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## Is Neurofeedback therapy beneficial for Attention Deficit Hyperactivity Disorder?

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### ABSTRACT

Attention-deficit hyperactivity disorder is a biological disease in brain function that is chronic, which results in the function of regulating response and decision making (executive function) not following the child's age development. Pharmacological therapy, especially methylphenidate, is still the primary therapy, even though it is not responsive to drugs. Multimodal therapy is a recommended therapy for ADHD treatment in Europe and the United States, which includes psycho-pharmaceutical therapy, behavioural therapy and family psycho-education. The administration of behaviour therapy alone does not provide satisfactory results, especially for long-term effects. Neurofeedback therapy is a form of behavioural therapy, with the principle of operant conditioning, which aims to train and condition the brain, with feedback from the brain's electrical waves. This paper aims to explain how far the benefits of neurofeedback therapy for people living with ADHD are based on available research data from the latest research results.

### 1. Introduction

At this time, psychiatric disorders in children which are one of the main problems for children's mental health are a disorder of concentration and hyperactivity or hyperkinetic disorders.<sup>1</sup> Child with impaired concentration and hyperactivity, shows the main symptoms of excessive activity, cannot be silent, always moving, unable to focus attention, and showing impulsivity. This disorder is a biological disorder in brain function that is chronic, which results in the function of regulating response and decision making (executive function) not following the child's age development.<sup>1</sup> Weakness in the area of cognitive function caused by this disorder includes reduced degrees of children's intelligence, decreased academic

achievement, short time observations, decreased verbal or nonverbal memory, and lack of planning ability. Difficulties in the field of academic skills are difficulty reading, spelling, counting, and writing. This disorder also poses obstacles to the development of language skills. Various research results show a worsening effect if this disorder is not immediately intervened as early as possible, namely decreased academic achievement, school failure, and psychosocial problems at school and at home.<sup>1,2</sup>

In the population of school-age children, the prevalence rate of ADHD ranges from 2-20%. In Indonesia, in a study among elementary school children, ages 6-13 years, in Jakarta, the prevalence

rate was 26.2%, which included 15.9% of the ADHD type unable to focus attention, 5.3% ADHD of the type combined, 2.2 % ADHD hyperactive-impulsive type. Patients with ADHD are often accompanied by other psychiatric disorders, resulting in decreased adaptability in daily life until adulthood.<sup>2,3</sup>

Until now, psycho-pharmaceutical therapy, especially methylphenidate, is still the primary therapy, although with various drawbacks and limitations, such as the presence of side effects, not being responsive to drugs, and rejection of drugs. Multimodal therapy is a recommended therapy for ADHD treatment in Europe and the United States, which includes psycho-pharmaceutical therapy, behavioral therapy, and family psycho-education.<sup>4,5</sup> The administration of behavior therapy alone does not provide satisfactory results, especially for long-term effects.

Neurofeedback therapy is a form of behavioral therapy, with the principle of operant conditioning, which aims to train and condition the brain, with feedback from the brain's electrical waves.<sup>3</sup> This therapy is done by installing electrodes on the scalp to record brain electrical wave activity. Neurofeedback therapy includes neurobehavioral therapy which aims to obtain self-control by regulating the activity of the brain's electrical waves to be further applied in daily life. This paper aims to explain how far the benefits of neurofeedback therapy for people living with ADHD are based on available research data from the latest research results.

### **ADHD psychopathology**

The known causes of ADHD are executive dysfunction and the regulations of behavioral responses related to cortico-subcortical dopaminergic and noradrenergic pathways. The results of event-related potential (ERP) research show that children with ADHD have lower amplitude and longer latency for various ERP components, including N1, N2, mismatch negativity (MMN), readiness potential, and P3b.<sup>1,3</sup> This condition indicates a deficit in information and attention processes. On electroencephalographic

examination, people living with ADHD consistently show spectral activity that is dominated by slow frequency waves, such as theta waves (4-7 Hz), especially in the frontal area, and a decrease in the power of fast frequency waves, such as alpha waves (8-12 Hz) and beta (9-22 Hz).<sup>6,7</sup> On functional and volumetric brain imaging studies show frontostriatal system dysfunction in people living with ADHD. This situation is under the discovery of high-ranking motor control dysfunction (high order motor control), low arousal, behavioral inhibition dysfunction, and impaired concentration of attention.<sup>5</sup>

These findings are consistent with the presence of biochemical and anatomic abnormalities in the cortex of the prefrontal area following the hypothesis of a primary deficit in ADHD proposed by Barkley. EEG findings, brain morphometrics, neurochemical changes, and molecular genetic abnormalities all point to the fact that ADHD is associated with early developmental deviations of the brain.<sup>8,9</sup>

The results of research related to the dysfunction of the prefrontal area, encourage research to improve the accuracy of diagnosis, namely the measurement of functional brain activity or brain wave activity in the frontal area of the cortex. The research includes: the first is the examination of brain electrical waves in the frontal area of the cortex associated with the neuropsychological examination of people with ADHD, the second is the Q-EEG examination, which is event-related potential in people living with ADHD, and the third is Q-EEG examination using spectral analysis (power spectral analysis, PSA) to study cortical activation patterns.<sup>9</sup>

In a subsequent study, which involved 314 sufferers of child and adolescent psychiatric disorders (176 ADHD disorders, 138 affective disorders, anxiety disorders, and resistance attitudes), Furutani et al., found that ADHD patients with a higher theta/beta power ratio compared with other psychiatric disorders ( $p < 0.001$ ), with a sensitivity of 78% and specificity of 95%.<sup>6</sup> This result shows that ADHD disorders have a pathophysiological background in the presence of cortical hypo-arousal. This finding is by the results of

Positron Emission Tomography (PET) and Single Photon Emission Computerized Tomography (SPECT) scanning tests in ADHD patients, namely hypoperfusion and decreased metabolic activity in the prefrontal cortex and caudate nucleus.

### **Neurofeedback therapy**

Utilization of a picture of brain electrical wave activity as feedback for patients when conducting conditioned behavior training has been carried out since 1970. At that time, research was carried out to what extent brain function can be changed or normalized through conditioned behavioral training with the principle of operant conditioning. Initially, training was conducted to increase alpha wave activity for relaxation. Research conducted a training study of electrical brain waves in patients with epilepsy who are not controlled.<sup>6</sup> Currently Q-EEG examination and neurofeedback therapy are used for assessment and therapy in several psychiatric and neurological disorders, such as ADHD, Learning Difficulties, Epilepsy, Brain Forced Abortion, Stroke, Alcoholism, Substance Abuse Disorder, Anxiety.<sup>5</sup>

Neurofeedback therapy is a learning process/strategy to improve the brain's ability to produce specific electrical wave activity. A picture of changes in brain electrical wave activity is presented to the patient so that the patient can train/learn to change his brain activity. During training, one or two electrodes are placed on the scalp, and two electrodes on the ear lobe. These electrodes measure the electrical activity of the brain in certain areas (vertex, Cz). Data on brain electrical waves are recorded and processed digitally and then can be presented in graphical form.<sup>3,9</sup>

Neurofeedback therapy in the last decade has become a therapeutic choice as an additional form of therapy for people living with ADHD. This therapy is a neurobehavioral therapy that aims to develop patient self-control of the brain's electric wave activity patterns and subsequently is applied in everyday life situations. In ADHD children, there are two types of this therapeutic protocol, namely slow cortical

potentials (SCP) training and theta/beta training. SCP training is related to cortical excitability regulation. SCP originates from the activity of the sensorimotor cortex. SCP negatively indicates an increase in excitation and preparation for an action, for example, the state of being prepared to do or think something. SCP is positively related to the state of behavioral inhibition.<sup>7</sup>

Theta/beta training aims to reduce theta wave activity (4-8 Hz) and increase beta wave activity (13-20 Hz), thereby reducing the power theta/beta ratio of brain electrical activity (EEG). When children have vigilance and reflection, the theta/beta ratio becomes lower. EEG images at rest, show increased slow-wave activity (delta and theta waves) and reduced alpha (8-13 Hz) and beta (13-30 Hz) fast-wave activity, especially in the frontal and central areas. This condition is the same as that found in ADHD children, which shows the activity of the central nervous system in a low arousal state. Neurofeedback training can be seen as a way to improve specific cognitive functions or the ability to focus attention. Based on this understanding, children with ADHD can use neurofeedback training to improve their self-regulation abilities, then apply them to everyday life situations.<sup>4-8</sup>

### **Are there benefits of neurofeedback therapy in ADHD children?**

Several studies in the past twenty years have shown positive results from the administration of neurofeedback therapy in ADHD children. Various studies found improvements in behavior in children with ADHD, namely reduced behavior problems and improved cognitive functions, after receiving training to reduce the theta/beta ratio and SCP training.<sup>6-8</sup>

Neurofeedback training includes two blocks, namely theta/beta ratio training and SCP training. From this study, the results obtained in the group of ADHD children with neurofeedback training showed better therapeutic results compared to the group that did not get neurofeedback training. The results of this study indicate the benefits of providing neurofeedback

therapy in children with ADHD.

Arns et al. have researched the administration of neurofeedback in ADHD children compared with methylphenidate administration.<sup>10</sup> This study compared the effects of therapeutic outcomes between the administration of neurofeedback therapy for three months and the administration of methylphenidate. This study involved 34 respondents, aged 8-12 years, 22 respondents were in the neurofeedback group, and 12 respondents were in the methylphenidate group. Neurofeedback therapy is given in the form of training to improve cortical motor sensory rhythms (SMR) and beta-1 wave activity (15-18 Hz). The results showed that the neurofeedback group and the methylphenidate group all showed improvement in the treatment outcome parameters: d2-TOVA, measuring endurance concentration, and the IOWA-Conners Behavior Rating Scale. These results indicate that the administration of neurofeedback therapy is beneficial for behavioral improvement in ADHD children whose parents do not want the administration of stimulant drugs.

Enriquez-Geppert et al. have conducted research on 100 children and adolescents with ADHD (DSM-IV), ages 6-19 years, 51 respondents received a combination of multimodal therapy with neurofeedback therapy, and a control group of 49 respondents received multimodal therapy without therapy neurofeedback.<sup>2</sup> Provision of therapy is given for one year. Neurofeedback therapy is given in as many as 34-50 sessions, each session for 30-40 minutes. Multimodal therapy includes the provision of methylphenidate (25mg/day), parental counseling, and academic support. The results showed the best results, namely increased concentration and reduction of hyperactivity in multimodal therapy groups accompanied by neurofeedback therapy.

The MTA Cooperative Group and Eunethyds (European Network for Hyperkinetic Disorders) recommend that ADHD treatment is multimodal therapy, which includes the provision of standard stimulant drugs, optimal behavioral therapy, and psycho-education for parents and teachers. The effect

of giving long-term stimulant drugs until now, there is no supporting data that guarantees safety for patient health. In addition to the problem of side effects, long-term drug administration also raises the burden of funding, in the United States, it is estimated that the burden of drug financing for a child with ADHD at school age is USD 1678 per year, resulting in an additional cost of living for a family with one child with ADHD of USD 1288. However, drug administration provides a real improvement that can be obtained immediately. The MTA Cooperative Group's research results show that giving behavioral therapy alone does not differ from the community care group.<sup>8,9</sup>

The provision of other types of therapy, such as neurofeedback therapy, provides alternative therapies that need to be considered, especially if the patient's parents refuse the drug, as well as in non-respondent ADHD children. Various studies have shown that not all ADHD children are responsive to psychostimulant administration; 20% of ADHD children are non-responders to psychostimulant treatment.

The provision of neurofeedback therapy in the long term does not cause harmful side effects; however, real improvement in behavior cannot be immediately obtained. Another thing that is beneficial in the administration of neurofeedback therapy is that the therapeutic results obtained are essentially the results of the learning process, namely lifestyle changes / behavioral habits that are expected to persist for an extended period of time.

## **2. Conclusion**

Neurofeedback therapy provides benefits and can be considered one of the treatment options for children with ADHD.

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