		Post	
Measure	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
MASC Total	59.08	13.94	52.00	6.21	70.50	12.15	67.08*	15.02	64.79	14.05	59.54	13.63
MASC Tense/ Restless	60.58	12.16	50.92	9.57	67.17	10.30	64.92*	11.67	63.88	11.52	57.92	12.64
MASC Somatic/ Autonomic	55.67	14.09	52.25	11.92	59.33	13.13	61.75*	11.38	57.50	13.45	57.00	12.38
CDI	58.41	13.29	49.00	11.75	55.50	11.49	54.83*	14.88	56.96	12.24	51.92	13.45
STAIC	39.25	7.50	33.75	6.20	42.00	7.41	42.25*	9.75	40.63	7.42	38.00	9.09

Note: * Group differences at post-test using ANCOVA; $P < 0.05$.

[$F(1,23) = 3.95$, $P = 0.035$; partial $\chi^2 = 0.327$], again favouring the intervention group.

To determine changes in depressive symptoms, the same analysis was used with CDI post-test *T*-scores as the dependent variable, and CDI total pre-test *T*-scores as the covariate. This revealed significant differences between the intervention and comparison groups at post test [$F(2,23) = 9.39$, $P = 0.001$; partial $\chi^2 = 0.47$] again favouring the intervention group.

Discussion

This study was the first to test the effects of biofeedback-assisted relaxation training with a video game format for anxious children and youths. The intervention employed an eight-session protocol combining relaxation training and practise with psychoeducation about the effects of stress on the mind and body, how relaxation can relieve or prevent stress, and the use of relaxation techniques in real life. Participants were also helped to identify signs of anxiety as well as events and thoughts that may trigger anxiety. These results suggest that this method may be effective in reducing anxiety in children and adolescents, as evidenced by scores on two different, well-established measures of anxiety. Furthermore, results are suggestive of the positive effects of this intervention on physiological parameters, as evidenced by positive findings on scales addressing physical tension and restlessness and somatic symptoms. Intervention participants' significantly improved scores on the MASC Tense/Restless and Somatic/Automatic subscales indicate that this intervention affects the physical and physiological state of anxious children. This study further suggests that teaching children and adolescents to alter physical and physiological parameters may affect depressive and anxiety symptoms in significant and meaningful ways.

The largest effect size in this study was evident in positive outcomes on the depression scale, which is noteworthy because these children were referred not for depression, but rather for anxiety. Although this finding may reflect the significant symptom overlap between youth depression and anxiety, it is also possible that this intervention provides an important secondary outcome, i.e. reduction of depressive symptoms. Despite the promise of these results, more research is needed to examine whether these outcomes can be replicated in children and youths with anxiety and those with depression. In addition, it was not possible to determine the contribution of each component of the treatment (psychoeducation, relaxation, biofeedback) to the outcomes.

Limitations of this study include a small sample size and non-random assignment to groups, both of which threaten the generalisability of the study. It should be noted that the current sample was largely white, and that these results may not be applicable

to children and youths of different ethnic groups. Furthermore, possibly as a side effect of non-random assignment to groups, the intervention and comparison groups differed on pre-test total MASC scores. Because of this finding, statistical methods were used to account for these differences. Nonetheless, this difference may have threatened the internal validity of the study and the findings should be considered in this light. Future studies should use random assignment and other methods to ensure equivalence of the two groups at pre-test. Future studies would benefit from collecting and reporting more detailed information about medications and other medical or mental health treatment the youths in the study are receiving. Information also was not available about the participants' comorbid disorders or symptoms other than depression and anxiety. Future studies should gather this information so that more clear conclusions can be made about the generalisability and implications of the findings.

Implications

The results of this study suggest that game-based biofeedback may be useful in the treatment for anxiety and depressive symptoms in children and youths. Further longitudinal research utilising larger samples is needed to replicate these findings and to examine whether these changes last over time.

REFERENCES

1 Bosquet M and Egeland B. The development and maintenance of anxiety symptoms from infancy through adolescence in a longitudinal sample. *Development and Psychopathology* 2006;18:517–50.
2 Masi G, Favilla L, Millepiedi S *et al.* Somatic symptoms in children and adolescents referred for emotional and behavioral disorders. *Psychiatry* 2000;63(2):140–9.
3 Stansbury K and Harris ML. Individual differences in stress reactions during a peer entry episode: effects of age, temperament, approach behavior, and self-perceived peer competence. *Journal of Experimental Child Psychology* 2000;76(1): 50–63.
4 Fallin K, Wallinga C and Coleman M. Helping children cope with stress in the classroom setting. *Childhood Education* 2001;78(1):17–24.
5 Barlow DH. *Anxiety and its Disorders: the nature and treatment of anxiety and panic* (2e). Guilford Press: New York, 2002.
6 Chambless DL and Ollendick TH.Empirically supported psychological interventions: controversies and evidence. *Annual Review of Psychology* 2001; 52:685–716.
7 Weisz JR, Weiss B, Han SS *et al.* Effects of psychotherapy with children and adolescents revisited: a meta-analysis of treatment outcome studies. *Psychological Bulletin* 1995;117:450–68.
8 Compton SN, Burns BJ, Egger HL *et al.* Review of the evidence base for treatment of childhood psychopathology: Internalizing disorders. *Journal of Consulting and Clinical Psychology* 2002;70:1240–66.
9 Chorpita BF and Southam-Gerow M. Fears and anxieties. In: Mash EJ and Barkley A (eds), *Treatment of Child Disorders* (3e). Guilford Press: New York, pp. 271–335, 2006.
10 March JS, Franklin M and Foa E. Cognitive–behavioral psychotherapy for pediatric obsessive compulsive disorders. In: Hibbs ED and Jensen PD (eds), *Psychosocial Treatments for Child and Adolescent Disorders: empirically based strategies for clinical practice* (2e). American Psychological Association: Washington, DC, pp. 121–42, 2005.
11 Kahana SY and Feeny NC. Cognitive behavioral treatment of health-related anxiety in youth: a case example. *Cognitive and Behavioral Practice* 2005;12:290–300.
12 Muris P, Mayer B and Bervoets S. Listen to your heart beat and shiver! An experimental study of anxiety-related emotional reasoning in children. *Journal of Anxiety Disorders* 2010;24(6):612–17.
13 Lohaus A and Klein-Hessling J. Relaxation in children: Effects of extended and intensified training. *Psychology & Health* 2003;18(2):237–49.
14 Culbert TP and Banez GA. Pediatric applications other than headache. In: Schwartz MS and Andrasik F (eds), *Biofeedback: a practitioner's guide* (3e). Guilford Press: New York, pp. 696–726, 2003.
15 Wenck LS, Leu PW and D'Amato RC. Evaluating the efficacy of biofeedback intervention to reduce children's anxiety. *Journal of Clinical Psychology* 1996;52(4):469–73.
16 Yahav R and Cohen M. Evaluation of a cognitive-behavioral intervention for adolescents. *International Journal of Stress Management* 2008;15(2): 173–88.
17 Smith MS, Womack WM and Chen AC (1991) Anxiety and depression in the behavioral treatment of headache in children and adolescents. *International Journal of Adolescent Medicine and Health* 1991;5(1):17–35.
18 Bradley RT, McCraty R, Atkinson M *et al.* Emotion self-regulation, psychophysiological coherence, and test anxiety: results from an experiment using electrophysiological measures. *Applied Psychophysiology Biofeedback* 2010;35(4):261–83.
19 Culbert TP, Kajander RL and Reaney JB. Biofeedback with children and adolescents: clinical observations and patient perspectives. *Developmental and Behavioral Pediatrics* 1996;17(5):342–50.
20 Angold A and Costello E. Depressive comorbidity in children and adolescents: empirical, theoretical, and methodological issues. *The American Journal of Psychiatry* 1993;150(12):1779–91.
21 Biederman J, Faraon S, Mich E *et al.* Psychiatric comorbidity among referred juveniles with major depression: fact or artifact? *Journal of the American Academy of Child & Adolescent Psychiatry* 1995;34(5): 579–90.

22 Wadsworth ME, Hudziak JJ, Heath AC *et al*. Latent class analysis of Child Behavior Checklist anxiety/depression in children and adolescents. *Journal of the American Academy of Child & Adolescent Psychiatry* 2001;40(1):106–14.
23 Birmaher B, Ryan ND, Williamson DE *et al*. Childhood and adolescent depression: a review of the past 10 years, Part I. *Journal of the American Academy of Child & Adolescent Psychiatry* 1996;35:1427–39.
24 Masi G, Mucci M, Favilla L, Romano R and Poli P. Symptomatology and comorbidity of generalized anxiety disorder in children and adolescents. *Comprehensive Psychiatry* 1999;40(3):210–15.
25 Reinecke MA and Ginsburg GS. Cognitive-behavioral treatment of depression during childhood and adolescence. In: Abela JRZ and Hankin BL (eds) *Handbook of Depression in Children and Adolescents*. Guilford Press: New York, pp. 179–206, 2008.
26 Blom HE, Olsson E, Serlachius E *et al*. Heart rate variability (HRV) in adolescent females with anxiety disorders and major depressive disorder. *Acta Paediatrica* 2010;99:604–11
27 Ehrenreich JT, Goldstein CR, Wright L *et al*. Development of a unified protocol for the treatment of emotional disorders in youth. *Child and Family Behavior Therapy* 2009;31(1):20–37.
28 Karavida MK, Lehrer PM, Vaschillo E *et al*. Preliminary results of an open label study of heart rate variability biofeedback for the treatment of major depression. *Applied Psychophysiology Biofeedback* 2007;32:19–30.
29 Gentile DA and Walsh DA. A normative study of family media habits. *Journal of Applied Developmental Psychology* 2002;23:157–78.
30 Gentile DA, Lynch PL, Linder JR *et al*. The effects of violent video game habits on adolescent hostility, aggressive behaviors, and school performance. *Journal of Adolescence* 2004;27:5–22.
31 Kato PM. Video games in health care: Closing the gap. *Review of General Psychology* 2010;14:113–21.
32 Radkowski R, Huck W, Domik G and Holtmann M. Serious games for the therapy of the posttraumatic stress disorder of children and adolescents. *Virtual and Mixed Reality – Systems and Applications: Lecture Notes in Computer Science* 2011;6774:44–53.
33 Pop-Jordanova N and Gucev Z. Game-based peripheral biofeedback for stress assessment in children. *Pediatrics International* 2010;52:428–431.
34 Bell C. *The Journey to the Wild Divine: users manual*. The Wild Divine Project: Boulder, CO, 2003.
35 Amon KL and Campbell F. Can children with AD/HD learn relaxation and breathing techniques through biofeedback video games? *Australian Journal of Educational & Developmental Psychology* 2008;8: 72–84.
36 March MD. *Multidimensional Anxiety Scale for Children: technical manual*. Multi-Health Systems: North Tonawanda, NY, 1997.
37 Spielberger CD. *STAIC Preliminary Manual*. Consulting Psychologists Press: Palo Alto, CA, 1973.
38 Kovacs M and Multi-Health Systems Staff. *Children's Depression Inventory Technical Manual Update*. Multi-Health Systems: North Tonawanda, NY, 2003.
39 Nakao K and Treas J. Updating occupational prestige and socioeconomic scores: how the new measures measure up. In: Marsden P (ed) *Sociological Methodology*. American Sociological Association: Washington, DC, pp. 1–72, 1994.
40 March JS, Sullivan K and Parker J. Test–retest reliability of the multidimensional anxiety scale for children. *Journal of Anxiety Disorders* 1999;13(4): 349–58.
41 Kirisci L and Clark DB. *Reliability and validity of the State–Trait Anxiety Inventory for children in an adolescent sample: confirmatory factor analysis and item response theory*. Paper presented at the Annual Meeting of the American Educational Research Association: New York, 1996.
42 Childre D. *Freeze-Framer 2.0 Manual*. HeartMath: Boulder Creek, CA, 2005.
43 Westerink JH, Ouwerkerk M, Overbeek T *et al*. *Probing Experience: from assessment of user emotions and behaviour to development of products*. Springer Science: Dordrecht, The Netherlands, 2008.

ADDRESS FOR CORRESPONDENCE

M Knox, University of Toledo College of Medicine, Department of Psychiatry, 3130 Glendale Avenue, Toledo, OH 43614, USA. Tel: +1 419 383 3815; fax: +1 419 383 3289; email: michele.knox@utoledo.edu

Accepted November 2011

Appendix 1

Biofeedback-assisted relaxation training study protocol: treatment condition

Session #1

- Pre-test measures.
- Rate anxiety on 1–10 Visual Analogue Scale (VAS).
- Feelings that get in my way; What it means to feel 'upset'.
- Feelings are OK. We need a healthy way to deal with them.
- How the brain affects the body (favourite food example).
- When we are frustrated, scared, worried, angry or upset, our heart rhythms are irregular and uneven.
- Activity: How stress gets in my way.
- List: Things and situations that make me feel anxious or stressed.
- List/Draw: Where I notice tension in my body.
- What will be better in my life when stress is no longer getting in my way.
- Teach relaxation.
- Introduce Freeze-Framer and Wild Divine.
- Rate anxiety on VAS.

Session #2

- Rate anxiety on VAS.
- REVIEW:
  - Feelings are OK.
  - Need a healthy way to deal with them.
- REVIEW:
  - How to relax.
- REVIEW:
  - How the brain affects the body (favourite food example).
  - When we are frustrated, scared, worried, angry or upset, our heart rhythms are irregular and uneven.
- REVIEW:
  - Where I notice tension in my body.
- TEACH AND IDENTIFY:
  - Triggers of fear, worry, and insecurity.
  - Examples of thought triggers:
    (i) I'll never pass the test
    (ii) I'm so stupid/ugly/fat/clumsy/unpopular...
    (iii) I'll never get all this done
    (iv) I can't believe I said that. I am so...
    (v) I know I'll screw this up
    (vi) I can't ...
    (vii) Everybody thinks I'm....
- Continue with Freeze-Framer and Wild Divine.
- Rate anxiety on VAS.
- PLAN: When I will relax this week.

Session #3

- Rate anxiety on VAS.
- REVIEW:
  - How did relaxation at home go?
- How to relax.
- Modify relaxation plan if needed.
- Continue with Freeze-Framer and Wild Divine.
- Rate anxiety on VAS.
- PLAN: When I will relax this week.

Session #4

- Rate anxiety on VAS.
- REVIEW:
  – How did relaxation at home go?
- Modify relaxation plan if needed.
- Continue with Freeze-Framer and Wild Divine.
- Rate anxiety on VAS.
- PLAN: When I will relax this week.

Session #5

- Rate anxiety on VAS.
- REVIEW:
  – How did relaxation at home go?
- Modify relaxation plan if needed.
- Continue with Freeze-Framer and Wild Divine.
- Rate anxiety on VAS.
- PLAN: When I will relax this week.

Session #6

- Rate anxiety on VAS.
- REVIEW:
  – How did relaxation at home go?
- Modify relaxation plan if needed.
- Continue with Freeze-Framer and Wild Divine.
- Rate anxiety on VAS.
- PLAN: When I will relax this week.

Session #7

- Rate anxiety on VAS.
- REVIEW:
  – How did relaxation at home go?
- Modify relaxation plan if needed.
- Continue with Freeze-Framer and Wild Divine.
- Rate anxiety on VAS.
- Identifying additional triggers, plan for *in vivo* use.
- PLAN: When I will relax this week.

Session #8

- Rate anxiety on VAS.
- REVIEW:
  – How did relaxation at home go?
- Modify relaxation plan if needed.
- Continue with Freeze-Framer and Wild Divine.
- Rate anxiety on VAS.
- Review triggers to stress, more plans for *in vivo* use.
- PLAN: When I will relax this week.
- Post-test measures.
- Referral if needed.