

The effectiveness of Neurofeedback as computer based programs for children with Attention Deficient Hyperactivity Disorder

مدي فاعلية النيروفيدباك كبرامج قائمة على تقنية الكمبيوتر لأطفال فرط الحركة وتشتت الانتباه

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المستخلص :

تهدف الى اثبات فعالية النيروفيدباك (البرامج المستندة إلى الكمبيوتر) كعلاج مساعد للأطفال ذوي اضطراب فرط الحركة ونقص الانتباه . ويعد اضطراب فرط الحركة ونقص الانتباه ، حالة تطورية من عدم الانتباه والتشتت ، مع أو بدون فرط النشاط المصاحب، وهناك ثلاث أشكال أساسية من اضطراب فرط الحركة ونقص الانتباه الموصوفة في الدليل التشخيصي والأحصائي (DSM-5) للجمعية الأمريكية للطب النفسي وهي إما عدم الانتباه ، أو فرط الحركة / الأندفاعية ، وإما يجمع ما بين فرط الحركة ونقص الانتباه. إن مسببات اضطراب فرط الحركة ونقص الانتباه غير معروفة ولكن يمكن تفسيرها إلى حد كبير على العوامل الوراثية ، والبيئية الوراثية ، كما إن الآباء والأمهات والأشقاء من الأطفال الذين يعانون فرط الحركة ونقص الانتباه هم أكثر عرضة للأصابة بالاضطراب بمعدل مرتين إلى ثمان اضعاف عن غيرهم، مما يشير إلى المساهمات الوراثية ، كما توجد فرضيات اخرى ترجع هذا الاضطراب إلى تعرض الرحم للمواد السامة ، أو المواد

الصناعية ، أو التعرض للحساسية، ولكن النظام الغذائي والسكر ليس سببا من اسباب النشاط الزائد وتشتت الانتباه. الدراسة الحالية عبارة عن دراسة تجريبية أجريت على ١٠ أطفال بمركز رايت واي الطبي لذوى الاحتياجات الخاصة فى محافظة الأسكندرية بجمهورية مصر العربية ، ومن خلال التقييم النفسى الموحد تم تشخيصهم على أنهم ADHD وفقا DSM – V وتم تقسيم العينة النى شملتهم الدراسة إلى مجموعتين رئيسيتين : ٥ أطفال ADHD يخضعون لجلسات النيروفيدباك كمجموعة تجريبية ، و٥ أطفال يخضعون لجلسات العلاج السلوكى كمجموعة ضابطة . وأكدت النتائج أنه تم إعطاء أطفال المجموعة التجريبية (٥) أطفال من ذوى فرط الحركة ونقص الانتباه (١٢) جلسة من جلسات النيروفيدباك وتم تطبيق اختبار كورنر - قبل / وبعد الجلسات حيث أظهرت قيمة $p = 0.98$ مع عدم وجود دلالة أحصائية. وتم إعطاء أطفال المجموعة الضابطة (٥) أطفال من ذوى فرط الحركة ونقص الانتباه (١٢) جلسة من جلسات العلاج السلوكى حيث كانت قيمة $p = 0.98$ مع عدم وجود دلالة أحصائية. وتم قياس موجات ثيتا / بيتا لأطفال المجموعة التجريبية (٥) أطفال قبل / بعد تطبيق جلسات النيروفيدباك بواقع (١٢) جلسة حيث كانت قيمة $p = 0.97$ مع عدم وجود دلالة أحصائية.

Introduction

Attention deficit hyperactivity disorder (ADHD) is a developmental condition of inattention and distractibility, with or without accompanying hyperactivity. There are 3 basic forms of ADHD described in the *Diagnostic and Statistical Manual, Fifth Edition (DSM-5)* of the American Psychiatric Association are : (1) predominantly inattentive, (2) predominantly hyperactive/impulsive, and (3) combined.

El-Gendy et al, 2017 revealed the prevalence of ADHD among primary school children in Egypt (Qalubia) was 21.8% based on the teacher rating scale and 16.2% based on the parent rating scale which was higher than the previous estimated prevalence of ADHD in primary school children.

Prevalence of ADHD among school children in Menoufia governorate, Egypt, was 6.9%. ADHD is associated with many risk factors either such as *consanguinity*, antenatal illness, antenatal drug

use, abnormality at birth, large family size, family history of psychiatric or medical illness, and sex.

The etiology of ADHD is unknown and can be explained to great extent to genetics environmental & personal factors. Parents and siblings of children with ADHD are 2-8 times more likely to develop ADHD than the general population, suggesting that ADHD is a highly familial disease. A study noted that ADHD had a 0.8 degree of inheritability and 80% of phenotypic variance could be attributed to genetics. Studies of cognitive deficits reveal another facet to the genetic contributions to ADHD . A family environment may exacerbate symptoms as exposure to second-hand smoke in the home is associated with a higher frequency of mental disorder among children. Although there remains much evidence for the genetic etiology of ADHD, one study indicated that the contribution of personality aspects in combination with genetics may be significant. Specifically, the presence of high neuroticism and low conscientiousness in conjunction with genetic vulnerability may constitute a risk factor in the expression of ADHD.

NFB science is attracting as a method to self-regulate one's own brain activity to directly alter the underlying neural mechanisms of both cognition and behavior. It does not only promise new avenues as a method for cognitive enhancement in healthy subjects, but also as a therapeutic tool. It is considered a comprehensive type of training therapy promoting growth and change at the brain's cellular level, taking science out of the laboratory into the hands of private health professionals. Neurofeedback, formerly called electroencephalographic (EEG) biofeedback) , is an intervention for ADHD based on findings that many individuals with ADHD show low levels of arousal in frontal brain areas, with excess of theta waves and deficit of beta waves

The principle of NF is that over time, participants learn operant control of their EEG and change from an ___abnormal___ state to one

resembling that of typically developing children. This process is thought to eventually remediate the symptoms associated with ADHD. Case studies and controlled-group studies of EEG biofeedback have demonstrated beneficial effects on measures.

of intelligence, behavioral rating scales assessing the frequency of the core symptoms of ADHD for theta/beta training.

This research tests a modern safe therapeutic tool (Neurofeedback technique) to improve symptoms of ADHD as well as enhance peak performance in normal children.

Aim of the Study:

Attention deficit hyperactivity disorder (ADHD) is an important global public health challenge that must be addressed. Early diagnosis and effective treatment will affect optimal growth and development of the child a trying to reduce disability later on. The Neurofeedback: another non- pharmaceutical and non-invasive approach aiming at the reduction of ADHD symptoms and can be added to the behavioral therapy to ADHD children with limiting the use of medication.

Review of Literature

Attention deficit hyperactivity disorder (ADHD) is neurodevelopmental disorder It is characterized by difficulty paying attention, excessive activity and acting without regards to consequences, which are otherwise not appropriate for a person's age. There are also often problems with regulating emotions.

El-Gendy et al, 2017 revealed the prevalence of ADHD among primary school children in Egypt (Qalubia) was 21.8% based on the teacher rating scale and 16.2% based on the parent rating scale which was higher than the previous estimated prevalence of ADHD in primary school children. In other African countries, such as South Africa, Democratic Republic of Congo, or Ethiopia, the prevalence of ADHD has been reported to vary from 5.4% to 8.7% among school children. However, children with possible organic brain pathology

have been reported to have a prevalence of ADHD of 45.5–100% .The Nigerian studies that have been published report a prevalence of ADHD of 7.6% . Saudi Arabian primary schools is reported to be as low as 2.7%, while that in Iran is reported to be as high as 13% .with a predominance of the hyperactive- impulsive type. In South America, the prevalence of ADHD in children is about 6%, while in the USA it is as high as 16% . In Germany, ADHD has been reported with a prevalence of 4.8%, while Ukraine has reported the highest incidence of ADHD to be 19% . Worldwide, the prevalence of ADHD is between 5.29% and 7.1% .

Despite being the most commonly studied and diagnosed mental disorder in children and adolescents, the exact cause is unknown in the majority of cases. Genetic factors are estimated to make up about 75% of the risk.¹ Nicotine exposure during pregnancy may be an environmental risk. It does not appear to be related to the style of parenting or discipline. As of 2015 it is estimated to affect about 51.1 million people globally. Rates are similar between countries and depend mostly on how it is diagnosed. ADHD is diagnosed approximately two times more often in boys than in girls, although the disorder is often overlooked in girls because their symptoms differ from those of boys. About 30–50% of people diagnosed in childhood continue to have symptoms into adulthoodHYPERLINK

"https://en.wikipedia.org/wiki/Adult_attention_deficit_hyperactivity_disorder" and between 2–5% of adults have the condition.

Diagnosis &Subtypes

Based on the DSM- V criteria, there are three sub-types of ADHD:

- ADHD predominantly inattentiveHYPERLINK "https://en.wikipedia.org/wiki/ADHD_prem dominantly_inattentive" type (ADHD-PI) presents with symptoms including being easily distracted, forgetful, daydreaming, disorganization, poor concentration, and difficulty completing tasks.

- ADHD, predominantly hyperactive-impulsive type presents with excessive fidgetiness and restlessness, hyperactivity, difficulty waiting and remaining seated, immature behavior; destructive behaviors may also be present.
- ADHD, combined type is a combination of the first two subtypes. This subdivision is based on presence of at least six out of nine long-term (lasting at least six months) symptoms of inattention, hyperactivity–impulsivity, or both. The symptoms must have appeared by the age of six to twelve and occur in more than one environment (e.g. at home and at school or work). The symptoms must be inappropriate [HYPERLINK "https://en.wikipedia.org/wiki/Age-inappropriate"](https://en.wikipedia.org/wiki/Age-inappropriate) for a child of that age and there must be clear evidence that they are causing social, school or work related problems. ADHD of all ages are more likely to have problems with social skills, such as social interaction and forming and maintaining friendships. About half of children and adolescents with ADHD experience social rejection by their peers compared to 10–15% of non-ADHD children and adolescents. People with attention deficits are prone to having difficulty processing verbal and nonverbal language which can negatively affect social interaction. They also may drift off during conversations, miss social cues, and have trouble learning social skills. Difficulties managing anger are more common in children with ADHD as are poor handwriting [HYPERLINK "https://en.wikipedia.org/wiki/Handwriting"](https://en.wikipedia.org/wiki/Handwriting) and delays in speech, language [HYPERLINK "https://en.wikipedia.org/wiki/Communication_disorder"](https://en.wikipedia.org/wiki/Communication_disorder) and motor development.

ADHD symptoms ^[50]	
Inattention	Hyperactivity-impulsivity
<ul style="list-style-type: none"> • difficulty paying close attention to details • has trouble holding attention on tasks • has trouble organizing tasks and activities • loses things necessary for tasks • appears forgetful in daily activities • has a shorter attention span and is easily distracted • difficulty with structured schoolwork • difficulty completing tasks that are tedious or time-consuming 	<ul style="list-style-type: none"> • unable to sit still • fidgets, squirms in seat • leaves seat in inappropriate situations • takes risks with little thought for the dangers • "on the go" or "driven by a motor" • talking more than others • often answers quickly • has trouble waiting their turn • interrupts or intrudes on conversations

Differential diagnosis

Symptoms of ADHD, such as low mood and poor self-image, mood swings, and irritability, can be confused with bipolar disorder [HYPERLINK](#)

"https://en.wikipedia.org/wiki/Bipolar_disorder" as well as with borderline personality disorder [HYPERLINK](#)

"https://en.wikipedia.org/wiki/Borderline_personality_disorder".

Some symptoms that are due to anxiety disorders, antisocial personality disorder, developmental disabilities or mental retardation or the effects of substance abuse such as intoxication and withdrawal can overlap with some ADHD. These disorders can also sometimes occur along with ADHD. Medical conditions which can cause ADHD symptoms include : hyperthyroidism [HYPERLINK](#)

"<https://en.wikipedia.org/wiki/Hyperthyroidism>" , [seizure disorder](#) [HYPERLINK](#)

"https://en.wikipedia.org/wiki/Seizure_disorder", lead toxicity [HYPERLINK](#) "https://en.wikipedia.org/wiki/Lead_toxicity",

hearing deficits, hepatic disease [HYPERLINK](#) "https://en.wikipedia.org/wiki/Hepatic_disease", sleep apnea, drug

interactions [HYPERLINK](#)

"https://en.wikipedia.org/wiki/Drug_interaction", untreated celiac disease [HYPERLINK](#) "https://en.wikipedia.org/wiki/Celiac_disease",

and head injury [HYPERLINK "https://en.wikipedia.org/wiki/Head_injury"](https://en.wikipedia.org/wiki/Head_injury).

Management of ADHD

The therapeutic approach to ADHD has been shifting. In some cases, environmental restructuring and behavioral therapy alone has been effective. Developments in behavioral parent training (BPT) and behavioral classroom management (BCM) have also proven useful. Furthermore, behavioral psychotherapy often is successful when used in conjunction with an effective medication regimen. The medications of choice are stimulants, and for adults with ADHD stimulants represent the best first-line therapeutic option. For related areas of functioning, such as social skills and academic performance, medications combined with behavioral treatments may be indicated.

Behavioral psychotherapy

Behavioral psychotherapy often is effective when used in combination with an effective medication regimen. Behavioral therapy or modification programs can help diminish uncertain expectations and increase organization. Working with parents and schools to ensure environments conducive to focus and attention is necessary.

Psychosocial interventions

A number of psychosocial treatments are effective. These include behavioral parent training (BPT) and behavioral classroom management (BCM). These are best used in conjunction with psychopharmacological approaches.

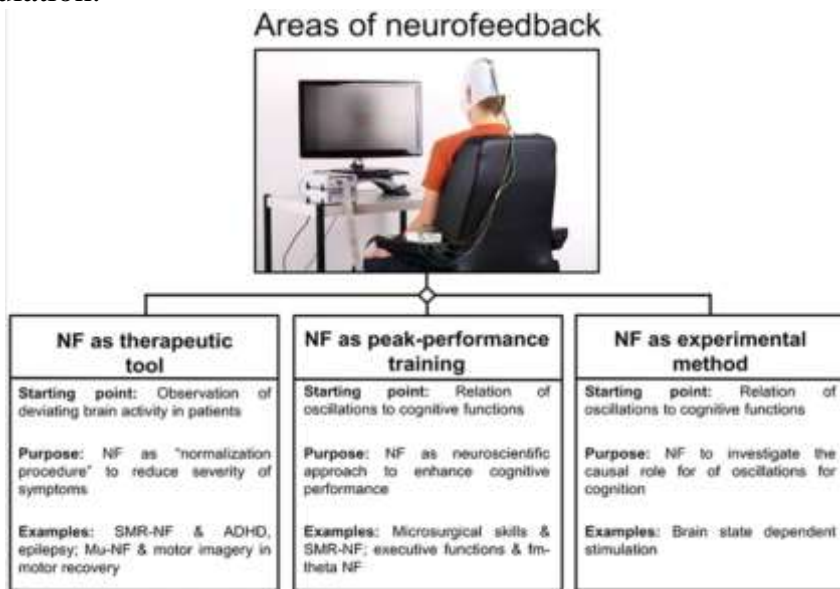
Non-pharmacological interventions

Emerging evidence shows that non-pharmacological treatments should be considered the first treatment for children with ADHD. For preschoolers, intervention is best with parental training. For school-aged children, interventions of group training for parents and classroom behavioral approaches might be enough. Concern about medications to treat ADHD has increased interest in alternative treatments. Researchers conducted a systematic review and meta-

analysis of randomized controlled trials of dietary and psychological treatments for ADHD and found that free fatty acid supplementation produced small but significant reductions in symptoms. Meta-analytic studies of NFB treatment for ADHD children & follow-up suggest that there are sustained symptom reductions over time in comparison with non-active control conditions. As such, NF can be considered a non-pharmacological treatment option for ADHD with evidence of treatment effects that are sustained when treatment is completed and withdrawn.

NFB can be used in at least three main ways:

- as a therapeutic tool to normalize patients' deviating brain activity in order to influence their symptoms (ii) as so-called peak-performance training to enhance cognitive performance in healthy participants and (iii) as an experimental method to investigate the causal role of specific neural events (such as brain oscillations) for cognition and behavior which is known as brain-state dependent stimulation.



Areas of neurofeedback application. An overview of three main areas is given for neurofeedback applications, namely neurofeedback as therapeutic tool, peak-performance training and experimental method. For each area, the rationale behind is given and protocols are listed as examples. Neurofeedback, formerly called electroencephalographic (EEG) biofeedback

, is an intervention for ADHD based on findings that many individuals with ADHD show low levels of arousal in frontal brain areas, with excess of theta waves and deficit of beta waves.

The principle of NF is that over time, participants learn operant control of their EEG and change from an abnormal state to one resembling that of typically developing children. This process is thought to eventually remediate the symptoms associated with ADHD.

Case studies and controlled-group studies of EEG biofeedback have demonstrated beneficial effects on measures of intelligence, behavioral rating scales assessing the frequency of the core symptoms of ADHD for theta/beta training

Standard Protocols with ADHD

Theta/beta (4-7 Hz/12-21 Hz) ratio (TBR) neurofeedback strives to decrease theta and/or increase beta power in central and frontal locations. This protocol directly targets important electrophysiological characteristics such as high theta/beta ratios, high theta power, and/or low beta power commonly observed in children. Recent randomized controlled trials suggest that 30 to 40 sessions of TBR neurofeedback were as effective as methylphenidate in reducing inattentive and hyperactivity symptoms and were even associated with superior post-treatment academic performance. It has been proposed that the effects of TBR neurofeedback on ADHD might be explained by the learned self-regulation of attention .

SMR neurofeedback training over the sensori-motor strip (predominantly in the central right hemispheric region) was first applied to ADHD children by Lubar and colleagues, based on the

functional association of the sensori-motor rhythm with behavioral inhibition and the promising results in reducing cortical excitability in epileptics obtained by Sterman, MacDonald, and Stone Lubars seminal studies revealed that the beneficial hyperactivity-reducing effects of a combined SMR/theta neurofeedback training were maintained after psychostimulants was withdrawn in hyperactive children.

Studies suggest that SMR neurofeedback training reduces inattentive and hyperactive/impulsive symptoms in ADHD children to the same extent as TBR training and comparable ADHD patients trained with the SMR protocol showed decreased sleep onset latency (SOL) and improved sleep quality in comparison to those administered with TBR, midway treatment. The improvements in ADHD symptoms following SMR training might hence be the result of the vigilance stabilization mediated by the regulation of the locus coeruleus noradrenergic system of which activation has been shown to impact the sleep spindle circuitry.

Methodology:

Type and Design of the study

The present study is a clinical trial randomized study that was conducted on 10 patients who were following up throughout 2019 at the outpatient clinic of RightWay medical center of special needs in Alexandria in Egypt.

By the standardized psychiatric evaluation, they were diagnosed as ADHD according to DSM-V. The studied children were divided into two main groups: group (A): 5 freshly diagnosed cases of ADHD patients who were only receiving sessions of NFB and group (B) as control: 5 cases of ADHD patients who were receiving behavioral therapy only.

All ADHD patients (cases & controls) will be subjected to the following;

- Full medical history and neurological examination.

- Standard EEG test.
- Conners' Parent Rating Scale Pre & Post Neurofeedback sessions for cases and before and after Behavioral Therapy for control group.
- IQ / Stanford Binnet 5 before Neurofeedback sessions
- Neurofeedback basic assessment on Cz before start of sessions for both cases and controls.
- Neurofeedback sessions for cases group (12 sessions / twice or three times weekly) using the SMR enhancement and inhibition of T/B ratio.
- Behavioral therapy sessions for control group(12 sessions / twice or three times weekly).
- Neurofeedback progress assessment after 12 sessions for cases group by assessment of T/B ratio.

Study Identification and Eligibility Criteria

The search parameters included combinations of key words: Attention Deficient Hyperactive Disorder, ADHD, pervasive developmental disorder, PDD-NOS, Neurofeedback, EEG Biofeedback, NFB. Relevant articles (judged on the basis of the title and abstract) were retrieved for more detailed evaluation and the bibliographies of relevant articles were searched for additional references.

Inclusion criteria:

- The study conducted on diagnosed as ADHD according to DSM-5.
- The study included age from 6 – 14 year .
- Both sexes were included in the study.
- The measures for efficacy Neurofeedback is valid and reliable instrument.
- Average IQ level (95- 110).

Exclusion criteria:

- ADHD children on medication.
- ADHD with psychiatric co-morbidity as Autism , OCD .

- ADHD with Past medical history affecting neuropsychiatric child development as trauma to head , meningitis ...etc

Statistical Analysis: SPSS (v.17) is the statistical method involved in carrying out the study include planning, designing, collecting data, analyzing , drawing meaningful interpretation and reporting of the findings

Research Ethical Aspects:

Informed consent will be taken from patients, in case of incompetent patients the informed consent will be taken from the guardians research work to the benefit of society and humanity with his commitment to comply with all standards and ethics set by the authorities for the control of medical research(18).

Conners' Parent Rating Scale: (CPRS-R:L)

The Conners' Parent Rating Scale – Revised (CPRS-R) is the parent form of the multimodal assessment of children and adolescent's behavioral difficulties , it is is useful when assessing children and adolescents for Attention Deficit/Hyperactive Disorder (ADHD) ages 3 through

17. There are two forms of the CPRS-R: the Long Form (CPRS-R:L) and the Short Form (CPRS-R:S). The Long Form contains 80 items and can be completed by most parents/guardians in approximately 20 minutes; the Short Form contains 27 Items and can be completed in 5 to 10 minutes. On each form, the parents/guardians rate how often their child or adolescent engages in the behaviors listed on a form based on a four point scale. The scale ranges from Not True at All (Never) to Very Much True (Very Often) [1HYPERLINK "https://link.springer.com/referenceworkentry/10.1007%2F978-0-387-79061-9_670",HYPERLINK

"https://link.springer.com/referenceworkentry/10.1007%2F978-0-387-79061-9_670" HYPERLINK

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"https://link.springer.com/referenceworkentry/10.1007%2F978-0-387-79061-9_670"5].

Stanford–Binet Intelligence Scale: Fifth Edition

Stanford–Binet Intelligence Scale: Fifth Edition (SB5) is based in the schooling process to assess intelligence. It continuously and efficiently assesses all levels of ability in individuals with a broader range in age. It is also capable of measuring multiple dimensions of abilities (Ruf, 2003).

The SB5 can be administered to individuals as early as two years of age. There are ten subsets included in this revision including both verbal and nonverbal domains. Five factors are also incorporated in this scale. These factors include fluid reasoning, knowledge, quantitative reasoning, visual-spatial processing, and working memory. The fifth edition incorporated a new scoring system, which can provide a wide range of information such as four intelligence score composites, five factor indices, and ten subtest scores.

IQ Range ("deviation IQ")	IQ Classification
145-160	Very gifted or highly advanced
130-144	Gifted or very advanced
120-129	Superior
110-119	High average
95-109	Average
80-89	Low average
70-79	Borderline impaired or delayed
65-69	Mildly impaired or delayed
55-64	Moderately impaired or delayed

The classifications of scores used in the 4th Edition differ from those used in earlier versions of the test

Subtests and factors (cont.)

Fluid reasoning	Knowledge	Quantitative reasoning	Visual-spatial processing	Working memory
Early reasoning	Vocabulary	Non-verbal quantitative reasoning (non-verbal)	Form board and figure patterns (non-verbal)	Delayed auditory (non-verbal)
Verbal analogies	Procedural knowledge (non-verbal)	Verbal quantitative reasoning	Picture and shapes	Block span (non-verbal)
Visual analogies	Picture analogies (non-verbal)			Memory for sentences
Object series matrices (non-verbal)				Last word

Results : Demographic Distribution of data:

F/H	ADHD-H	ADHD-I	ADHD-C	BT	NFB	Gender	Age years	NO	
4	1	1	3	+	12 session	male	7 - 12.5	5	Cases
2	2	-----	3	+	-----	male	7.5 - 12	5	Control

Cases : CPRS-RL before and after Neurofeedback sessions

Five ADHD children were given 12 sessions of NFB and CPRS-RL was done before and after the NFB therapy , P value =0.98 with no statistical significance

Post - NFB	Pre - NFB	Cases
68	81	1
50	66	2
65	77	3
61	80	4
66	82	5
	0.35	Chi2
	0.986	p

Control : CPRS-RL before and after BT sessions

Five ADHD children were given 12 sessions of Behavioral Therapy and CPRS-RL was done before and after the BT therapy , P value =0.98 with no statistical significance.

Post - BT	Pre - BT	Control
67	70	1
80	84	2
71	79	3

65	76	4
74	77	5
0.38		Chi2
0.98		p

Cases : T/B ratio before and after Neurofeedback sessions

Five ADHD children were given 12 sessions of NFB and T/B Ratio was done before and after the NFB therapy , P value =0.97 with no statistical significance

Reduction	Post – NFB	Pre – NFB	Cases
0.8	2.4	3.2	1
1.2	3.5	4.7	2
0.2	3.3	3.5	3
1.5	1.4	2.9	4

1.3	2.05	3.4	5
0.47			Chi2
0.97			p

Discussion

Our study was done on 10 ADHD children , 5 cases who received 12 sessions of NFB and 5 control who received only behavioral therapy . The mean age for all ADHD children was 8.7 and 100% were males, this goes in hand with the following Fast Facts:

- Males are almost three times more likely to be diagnosed with ADHD than females.
 - During their lifetimes, 12.9 percent of men will be diagnosed with the attention disorder. Just 4.9 percent of women will be diagnosed.
 - The average age of ADHD diagnosis is 7 years old.
 - Symptoms of ADHD typically first appear between the ages of 3 and 7.
- and [HYPERLINK "http://www.cdc.gov/ncbddd/adhd/features/key-findings-adhd72013.html/"](http://www.cdc.gov/ncbddd/adhd/features/key-findings-adhd72013.html/) [HYPERLINK "http://www.cdc.gov/ncbddd/adhd/features/key-findings-adhd72013.html/"](http://www.cdc.gov/ncbddd/adhd/features/key-findings-adhd72013.html/)

- ADHD isn't just a childhood disorder. Today, about 4 percent of American adults over the age of 18 deal with ADHD on a daily basis. 60% were of combined ADHD type ,similar to our results, studies of the prevalence of DSM-IV subtypes in clinically referred ADHD children and adolescents in the DSM-IV field trials , show that the combined type is the most prevalent type of ADHD (66%) followed by the inattentive (33%), and the hyperactive-impulsive types (8%).42)

At present, genetic loading appears to be the primary and perhaps only cause of ADHD . However, many environmental factors have been correlated with ADHD (ADD), and future research may prove these to be etiologic factors. Morbidity, as evidenced by signs and symptoms in people with ADHD (ADD), may be strongly correlated with the patient's home and school environments this is correlated that 60% of our ADHD in the study have family history of ADHD (40% of cases & 20% of controls).

The results of CPRS-RL before and after NFB therapy was statistically insignificant , in other clinical trial randomized study was conducted on 84 ADHD children who were following up at the outpatient clinics of center of special needs, institute of postgraduate childhood studies, Ain Shams University and Right Way clinic. Mekkawy L et al, has found statistically significant decrease in the Conner's scores before and after treatment with NFB reflects significant improvement in behavior and cognition. Also a comparison of the reduction rate among the three different types of ADHD ,the inattentive type was statistically significant and showed the best effect following NFB , followed by the hyperactive type which was statistically significant too, whereas the combined type was statistically insignificant.In Alexandria University 2014, ElRasheedy revealed that neurofeedback was superior to medication in reduction of the oppositional, anxiety and psychosomatic symptoms among ADHD children .

The link between ADHD and attention has prompted investigation with EEG to try and

come up with a suitable metric for diagnostic purposes. Significantly, the Food and Drug Administration (FDA) in 2013, approved a particular EEG-marker – the theta/beta ratio – for the diagnosis of ADHD as part of the Neuropsychiatric EEG-Based Assessment Aid for ADHD or —NEBA^{||} system. This is the first instance of an FDA approved EEG based diagnostic for a mental health condition.

Conclusion & Recommendations

Neurofeedback training although did not reveal statistically significant improvement on ADHD symptoms overall, and we were unable to prove that the effects of neurofeedback training were superior to those of Behavioral Therapy with regard to CPR rating scales.

There are three randomized controlled trials from Bakhshayesh, Gevensleben et al. and Holtmann et al. have shown neurofeedback to be superior to a (semi-active) control group. And, in line with the guidelines for rating clinical efficacy, they conclude that neurofeedback treatment for ADHD can be considered —Efficacious and Specific^{||} (level 5) with a high ES for inattention and impulsivity and a medium ES for hyperactivity.

Therefore its highly recommended to go on further studies on large sample sizes and different NFB protocols to judge for this new model of therapy for ADHD .

Expected limitations of the study:

- Limitations of current researches on Neurofeedback
- High cost of Neurofeedback sessions.
- Fluency Different language research studies on the Neurofeedback.

Summary

Introduction: Attention deficit hyperactivity disorder (ADHD) is a developmental condition of inattention and distractibility, with or

without accompanying hyperactivity. There are 3 basic forms of ADHD described in the Diagnostic and Statistical Manual, Fifth Edition (DSM-5) of the American Psychiatric Association are : (1) predominantly inattentive, (2) predominantly hyperactive/impulsive, and (3) combined. The etiology of ADHD is unknown and can be explained to great extent to genetics environmental & personal factors. Parents and siblings of children with ADHD are 2-8 times more likely to develop ADHD than the general population, suggesting that ADHD is a highly familial disease. Studies of cognitive deficits reveal another facet to the genetic contributions to ADHD. Hypotheses exist that include in utero exposures to toxic substances, food additives or colorings, or allergic causes. However, diet, especially sugar, is not a cause of ADHD. NFB science is attracting renewed interest as a method to self-regulate one's own brain activity to directly alter the underlying neural mechanisms of both cognition and behavior. It does not only promise new avenues as a method for cognitive enhancement in healthy subjects, but also as a therapeutic tool. It is considered a comprehensive type of training therapy promoting growth and change at the brain's cellular level. NFB can be used in at least three main ways: (i) as a therapeutic tool to normalize patients'

deviating brain activity in order to influence their symptoms (ii) as so-called peak-performance training to enhance cognitive performance in healthy participants and (iii) as an experimental method to investigate the causal role of specific neural events (such as brain oscillations) for cognition and behavior which is known as brain-state dependent stimulation. Neurofeedback, formerly called electroencephalographic (EEG) biofeedback , is an intervention for ADHD based on findings that many individuals with ADHD show low levels of arousal in frontal brain areas, with excess of theta waves and deficit of beta waves. The principle of NF is that over time, participants learn operant control of their EEG and change from an

__abnormal__“ state to one resembling that of typically developing children. This process is thought to eventually remediate the symptoms associated with ADHD).Case studies and controlled-group studies of EEG biofeedback have demonstrated beneficial effects on measures of intelligence, behavioral rating scales assessing the frequency of the core symptoms of ADHD for theta/beta training

Aim of the work:

The aim of the present study is to demonstrate the efficacy of Neurofeedback (computer based programs) as adjuvant therapy for children with ADHD.

Importance of the Study:

Attention deficit hyperactivity disorder (ADHD) is an important global public health challenge that must be addressed. Early diagnosis and effective treatment will affect optimal growth and development of the child a trying to reduce disability later on. The Neurofeedback: another non- pharmaceutical and non-invasive approach aiming at the reduction of ADHD symptoms and can be added to the behavioral therapy to ADHD children with limiting the use of medication.

Methodology:

The present study is a clinical trial randomized study that was conducted on 10 patients who were following up at the outpatient clinic of RightWay medical center of special needs in Alexandria in Egypt. By the standardized psychiatric evaluation, they were diagnosed as ADHD according to DSM-V. The studied children were divided into two main groups: group (A): 5 freshly diagnosed cases of ADHD patients who were only receiving sessions of NFB and group

- as control: 5 cases of ADHD patients who were receiving behavioral therapy only. All ADHD patients (cases & controls) will be subjected to the following;

- Full medical history and neurological examination.
- Standard EEG test.

- Conner's Test Pre & Post Neurofeedback sessions.
- IQ / Stanford Binnet 5 Pre- Neurofeedback sessions
- Neurofeedback basic assessment on Cz before start of sessions.
- Neurofeedback sessions for cases group (12 sessions / twice or three times weekly) and Behavioral therapy sessions for control group(12 sessions / twice or three times weekly).
- Neurofeedback progress assessment after 12 sessions for cases group.

Results:

Five ADHD children were given 12 sessions of NFB and CPRS-RL was done before and after the NFB therapy , P value =0.98 with no statistical significance.

Five ADHD children were given 12 sessions of Behavioral Therapy and CPRS-RL was done before and after the BT therapy , P value =0.98 with no statistical significance.

Five ADHD children were given 12 sessions of NFB and T/B Ratio was done before and after the NFB therapy , P value =0.97 with no statistical significance

Discussion:

Our study was done on 10 ADHD children , 5 cases who received 12 sessions of NFB and 5 control who received only behavioral therapy . The mean age for all ADHD children was 8.7 and 100% were males, this goes in hand with the following Fast Facts:

- Males are almost three times more likely to be diagnosed with ADHD than females.
- The average age of ADHD diagnosis is 7 years old.
- Symptoms of ADHD typically first appear between the [ages of 3 and 6](http://www.cdc.gov/ncbddd/adhd/features/key-findings-adhd72013.html) [andHYPERLINK "http://www.cdc.gov/ncbddd/adhd/features/key-findings-adhd72013.html/"HYPERLINK "http://www.cdc.gov/ncbddd/adhd/features/key-findings-adhd72013.html/"6.](http://www.cdc.gov/ncbddd/adhd/features/key-findings-adhd72013.html)

60% were of combined ADHD type ,similar to our results, studies of the prevalence of DSM-IV subtypes in clinically referred ADHD children and adolescents in the DSM-IV field trials , show that the combined type is the most prevalent type of ADHD (66%) followed by the inattentive (33%), and the hyperactive-impulsive types (8%). At present, genetic loading appears to be the primary and perhaps only cause of ADHD . this is correlated that 60% of our ADHD in the study have family history of ADHD (40% of cases & 20% of controls).The results of CPRS-RL before and after NFB therapy was statistically insignificant , in other clinical trial randomized study was conducted on 84 ADHD children Mekkawy L et al, has found statistically significant decrease in the Conner's scores before and after treatment with NFB reflects significant improvement in behavior and cognition. Also a comparison of the reduction rate among the three different types of ADHD ,the inattentive type was statistically significant and showed the best effect following NFB , followed by the hyperactive type which was statistically significant too, whereas the combined type was statistically insignificant.In Alexandria University 2014, ElRasheedy revealed that neurofeedback was superior to medication in reduction of the oppositional, anxiety and psychosomatic symptoms among ADHD children .

Conclusion &Recommendation:Neurofeedback training although did not reveal statistically significant improvement on ADHD symptoms overall, and we were unable to prove that the effects of neurofeedback training were superior to those of Behavioral Therapy with regard to CPR rating scales. There are three randomized controlled trials from Bakhshayesh,Gevensleben et al. and Holtmann et al.have shown neurofeedback to be superior to a (semi-active) control group. Therefore its highly recommended to go on further studies on large sample sizes and different NFB protocols to judge for this new model of therapy for ADHD

References:

- American Psychiatric Association (2013): Diagnostic and statistical Manual of Mental Disorders 5th edition. Washington.
- Moffitt TE, Houts R, Asherson P, Belsky DW, Corcoran DL, Hammerle M et al. Is Adult ADHD a Childhood-Onset Neurodevelopmental Disorder? Evidence From a Four-Decade Longitudinal Cohort Study. *Am J Psychiatry*. 2015 May 22.
- ElGendy SD et al. Attention Deficit/Hyperactivity Disorder :prevalence and risk factors in Egyptian primary school children. *The Egyptian Journal of Community Medicine* 2017;35:1 .
- Taghreed Farahat, Mohammad Alkot, Afaf Rajab, and Reda Anbar Attention-Deficit Hyperactive Disorder among Primary School Children in Menoufia Governorate, Egypt. *Int J Family Med*. 2014: 257369.
- Arcos-Burgos M, Jain M, Acosta MT, Shively S, Stanescu H, Wallis D, et al. A common variant of the latrophilin 3 gene, LPHN3, confers susceptibility to ADHD and predicts effectiveness of stimulant medication. *Mol Psychiatry*. 2010 Feb 16.
- Bellgrove MA, O'Connell RG, Vance A. Genetics of cognitive deficits in ADHD: clues for novel treatment methods. *Expert Rev Neurother*. 2008 Apr. 8(4):553-61.
- Padrón A, Galán I, García-Esquinas E, Fernández E, Ballbè M, Rodríguez-Artalejo
- F. Exposure to secondhand smoke in the home and mental health in children: a population-based study. *Tob Control*. 2015 Mar 25.
- Martel MM, Nikolas M, Jernigan K, Friderici K, Nigg JT. Personality Mediation of Genetic Effects on Attention-Deficit/Hyperactivity Disorder. *J Abnorm Child Psychol*. 2010 Feb 10.
- Pfurtscheller G, Neuper C(2006). Future prospects of ERD/ERS in the context of brain-computer interface (BCI) developments. *Prog. Brain Res*. 159, 433-437.

- Gruzelier J. H(2014b). EEG-neurofeedback for optimising performance. III: a review of methodological and theoretical considerations. *Neurosci. Biobehav. Rev.* 44, 159–182.
- Guhathakurta D, Dutta A(2016). Computational pipeline for NRIS-EEG joint imaging of tDCS-evoked cerebral responses—an application in ischemic stroke. *Front. Neurosci.* 10:261.
- Monastra VJ(2005).Electroencephalographicbiofeedback (neurotherapy) as a treatment for attention deficit hyperactivity disorder: rationale and empirical foundation. *Child Adolesc Psychiatr Clin N Am* 14:55–82.
- Monastra VJ, Lynn S, Linden M, Lubar JF, Gruzelier J(2005). Electroencephalographic biofeedback in the treatment of attention-deficit/hyperactivity disorder. *Appl Psychophysiol Biofeedback* 30(2):95–114.
- Vernon DJ (2005).Can neurofeedback training enhance performance? An evaluation of the evidence with implications for future research. *Appl Psychophysiol Biofeedback* 30(4):347–364.
- Sterman MB (1996). Physiological origins and functional correlates of EEG rhythmic activities: implications for self-regulation.*Biofeedback Self Regul* 21(1):3– 49.
- Thompson L, Thompson M (1998).Neurofeedback combined with training in metacognitive strategies: effectiveness in students with ADD. *Appl Psychophysiol and Biofeedback* 23(4):243–263
- IBM 2016*, IBM Knowledge Center: SPSS Statistics, *IBM*.
- Law No. 82 of 2002 promulgating the Code of Intellectual Property Rights.
- Doren JV , Arns M , Heinrich H, Madelon A et al (2018).Sustained effects of neurofeedback in ADHD: a systematic review and meta-analysis. *European Child & Adolescent Psychiatry* (<https://doi.org/10.1007/s00787-018-1121-4>).

- Lubar JF, Shouse MN. EEG and behavioral changes in a hyperkinetic child concurrent with training of the sensorimotor rhythm(SMR). *Biofeedback Self Regul.* 1976;1(3):293–306.
- McAdam DW, Irwin DA, Rebert CS, Knott JR. Conative control of the contingent negative variation. *Electroencephalogr Clin Neurophysiol.* 1966;21(2):194–5.
- Heinrich H, Gevensleben H, Freisleder FJ, Moll GH, Rothenberger A. Training of slow cortical potentials in attention-deficit/46Page 6 of 7
- Barry RJ, Clarke AR, Johnstone SJ. A review of electrophysiology inattention- deficit /hyperactivity disorder: I. Qualitative and quantitative electroencephalography. *Clin Neurophysiol.* 2003;114(2):171–83.
- Bresnahan SM, Barry RJ. Specificity of quantitative EEG analysis in adults with attention deficit hyperactivity disorder. *Psychiatry Res.* 2002;112(2):133–44.
- Bresnahan SM, Anderson JW, Barry RJ. Age-related changes in quantitative EEG in attention-deficit/hyperactivity disorder. *Biol Psychiatry.* 1999;46(12):1690–7.
- Clarke AR, Barry RJ, Heaven PCL, McCarthy R, Selikowitz M, Byrne MK. EEG in adults with attention-deficit/hyperactivity disorder. *Int J Psychophysiol.* 2008;70(3):176 –83.
- Duric NS, Assmus J, Gundersen D, Elgen IB. Neurofeedback for the treatment of children and adolescents with ADHD: a randomized and controlled clinical trial using parental reports. *BMC Psychiatry.* 2012;12:107.
- Meisel V, Servera M, Garcia-Banda G, Cardo E, Moreno I. Neurofeedback and standard pharmacological intervention in ADHD: a randomized controlled trial with six-month follow-up. *Biol Psychol.* 2013;94(1):12 –21.

- Gevensleben H, Rothenberger A, Moll GH, Heinrich H. Neurofeedback in children with ADHD: validation and challenges. *Expert Rev Neurother.* 2012;12(4):447–60.
- Egner T, Gruzelier JH. EEG biofeedback of low beta band components: frequency- specific effects on variables of attention and event-related brain potentials. *Clin Neurophysiol.* 2004;115(1):131– 9.
- Shouse MN, Lubar JF. Operant conditioning of EEG rhythms and Ritalin in the treatment of hyperkinesis. *Biofeedback Self Regul.* 1979;4(4):299 – 312.
- Sterman MB, Macdonald LR, Stone RK. Biofeedback training of the sensorimotor electroencephalogram rhythm in man: effects on epilepsy. *Epilepsia.* 1974;15(3):395 –416.
- Arns M, Feddema I, Kenemans JL. Differential effects of theta/beta and SMR neurofeedback in ADHD on sleep onset latency. *Front Hum Neurosci.* 2014a;8:1019.
- Sinha SR. Basic mechanisms of sleep and epilepsy. *J Clin Neurophysiol.* 2011;28(2):103–10.
- Mekkawy LE, Elnashar MM, Eid EM. The effect of Neurofeedback on children with Attention Deficit Hyperactive Disorder 2018. Thesis(PhD)-Ain Shams University.Faculty of Postgraduate Childhood Studies.
- Elrashidy LG , Omar T, Abdel-Latif F (2014). Study Of Neurofeedback Technique As A New Rehabilitative Method For Management Of Egyptian Children With Attention Deficit Hyperactivity Disorder . Thesis(M.S.)-Alexandria University.Faculty of Medicine.Department Of Pediatrics.
- Gianarris, W. J., Golden, C. J., & Greene, L. (2001). The Conners' Parent Rating Scales: A critical review of the literature. *Clinical Psychology Review, 21*, 1061– 1093.

- Kumar, G., & Steer, R. (2003). Factorial validity of the Conners' Parent Rating Scale – Revised: Short form with psychiatric outpatients. *Journal of Personality Assessment*, 80, 252–259.
- Bain, S. K., & Allin, J. D. (2005). Book review: Stanford–Binet intelligence scales, fifth edition. *Journal of Psychoeducational Assessment*, 23, 87–95.
- Janzen, H., Obrzut, J., & Marusiak, C. (2004). Test review: Roid, G. H. (2003). Stanford–binet intelligence scales, fifth edition (sb:v). *Canadian Journal of School Psychology*, 19, 235–244.
- ADHD Numbers:Facts,Statistics, and You 2017.<https://www.addrc.org> > adhd- numbers-facts-statistics-and-you.
- Lahey B, Applegate B, Barkley R, et al. DSM-IV field trials for oppositional defiant disorder and conduct disorder in children and adolescents. *American Journal of Psychiatry*. 1994;151(8):1163–1172.
- US Department of Health and Human Services. FDA approval letter for NEBA System. Available at: accessdata.fda.gov/cdrh_docs/pdf11/K112711.pdf. Accessed November 20, 2014.
- Arns M, Ridder S, Strehl U et al.(2009).Efficacy of Neurofeedback Treatment in ADHD: The Effects on Inattention, Impulsivity and Hyperactivity: A Meta-Analysis SAGE2009 : 40 issue: 3, page(s): 180-189