Effects of Neurofeedback

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Attention deficit/hyperactivity disorder (ADHD) is one of the most frequent neurodevelopmental disorders in childhood and adolescence. Choosing the right treatment is critical to controlling and improving symptoms. An innovative ADHD treatment is neurofeedback (NF) that trains participants to self-regulate brain activity.

Keywords: attention deficit/hyperactivity disorder ; child ; neurofeedback

1. Introduction

Attention deficit/hyperactivity disorder (ADHD) or hyperkinetic disorder is one of the most common mental disorders in childhood and adolescence [1]. It is a neurodevelopmental disorder characterized by primary symptoms of inattention, hyperactivity and/or impulsivity [2]. There are three types of ADHD, inattentive, hyperactive-impulsive, and combined type [3]. Worldwide, its prevalence is 5.8% [2][4].

There are different genetic and environmental factors among the causes of attention deficit/hyperactivity disorder. ADHD tends to run in families, with a risk of 5 to 10 times higher among first-degree relatives [5]. Regarding environmental factors, these mainly include prenatal and perinatal risk factors (maternal stress, smoking or alcohol consumption during pregnancy, low birth weight, prematurity), environmental toxins (organophosphates, polychlorinated biphenyls, lead) and unfavorable psychosocial conditions (maternal hostility, severe deprivation in early childhood) [5].

Throughout childhood, ADHD is related to inattention, poor planning ability, and impulsivity, causing further deterioration as external demands increase [6]. This generates a series of alterations in personal, school, and social functionality, which lead the individual in the full stage of formation of his personality and identity, to interact in an erroneous way with society, causing conflicts with the environment (parents, siblings, colleagues) and that fact can lead to social marginalization [7][8]. These children, from preschool to 13 years of age, show a risk of suicidal ideation almost six times greater than that of a child without ADHD [2][9].

Therefore, early interventions in children are essential, in order to reduce the repercussions in adolescence and adulthood. Among the effective treatments available for ADHD, the main differences are related to the type of intervention (pharmacological and non-pharmacological), the age of the patient, the cost, the available patient and caregiver time, the expected effectiveness in the reduction of symptoms, the adverse effects, safety, and tolerability [10][11].

The main treatment for ADHD continues to be pharmacological, with psychostimulant drugs (methylphenidate or amphetamines) being the most widely used [12]. However, the benefits are limited due to frequent adverse effects such as decreased appetite, headache, and insomnia, as well as poor adherence to treatment [5]. This fact makes many families reject the medication [13].

Among the different non-pharmacological treatment strategies, neurofeedback (NF) has been considered an innovative ADHD treatment [14]. NF is a computer-based behavior training enabling a patient to self-regulate aspects of brain activity [15]. The training protocols followed in ADHD procedures are training of slow cortical potentials (SCPs), theta/beta wave training and sensory-motor rhythm training (SMR) [16].

The NF focuses mainly on improving self-control over patterns of brain activity, decreasing theta waves (low frequency waves related to decreased alertness), and/or increasing beta waves (high frequency waves related to concentration and neuronal excitability) [17][18]. This is achieved by measuring the activity of the electroencephalography (EEG) while the patient performs a task, often a simple computer game, that modulates performance and reward according to specific changes in the EEG pattern [19].

Some systematic reviews have analyzed the positive effects of non-pharmacological interventions [20][21], and other studies have compared the effects of NF interventions versus psychostimulants [22]. Also, in the last years, a meta-analysis in children and adolescents suggested sustained symptom reductions over time after NF interventions [16]. However, the age range of the study population was large and the authors indicated serious limitations related to the scarcity of studies found and short-terms follow-up. Recently, an increasing number of studies investigating NF interventions with longer follow-up have been published, so researching the latest evidence can provide more information about this population. Therefore, the aim of this systematic review was to analyze the effects of interventions with NF exclusively in children with ADHD.

2. NF interventions in children

ADHD is one of the most common neurological disorders in childhood.

NF improved the symptomatology in children with ADHD, because of learning through video games, attending to their mistakes, and training functions nonconscious control—such as attention, achievement of objectives, self-control, and self-regulation of attention levels, and concentration—in addition to inhibiting distracting stimuli [23]. Also, it was found evidence of comparative effectiveness of NF and CogT for children with ADHD. As other studies point out, NF is a treatment with great benefits due to its positive and lasting effect on symptoms [3], significantly improving behaviour, attention, IQ [24][25], and reaction times on the psychometric measures such as hyperactivity and impulsivity symptoms [25].

In addition, another of the benefits found was the improvement in motor control and bimanual coordination. ADHD in children is often associated with poor motor control, coordination problems, and difficulty controlling strength [26], which affects the performance of distal, complex, and accelerated tasks that lead to poor writing and poor academic performance [27].

It seems that the NF is related to a reduction in theta waves, although the results were not clear. Literature also shows divergences, some authors found significant individual learning curves for both theta and beta over the course of the intervention, although individual learning curves were not significantly correlated with behavioral changes [25][28]. Other authors provided evidence that children with ADHD learned to decrease theta/beta ratio during NF sessions being the learning effects mainly attributable to the increase in the power of the beta waves both, in the group level sessions and in the individual level sessions. However, it is unknown whether the decrease in theta waves is attributed to the efficacy of NF sessions or to developmental changes in children [28].

Regarding drug treatment, NF is considered a viable alternative therapy for specific groups of children with ADHD who do not respond to medication or have severe side effects [5][22]. The combined use of drugs and NF enhances the durability of the positive effects [17] and even other studies corroborate that multimodal treatment of NF plus stimulant medication at low doses was positive in improving symptoms such as inattention and hyperactivity [22]. As other studies point out, drug doses can be reduced when both treatments are administered [3][29].

Alternative therapies combining NF plus physical activity improved attention and short/long-term memory. Other studies indicate great benefits in the improvement of cognitive, behavioral and physical symptoms after mixed physical exercise programs, particularly moderate to intense aerobic exercise [30][31]. Indeed, physical exercise generates an increase in the levels of norepinephrine, serotonin, and dopamine [32], which translates into the better motor and cognitive functioning and greater control of executive functions and impulses, so many authors bet on complementing NF and physical activity [33].

Behavioral therapy with NF improved response and attention control, as pointed out by other authors [34]. Even other studies indicate that NF through video game-based cognitive training normalizes brain function in patients with ADHD, since these therapeutic interventions are generally effective in improving cognitive areas and producing a decrease in symptoms of ADHD [35].

NF combinate with the training of attention based on the brain–computer interface shows benefits in inattentive symptoms, even some authors indicate that this type of training program is beneficial in cases of ADHD that present more severe symptoms [36].

One promising aspect of NF is its relationship to procedural learning, so its benefits can be more durable over time after treatment. Technology development provides different treatment options, combining traditional drug treatment, along with NF, physical activity, or cognitive training, all strategies provide positive therapeutic effects on brainwaves and ADHD symptomatology.

Although NF can be used as complementary in patients who have significant side effects to stimulant medication or in patients whose family refuses to try the medication, further research is needed to corroborate its effects in each of the behavioural areas of the children with ADHD.

3. Limitations

First, although all studies use NF as an intervention, the great variability in the duration of the intervention may influence the heterogeneity of the results. Also, the sample sizes of the controlled randomized trial were small. Future research would be necessary to analyze the NF effects in each of the behavior areas of children with ADHD. Furthermore, more randomized controlled trials would be necessary to determine the significant effects and the duration of the effects over time.

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