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Neurofeedback Training and Cognitive Behavior Therapy for Treatment of Generalized Anxiety Disorder in Children and Adolescents: A Comparative Study

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Abstract

Introduction. The present study aimed to evaluate the effectiveness of neurofeedback (NF) and cognitive-behavioral therapy (CBT) on the reduction of anxiety symptoms in children and adolescents with generalized anxiety disorder. **Methods**. The current pseudo-experimental study with a pre–posttest design was conducted on a population of patients with a generalized anxiety disorder (GAD) referring to the child psychiatry clinic in Alexandria's University Hospital, Egypt. The sample size comprised of 30 children and adolescents selected by random sampling method and assigned to groups of NF and CBT. Data elicited from the State-Trait Anxiety Inventory (STAI), which is a self-report scale for measuring two distinct anxiety concepts. Data were analyzed with SPSS. Student *t*-test was performed on CBT and NF groups. **Results**. The current study showed that both CBT and NF are effective in reducing the level of anxiety in the study subjects with no significant differences between the two groups. The obtained results also showed that NF therapy is an effective method with more improvement on state anxiety score, while CBT showed more improvement in trait anxiety score. **Conclusion**. Both treatments were significantly effective, and therefore neurofeedback training can be effectively used as a treatment approach for children and adolescents with GAD.

Keywords: generalized anxiety disorder; cognitive behavioral therapy; neurofeedback; State-Trait Anxiety Inventory; children and adolescents

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Introduction

Anxiety represents the most common category of psychiatric disorders in children and adolescents, constituting the main reason children and their families seek specialty mental health services. The majority of children experience stress periodically within their lifespan. This stress is related to family and academic demands, combined with changing developmental and social pressures, which makes the environment in which effective functioning may be difficult.

Epidemiological studies estimate the prevalence of anxiety disorders in youth to be between 2.2% and 9.5%, with generalized anxiety disorder (GAD) and separation anxiety disorder (SAD) being the most common (Merikangas, 2009).

Generalized anxiety disorder is one of the commonly diagnosed types of anxiety disorders, characterized by chronic worrying that can occur every day and for extended periods, affecting approximately one in eight children over a lifetime. Children with GAD express worry about daily performance, and the focus of the worry may shift from topic to topic. The

anxiety affects their ability to complete tasks or enjoy activities and may be accompanied by difficulties falling or staying asleep, fatigue, trouble with concentration, muscle tension, or irritability (American Psychiatric Association, 2013).

Childhood anxiety disorders have been found to associate with several adolescent mental health issues. In one prospective study, children who suffer from GAD are at risk to develop conduct disorder during adolescence. Also, childhood-onset anxiety disorders have been found to have a role in psychopathology of personality disorders in young adulthood, along with significantly increased suicidal behaviors. Furthermore, young adults with a history of childhood anxiety have increased rates of drug abuse, suicide attempts, utilization of health services, and employment issues compared to controls (Rudd, 2004; Weissman, 1999).

The literature review supported the application of cognitive-behavioral therapy (CBT) in children and adolescents with anxiety disorders and found that this treatment can reduce anxiety in such patients. Therefore, the current study results were consistent with such findings (Higa-McMillan et al., 2016; James et al., 2013; Reynolds, et al., 2012).

Kendall (1994) investigated the efficacy of CBT for 47 children (9–13 years) with generalized anxiety and separation anxiety disorders. The cognitive-behavioral therapy was compared with a wait-list condition. Posttreatment result was evaluated using child self-report, parent report, and behavioral observations. Also, the maintenance of gains at 1-year follow-up was examined. Results revealed that 64% of those treated no longer met diagnostic criteria. Of the subjects in the wait-list condition, only one did not qualify for an anxiety disorder diagnosis after the waiting period (Kendall, 1994).

The studies by Fisak et al. and Mychailyszyn et al. showed that programs based on CBT are among the most effective current approaches for the prevention of anxiety in children and adolescents (Fisak et al., 2011; Mychailyszyn et al., 2012).

The American Academy of Child and Adolescent Psychiatry has risen to this challenge by developing and disseminating evidence-based treatment guidelines for childhood anxiety. These practice parameters acknowledge CBT as the most studied and empirically supported type of psychotherapy for anxious youth. Furthermore, these guidelines recommend CBT as a first-line treatment for children and adolescents with mild to moderate anxiety (Connolly et al., 2007).

Drawing from a cognitive framework, the CBT model posits that thoughts affect beliefs, which affect corresponding emotions and behaviors. Therefore, CBT aims to correct distorted beliefs and learning patterns that develop emotional and behavioral disturbances (Seligman et al., 2011).

In general, CBT calls for a structured therapeutic approach, with didactic sessions, brief windows of intervention, and homework assignments. The core components of CBT programs are cognitive restructuring; skills-building that can include mindfulness, social skills, assertiveness, problem-solving techniques, self-reinforcement and reward; and exposure training. The strategy of exposure typically involves a child's real or imagined confrontation gradually with anxiety-producing stimuli and then working with the child to combat the anxiety with a variety of coping skills (Lyneham, 2005).

In the late 1960s, research established that it was possible to recondition and retrain brainwave patterns. This brainwave training is called EEG biofeedback or neurofeedback (NF; Hammond, 2011; Kamiya, 2011; Sterman et al., 2010).

There are two learning paradigms involved in neurofeedback, these are operant and classical conditioning. Operant conditioning occurs when the child is rewarded for finding a targeted brainwave state with a visual or auditory reward. It is worth noting that the brain is inherently motivated to seek pleasure and although initial attempts at finding the desired brainwave state may be awkward and sometimes frustrating, with the continued effort the brain will succeed, and the new brainwave response will be strengthened until it becomes automatic. While classical conditioning in neurofeedback occurs when the desired brainwave state is paired with another behavior, such as calm focus during an athletic performance or cognitive activation during an academic task. By pairing the desired brainwave response with a specific behavior, the child is better able to optimize his or her performance (Skinner, 2021; Turner, 2016).

Neurofeedback as a clinical approach to the resolution of psychological and behavioral problems has it is origin in the study of the brain's electrical activity and behavioral psychology. The development of the human electroencephalogram (EEG) combined with the application of principles of

learning, knowledge of the brain's neuroplasticity, and principles of biofeedback and self-regulation have made it possible to detect, monitor, and change the brain's electrical activity related to many emotional and physiological disorders. More recent advances in electronic technology have allowed these research discoveries to be readily applied to the clinical setting (Turner, 2016).

The successful use of neurofeedback training has been established with numerous adults (Dadashi et al., 2015; Hardt et al., 1978; Plotkin et al., 1981) and small groups of children with anxiety disorders. Therefore, more studies are still needed to evaluate its effectiveness. In this study, we examine the effectiveness of neurofeedback training in the treatment of anxiety disorders in children and adolescents by comparing it with cognitive behavior therapy.

Material and Methods

Participants

The present study was conducted on children and adolescents who met the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; DSM-5; APA, 2013) criteria of GAD and were attending child psychiatry clinics at El Hadara Alexandria University Hospital, Egypt.

All children and adolescents suffering from GAD attending the selected clinic who met inclusion criteria (Table 1) were invited to participate. After obtaining ethical clearance from the Ethical Committee faculty of medicine, Alexandria University, then obtained informed written consent from participants and their caregivers. First, they were informed that the study was about GAD and its treatment. Then, they were informed about the aims of the study and their right to refuse giving information as well as their right not to participate or end their participation in any stage of the treatment process.

The sample comprised of 30 participants in the age range of 7–17 years, who were selected by random sampling method and assigned to group A for neurofeedback training and group B for cognitive behavior therapy (CBT), such that each group was comprised of 15 participants. The mean age of the NF group was 12.13 ± 2.69 years (12 male and 3 females) while the mean age of the CBT group was 10.80 ± 1.52 years (7 males and 8 females).

Table 1
A Summary of the Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
• Both genders • Age 7–17 years old • Average or above age-related reading ability • DSM-5 diagnostic criteria of generalized anxiety disorder (GAD) • Intact sensory system • Informed written consent from the caregiver and assent from the child	• Previous head injury, or neurological disorders and treatment with medications known to influence EEG, such as tranquilizers • Intellectual disability • Substance abuse • Psychiatric disorders other than anxiety disorders • Absence of more than two sessions in the treatment process

Procedure

All studied sample was subjected to structured interviews using a predesigned questionnaire to collect the following data: sociodemographic details; developmental, education, social, past psychiatric and medical history; drug history, in addition to family psychiatric and medical history; and finally mental status examination.

Baseline assessments were conducted using the State-Trait Anxiety Inventory for Children (STAI-C) while adolescents ≥ 12 years old received State-Trait Anxiety Inventory (adult form; STAI). To examine the posttraining effect, the same baseline assessments were readministered immediately after the completion of the therapy sessions for both groups.

The State-Trait Anxiety Inventory for Children (STAI-C). It consists of separate, self-report questionnaires for assessing two distinct anxiety concepts: state anxiety and trait anxiety. The STAIC State-Anxiety scale consists of 20 statements that ask children how they feel at a specified moment in time. The STAIC Trait-Anxiety scale also consists of 20 item statements that measure relatively stable individual differences in anxiety proneness; that is, differences between children in the tendency to experience anxiety states. Individual STAI-C items are similar in content to those included in the STAI, but the format for responding to the STAI-C has been simplified to facilitate its use with young children. Also, the adult form is a 4-point scale while the child version is a 3-point scale (Spielberger et al., 1973; Spielberger et al., 1983).

Neurofeedback Training Group (A). All participants in this group were subjected to a quantitative electroencephalogram (qEEG) study. The EEG was conducted in a dimly lit, sound-attenuated room while the patient was seated comfortably. The total recording time was 40 minutes, then the raw EEG was reviewed to be sure of the absence of any abnormal or epileptogenic discharges then through NeuroGuide software (Applied Neuroscience, Inc., St. Petersburg, FL) that analyze the data quantitively then compare it with a normative database through which could be detected the electric frequency interval with an abnormal amplitude that needs to be trained depend on the absolute power, relative power, and *Z* score power ratio (Collura et al., 2016).

According to qEEG studies for the participants, the target frequency bands for training were reduced high beta in six candidates, enhanced alpha in four, enhanced sensorimotor rhythm in two, enhanced both alpha and sensorimotor rhythm in two, while only one candidate combined enhanced alpha and reduced high beta (Table 2, Figure 1, Figure 2).

Table 2

A Summary of the Target Frequency Bands According to qEEG Studies for the Participants

Target Frequency Band	Number of Candidates
Reduced high beta	6
Enhanced alpha	4
Enhanced sensorimotor rhythm (SMR)	2
Enhanced alpha and sensorimotor rhythm (SMR)	2
Enhanced alpha and reduced high beta	1

Figure 1. *qEEG Brain Mapping Shows a Decrease in Both 11–12 Hz (High Alpha) and 13–15 Hz Activity (Sensorimotor Rhythm) at Cz (Blue-colored Areas).*

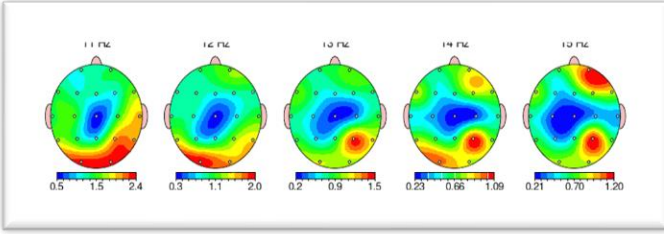
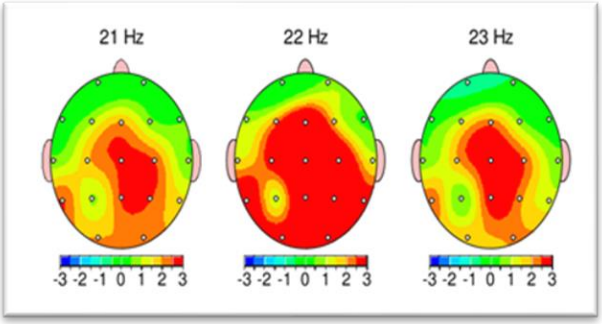


Figure 2. *qEEG Brain Mapping Shows an Increase in 21–23 Hz Activity (High Beta) at Cz (Red-colored Areas).*



***Neurofeedback Training Sessions*.** According to the international 10/20 system, to record the activity of electrical waves, the active electrode located at the selected area and two electrodes of reference and ground were placed on the left and right mastoid process, while the patient is sitting in a comfortable chair with eyes open in front of the screen. Each patient attended 20 neurofeedback sessions for training the selected brain waves amplitude twice weekly (Demos, 2005).

All of the neurofeedback sessions were arranged to follow 5 min devoted to the attainment of preparatory relaxation, 2 min devoted to recording EEG baseline data, then 30 min devoted to the training process.

The NeXus-10 MKII device with BioTrace+ software (Mind Media, Netherlands) was used. NeXus-10 and BioTrace+ are highly customizable platforms with a wide range of powerful tools for physiological research and signal processing.

Cognitive Behavior Therapy Group (B). The cognitive-behavioral therapy was applied in the current study according to the Cognitive-Behavioral Therapy for Childhood Anxiety Disorders that was designed by Bruce F. Chorpita.

Each candidate in this group was subjected to 8–12 individual sessions, with each session 50–90 minutes on a weekly basis. Parents are involved in the child-focused (individual treatment) program and meet in sessions 1, 4, and 8, as well as in other sessions as needed for the exposure tasks (Chorpita, 2007).

***Cognitive Behavior Therapy Sessions*.** The CBT protocol is presented in Table 3.

Table 3
Description of Cognitive-Behavioral Therapy Sessions

Session	Goals
1	Building rapport, treatment orientation, and the first parent meeting
2	Learning to relax by teaching relaxation exercises
3	Identifying anxious feelings, self-talk, and learning to challenge thoughts
4	Introducing problem-solving, self-evaluation, and self-reward
5	Reviewing skills already learned, practicing in low anxiety-provoking situations, and the second parent meeting
6–7	Practicing with increasingly anxiety-provoking situations
8	Practicing in high-anxiety situations, the third parent meeting, and celebrating success

***Data Analysis*.** Data were entered and checked using IBM SPSS software package version 20.0**.**

Qualitative data were presented using absolute and relative frequency. Quantitative data were tested for normality using the Shapiro Wilk test (Shapiro & Wilk, 1965). Data were normally distributed so presented as a range, mean and standard deviation.

Comparison between the two intervention groups was done using the Student *t*-test for quantitative variables and the chi-square test for the qualitative variable. Paired comparison within each intervention group (before and after comparison) regarding quantitative variables was conducted using paired *t*-test.

Percent of improvement regarding anxiety scores after intervention was calculated as follows: Percent improvement = {(pretreatment score − posttreatment score) / pretreatment score} * 100

Analysis was carried out at a 5% level of significance.

Results

The Effect of Neurofeedback Training on Trait-Anxiety Score and State-Anxiety Score

Table 4 illustrates there was a significant difference in Trait-Anxiety scores and State-Anxiety scores before and after neurofeedback training.

Regarding the percentage of improvement, NF training showed a 21.5% improvement in Trait-Anxiety score while 25.6% for State-Anxiety score. Thus, the obtained results showed that NF therapy caused the reduction of anxiety symptoms in children and adolescents with GAD with more improvement on the State- than Trait-Anxiety score.

Table 4
Results of t-Test for Neurofeedback Treatment

	Pretest	Posttest	Percentage of Improvement %	Paired Comparison
Trait-Anxiety Score				
Min-Max	29–62	21–49	0–36.84	$t = 6.955$ $p < .001$*
Mean ± *SD*	47.40 ± 8.36	37.26 ± 8.21	21.45 ± 10.99	
Median (IQR)	47 (44–52)	39 (32–43)	20.97 (15.21–29.79)	
State-Anxiety Score				
Min-Max	24–59	20–46	3.45–51.02	$t = 5.981$ $p < .001$*
Mean ± *SD*	41.20 ± 10.58	30.06 ± 8.26	25.63 ± 14.42	
Median (IQR)	41 (33–49)	30 (23–35)	23.73 (16.36–33.33)	

The Effect of Cognitive Behavior Therapy on Trait-Anxiety Score and State-Anxiety Score

Table 5 illustrates there was a significant difference in Trait-Anxiety scores and State-Anxiety scores before and after cognitive behavior therapy.

The mean difference between pretest–posttest of State-Anxiety score in CBT group was 39.04, while for Trait-Anxiety score was 13.4, and based on these results the difference was significant ($p < .05$), which confirms that cognitive behavior therapy had a significant impact on generalized anxiety symptoms reduction in children and adolescents.

Regarding the percentage of improvement, CBT showed 28.9% improvement in Trait-Anxiety score while 21% for State-Anxiety score, with more improvement in Trait-Anxiety than in State-Anxiety scores.

Table 5

Results of t-Test for Cognitive Behavior Treatment

	Pretest	Posttest	Percentage of Improvement %	Paired Comparison
Trait-Anxiety Score				
Min-Max	39–62	25–51	12.20–48.98	$t = 8.942$ $p < .001$*
Mean ± *SD*	46.6 ± 6.66	33.20 ± 8.31	28.99 ± 12.47	
Median (IQR)	46 (41–49)	31 (26–37)	35.00 (15.90–35.00)	
State-Anxiety Score				
Min-Max	26–50	20–44	5.88–47.50	$t = 5.223$ $p < .001$*
Mean ± *SD*	67.24 ± 7.34	28.20 ± 7.09	21.07 ± 7.14	
Median (IQR)	34 (31–40)	37 (32–49.75)	22.00 (7.14–29.41)	

Comparison Between the Two Intervention Groups Regarding Trait-Anxiety Scores, State-Anxiety Scores, and Percentage of Improvement

Table 6 illustrates that comparing CBT and NF therapy groups, revealed no significant differences in reducing anxiety symptoms as regard trait anxiety score and state anxiety score between the two studied groups, which mean that NF therapy is as effective as CBT in reducing anxiety symptoms.

Table 6

Results of Compare CBT and Neurofeedback Treatment

	Type of Intervention			
	NFB ($n = 15$) Mean ± *SD*	CBT ($n = 15$) Mean ± *SD*	Test of Significance	*p* Value
Trait-Anxiety Score				
Pre-test	47.40 ± 8.36	46.60 ± 6.66	$t = 0.290$	0.774
Post-test	37.26 ± 8.21	33.20 ± 8.31	$t = 1.349$	0.188
% Improvement	21.45 ± 10.99	28.99 ± 12.47	$t = -1.757$	0.090
State-Anxiety Score				
Pre-test	41.20 ± 10.58	36.00 ± 7.52	$t = 1.552$	0.132
Post-test	30.06 ± 8.26	28.20 ± 7.09	$t = 0.664$	0.512
% Improvement	25.63 ± 14.42	21.07 ± 7.14	$t = 0.881$	0.386

Figure 3 shows the mean Trait-Anxiety score with error bars representing 95% CI among the two intervention groups. The 95% confidence interval (CI) of the mean shows no statistically significant difference between both studied groups regarding the pretest as well as the posttest a trait anxiety score.

Figure 3. *Mean of Trait-Anxiety Score Among the Two Studied Groups Before and After the Therapy.*

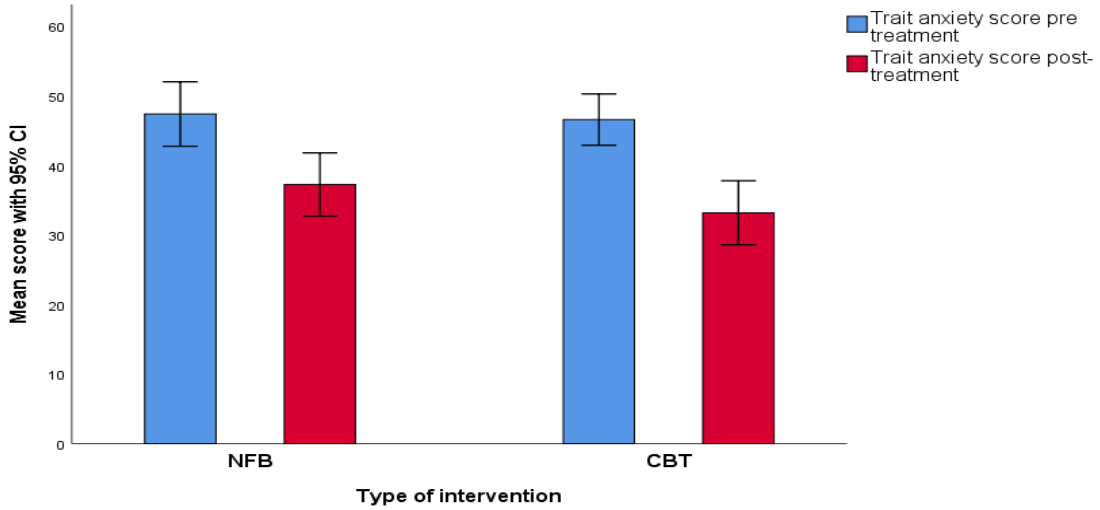
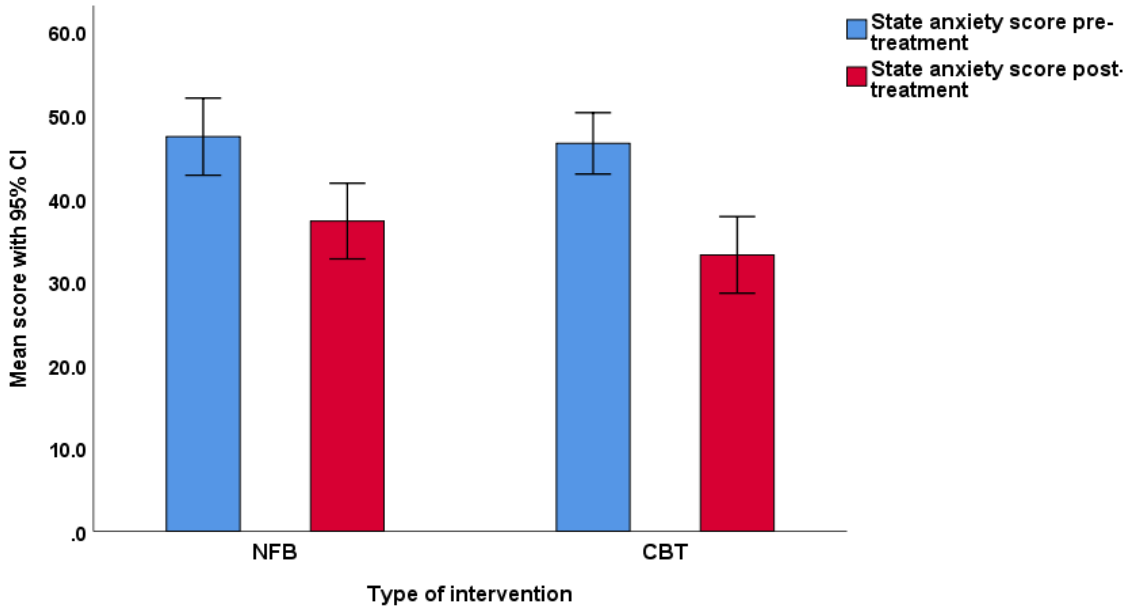


Figure 4 shows the mean State-Anxiety score with error bars representing 95% CI among the two intervention groups. The 95% CI of the mean shows no statistically significant difference between both studied groups regarding the pretest as well as the posttest State-Anxiety score.

Figure 4. *Mean of State-Anxiety Score Among the Two Studied Groups Before and After the Therapy.*



Discussion

Anxiety can affect one's everyday life and may contribute to psychological and physical well-being. The present study examined the effectiveness of neurofeedback training on reducing anxiety symptoms among children and adolescents with GAD. The result showed both CBT and NF were effective methods for reducing anxiety symptoms, but the application of neurofeedback training compared with cognitive behavior therapy did not show significant differences to reduce anxiety. This result showed that neurofeedback training may be a promising treatment for anxiety-related disorders.

Various biofeedback modalities have been implemented by clinicians before neurofeedback emerged in the treatment of anxiety such as electromyography (EMG), peripheral temperature, and electrodermal response (EDR; Price & Budzynski, 2009). NF, an EEG biofeedback, is a method of self-regulation that depends on a brain–computer interface to promote neural plasticity, by providing feedback to an individual about their brain's electrical activity at a certain location in a specified frequency band (Cannon, 2015). NF therapy makes the human brain learn to relax.

NF has been used to lower anxiety symptoms in a variety of populations. However, according to the available information, practitioners are focusing on using NF with the adult population, with few studies on children with anxiety disorders. Regarding neurofeedback therapy in adults with GAD, the studies showed positive effects on the reduction of anxiety symptoms which were consistent with those of the current study. Below are some examples.

Dadashi et al. (2015) conducted a study on 28 adult patients with ages between 18–50 divided into two groups; 14 subjects were assigned to the neurofeedback treatment group and 14 subjects in the waiting list group. The results showed that enhancement of alpha and theta brain waves amplitude in people with GAD in the occipital area can reduce symptoms of GAD and increase the global functioning level in a treatment group, but no such change was observed in the wait-list group (Dadashi et al, 2015).

The study by Hardt and Kamiya showed alpha-enhancement reduced both state and trait anxiety in high trait-anxiety subjects, suggesting it would benefit anxious patients (Hardt & Kamiya, 1978). Rice et al. (1993) suggested EMG and EEG alpha-increased feedback showed the positive effects on reduction of generalized anxiety symptoms, the improvements in anxiety were maintained 6 weeks after treatment, and the only alpha increase resulted in reductions of heart rate reactivity to stress (Rice, Blanchard, & Purcell, 1993).

Although neurofeedback studies of children and adolescents with anxiety disorders are limited, the available studies suggest that neurofeedback training is an effective method in reducing anxiety symptoms in this age group which is consistent with those of the current study. Below are some examples.

Sadjadi and Hashemian conducted a study to find out the effect of neurofeedback therapy in children with a separation anxiety disorder. The study population was school-age children from 7 to 12 years old with separation anxiety disorder, and they were assigned randomly into two groups. One group received neurofeedback therapy and the other group received sham neurofeedback therapy. Each group included 12 participants. Each child had 20 sessions, and each session was about 30 minutes in duration. The children are trained to enhance the ratio of alpha/theta in F3 throughout the 20 sessions. Results showed that neurofeedback was effective in reducing separation anxiety and the efficacy of treatment was great compared with the placebo group (Sadjadi, & Hashemian, 2014).

Éismont, Lutsyuk, and Pavlenko (2011) implemented a study to estimate the efficacy of using neurofeedback training for reducing increased anxiety levels in healthy 10- to 14-year-old children. Thirty-minute-long NF sessions were performed twice per week. The results showed significant enhancement in the ratios of the amplitudes of alpha and theta rhythms, sensorimotor and theta rhythms in tested persons of the experimental group which associated with the anxiety level decreased appreciably; in addition, the indices "feeling of inferiority" and "frustration" decreased significantly, while in the control group, changes in these values did not reach the significance level (Éismontet al., 2011).

All previously mentioned studies illustrate how NF can be a viable tool in lowering anxiety symptoms. They each have their strengths and limitations. A substantial limitation is either using the same protocol for each patient or using a protocol based on symptoms alone. Protocols based on symptoms alone or using the same protocol for each patient bypasses the time, cost, and training of running a qEEG (Thompson & Thompson, 2003). In our study,

the training protocol is not the same for all participants in the neurofeedback group. It is unreasonable to expect a one-size-fits-all approach in neurofeedback training as the brain is complex and different for everyone, so we depend on the more accurate method which is quantitative encephalogram (qEEG) to determine the target frequency band which was agreed with Hammond (Hammond, 2011) who expresses the importance of using a qEEG to identify heterogeneity in brain wave patterns, finding comorbidities, and looking for effects from medication.

Interestingly, the protocols selected in our study, based on individualized qEEG include enhanced alpha, enhanced SMR, reduced high beta, or combined between them, reflected markers already found to be associated with anxiety symptoms in literature (Hammond, 2005; Wiedemann et al., 1999)

Krigbaum and Wigton proposed the importance of qEEG guided neurofeedback as it allows the clinician to develop a more individualized treatment plan which depends on a qEEG baseline, and clinical status of the client (Wigton & Krigbaum, 2015). A study by Dreis et al. assessed 14 clients for anxiety spectrum disorders with age ranges from 11–61 years old, nine male and five female. Thirty-minute-long qEEG-guided NF treatment sessions were performed twice per week. Results showed enhancement in clients' well-being as evidenced by statistically significant improvement in symptom measures scores (Dreis et al., 2015).

In the last decade, despite an increase in the number of publications regarding neurofeedback for anxiety disorders, little attention has been paid to compare its effectiveness with established treatment methods such as CBT which consider the main behavior approach to anxiety disorders. The current study considers a step to cover this point especially in the children and adolescent population.

Limitations and Future Perspectives

There were some limitations to the current study including the small sample size. The small sample size may affect the statistical power to distinguish the efficacy of neurofeedback training. Thus, a larger sample size with an appropriate effect size is warranted. Another limitation of the present study was the problem of the absence of a placebo treatment group (placebo) such as a wait-list, which means that we cannot be sure that the improvement in anxiety symptoms was any greater than without intervention at all. This problem is due to the limitations of the sample and ethical concerns.

To conclude, the findings suggested that neurofeedback training can be effectively used as a part of a multimodal treatment approach of generalized anxiety disorders in children and adolescents. The present study also holds an implication for using different qEEG-based protocols to reduce anxiety symptoms such as alpha enhancement, sensorimotor enhancement, reduced high beta, or combined between them. Finally, further studies are now needed to pinpoint the longevity of neurofeedback training gains on anxiety symptoms across time and to understand the interindividual differences in the improvement of symptoms, self-regulation, and learning process.

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