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Effects of a Neuropsychopedagogical Parenting Program on the Cognitive and Motor Development of Children with ADHD

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Abstract

This study aimed to evaluate the effects of a neuropsychopedagogical parenting program (NPP) on the cognitive and motor development of children with ADHD. 70 children with ADHD participated in the present study, of both sexes, aged between 06 and 08 years old (7.08 years old), who were divided into two groups: (A—35 children with ADHD who did not undergo the NPP; B—35 children with ADHD who underwent the NPP). The NPP had a duration of 25 sessions of 15 minutes each, at a frequency of 3 times a week. To evaluate the effects of the NPP, the children were submitted to the following protocols: 1) Swanson, Nolan and Pelham Questionaire (SNAP-IV); 2) Assessment of Motor Competence through the Supine-to Stand (STS); 3) Assessment of executive functioning through the HEAD-FOOT-KNEE-SHOULDER (HFKS) protocol; 4) Assessment of Reading Comprehension. Both groups were evaluated before the NPP, after the NPP and four months after the end of the NPP. Our results show that GB children in the signs/symptoms evaluated by SNAP-IV had a superior performance by ±11% ($p < 0.01$) in relation to GA children. Regarding motor competence, the children from GB had a superior performance by ±24% ($p < 0.01$) in relation to children from GA. When assessed for executive functioning when establishing an intergroup comparison, GB children performed ±23% better ($p < 0.01$) than GA children. Regarding reading ability, children from (GB) had a superior performance by ±9% ($p < 0.05$) compared to children from (GA), after undergoing the NPP.

Keywords

Children, ADHD, Parental Program

1. Introduction

The origin of ADHD is multifactorial, since the manifestation of its symptoms consists of a combination of genetic, environmental, social and cultural factors, in addition to changes in the structure and/or functioning of brain regions. It should also be noted that the mechanisms behind these phenotypes are still unknown. However, variants in several genes with known roles in neurodevelopment are associated with ADHD [1].

Therefore, it is believed that changes in the central nervous system of individuals with ADHD are the result of a deficient development process during pregnancy and/or early postnatal life, as the migration of newly formed neurons would not occur as expected. and, in this way, there would not be the establishment of adequate networks of connections, including short-range connections with neighboring neurons in the same region and long-range projections to other regions, for example, between the thalamic nuclei and the neocortex, including the motor and sensory cortices and areas responsible for higher-order cognitive-motor functions and basal ganglia and cerebellum [2] [3] [4] [5]. In addition to changes in cortical volume, thickening in the prefrontal areas is delayed in ADHD, taking about 2.5 to 5 years longer than controls to achieve normal cortical thickness [6] [7].

Studies done with magnetic resonance imaging (MRI) indicate that there is a reduction in neural activity in the frontal region, anterior cingular cortex and basal ganglia [8]. Children with ADHD have a smaller brain volume in all its structures. In addition, there is impairment of dopaminergic neurotransmission systems, reduced production of catecholamines, and dysfunctions in serotonin mechanisms [9] [10].

In addition to decreased activity in attention-demanding tasks and response inhibition, both of which are directly related to the ADHD phenotype, a number of other activities/functions are disrupted in ADHD. These include reduced activity in the striatum in reward anticipation tasks [11], in the cerebellum in cognitive tasks, and in the motor cortex in the resting state [12] [13] [14]. In general, consistently decreased brain volumes and hypoactivation of regions known for their roles in inhibitory control and attention are consistent with the behavioral phenotype of ADHD.

Such impairments, of the striatum in the anticipation of rewards, of the cerebellum in cognitive functions, of the neocortex in relation to inhibitory control and attention, result in symptoms and severe impairments in the executive functions of individuals with ADHD, which compromises their family, social and academic. Difficulty completing activities, perceiving details, sustaining attention when spoken to; lack of organization and planning, inability to follow instructions or stay at one's desk during classes, inability to play silently, wait for one's turn, inhibit hasty behaviors or responses, and aggressive reactions and low frustration tolerance [15] [16] [17], are some of the countless examples of how the disorder generates significant dysfunction in executive skills and com-

promises their development and living environment on a daily basis. The deficit in the Executive Functions of children with ADHD, the impairment of the following aspects: inhibition of responses, sustained attention, non-verbal and verbal working memory, planning, sense of time, emotion regulation, perseverance and in verbal and non-verbal fluency [18] [19].

Research indicates that children stimulated, in a contextualized way, through programs, can produce better articulated networks and connection patterns, as well as the presence of a greater number of ramifications (dendrites) responsible for the communication and formation of this network, which would provide a better ability to integrate information [20] [21]. In literature, studies suggest that games can favor the learning of children with the ADHD. Ludomotor stimulation is an efficient way to promote procedural or procedural memory, which is fundamentally related to the potential increase in performance capable of increasing the precision of motor gestures and the development of executive functions [22]. Thus, different approaches consider that factors such as task, individual and environment interact to influence the rhythm, acquisition and improvement of skills [23] [24].

A child's performance reflects past experiences and can predict future movements. In this sense, the participation of the family as a protective factor stands out, being able to minimize symptoms or, practically, extinguish them [25] [26]. Therefore, discussing ADHD, its diagnosis and treatment, involves the need to consider the role of the family, its context and its role in the development and evolution of the disorder [27].

The quality of the family context is crucial for the way the child will experience difficulties with ADHD and what mechanisms he will have to overcome them. Parents and family dynamics represent a central aspect in the development of children with ADHD and in the reduction of their symptoms. Some authors have researched the importance of involving parents and/or caregivers of children with ADHD and developed parenting guidance programs as they perceive their effectiveness when associated with drug treatment [28]. Parenting programs began to be used in the 1980s to transmit knowledge to family members and psychotic patients and in the 1990s to other groups of patients with various disorders [29] [30].

Studies show that the development of a parenting program for parents of children with ADHD is effective in improving behavioral and internalizing symptoms and reducing parental stress [31] [32]. Such programs generate positive changes in their social skills and promote a significant reduction in problematic behaviors [33]. By reducing the symptoms of ADHD, reducing parental conflicts and between parents and children, a favorable environment for the child is created, being a relevant and necessary intervention model [34] [35] [36], since such an intervention, in addition to promoting positive impacts, allows generalization to other spheres [37].

Based on what was previously mentioned, this study aimed to evaluate the ef-

fects of a neuropsychopedagogical parenting program on the cognitive and motor development of children with ADHD.

2. Method

2.1. Study Design

The present study was developed from an experimental design and operationalized as follows: an evaluation (1st evaluation, EVA1) prior to the intervention carried out by the Program, the execution of the Neuropsychopedagogical Parental Program (PPN, 25 sessions of 15 minutes each, at a frequency 3 times a week), an assessment after the end of the PPN (2nd evaluation, EVA2), follow-up assessment performed after 4 months (3rd evaluation, EVA3). Thus, the children participated in this research for approximately 06 months, from the presentation of the research until the last evaluation (EVA3).

2.2. Participants

70 children with ADHD participated in the present study, of both sexes, aged between 06 and 08 years old (mean age 7.08 years).

Participants were initially divided into two groups:

- A—Consisting of 35 children with ADHD who did not undergo the a neuropsychopedagogical parenting program (NPP);
- B—Consisting of 35 children with ADHD who underwent the NPP.

The division of the members into groups A and B took place at random (casual/as a draw) after the completion of EVA1, using the Konkuri© software, which also allowed the groups to be divided in a way that respected the gender distinction (uniform distribution between boys and girls).

It should be noted that due to absences in EVA2 and EVA3, 03 children were excluded from group A and 04 children were excluded from group B.

Therefore, the final composition of the groups was as follows:

- A—Consisting of 32 children with ADHD who did not undergo the NPP;
- B—Consisting of 31 children with ADHD who underwent the NPP;

The inclusion criteria for the selection of children with ADHD were:

- Present a medical diagnosis of ADHD based on the interview guide proposed by the DSM-V, having been diagnosed by a neuropediatric and other concomitant health professionals, that is, being a multidisciplinary diagnosis;
- Be in outpatient medical follow-up by a multidisciplinary team for at least a year and a half;
- Have an estimated IQ (Wechsler Intelligence Scale for Children—WISC-IV) above 80;
- Not having comorbidities;
- Make use of medication (methylphenidate or similar) for at least six months.

2.3. Assessment Procedures

Initially, the children were submitted to an assessment of the signs/symptoms of

ADHD using the Swanson, Nolan and Pelham Questionaire (SNAP-IV). It is a questionnaire with 26 items corresponding to the A criteria of the DSM-IV for ADHD and ODD (Oppositional Defiant Disorder).

Parents rate behaviors of inattention (items 1 - 9), hyperactivity/impulsivity (items 10 - 18), and oppositional defiant (items 19 - 26). Using a 4-point Likert scale ranging from 0 (not at all) to 3 (very much). The score was calculated through the raw sum of each item.

Soon after, the participants were submitted to the Supine-to Stand (STS) which is an assessment of motor competence and which consists of getting up from the floor, from the lying position in the supine position, and touching a target fixed on the wall, ASAP. For the evaluation in relation to the quality of the movement pattern during the accomplishment of the task of getting up from the floor, an analysis of three categories of components of the movements used to leave the supine position to the upright position was used: Upper Limbs (UL), Axial Region (AX) and lower limbs (LL). The total score can range from 0 to 14 points.

Then, the children were submitted to an assessment of executive functioning through the HEAD-FOOT-KNEE-SHOULDER (HFKS) protocol, which consists of evaluating inhibitory control and cognitive flexibility through tasks that require touching parts of the body, according to with the evaluator's orders. The familiarization phase of the test consists of direct execution orders and, after understanding the purpose of the test, the participant is instructed to execute the orders in reverse (e.g. head tap = foot/foot tap = head). After this step, the participant is evaluated with 30 random orders to be executed in reverse, divided into 3 phases. The maximum score is 60 points on this test, with the highest score being the best performance.

After 24 hours, the children were submitted to the Expository Text Reading Comprehension Assessment Test. It is a compilation of texts indicated for each grade of Elementary School, for the present study taking into account the age group of the participants and the grade of the same the text "O Bebê Elefante" was used The children were asked to read the text according to the instructions given by the evaluator, which permeated the following aspects: keeping the text on the table during the entire reading, proper body posture during the evaluation, starting the reading and going to the end of the text, avoiding interruptions, because if otherwise, it would be restarted. In this analysis, the total reading time was computed, with pauses resulting from coughing, throat clearing, or nasal congestion and colds being disregarded. The videos were played in the software and the excerpts that presented pauses were excluded through the resources of the aforementioned software. Speed was calculated by words read per minute.

2.4. Intervention Procedures

The neuropsychopedagogical parental program consisted of a plan of activities that were carried out by the family, together with the child with ADHD. Altogether there are 75 activities, divided into three major areas: cognitive, motor

and socio-emotional. The family received a table with the activities to be carried out in each session and guidelines for their execution. The NPP was performed in 25 sessions (1 activity in the cognitive area; 1 activity in the motor area; 1 activity in the socio-emotional area) of 15 minutes each, at a frequency of 3 times a week.

It should be noted that all participants continued their consultations with psychologists in weekly 50-minute sessions and by neuropsychopedagogues in weekly 50-minute sessions during the period of

2.5. Statistical Procedures

Data analysis was performed based on the comparison of statistical results using the GraphpadPrism 6.0 statistical program. The results obtained in relation to the were initially tested to verify its normality using the Shapiro-Wilk test, being classified as parametric. Therefore, for an analysis of intra-group results first evaluation versus second evaluation and third evaluation versus first evaluation the t test for two paired samples was used. For an intergroup comparison, the ANOVA was used to assess the possible benefits of the intervention developed in the present study.

3. Results

3.1. Signs/Symptoms of ADHD

When looking at Table 1, it can be seen that when evaluated in relation to the presence of signs/symptoms characteristic of individuals with ADHD through SNAP-IV, children in Group A (GA) showed a reduction of ± in the second evaluation (AV2) ±3% in the evaluated signs/symptoms. Children in Group B (GB) showed a reduction of ±10% ($p < 0.05$) in the signs/symptoms evaluated through the SNAP-IV after undergoing NPP.

When establishing a comparison between the groups, it is noted that in EVA2 the children from (GB) showed a superior performance by ±10% compared to children from (GA), a reduction that through the ANOVA, for two independent samples, revealed a $p < 0.01$. It should be noted that for that scale, the lower the

Table 1. Description of the results of children in Group A and B in SNAP-IV.

Categories	GA (EVA1)	GA (EVA2)	GA (EVA3)	GB (EVA1)	GB (EVA2)	GB (AV3)
Minimum	36.00	36.00	36.00	37.00	28.00	28.00
Maximum	61.00	59.00	57.00	64.00	62.00	61.00
Average	48.22	46.94	45.91	49.16	42.16*	40.53*
Standard deviation	5.917	6.010	5.704	7.323	8.606	8.219

EVA, Evaluation; GA—Group A; GB—Group B; *$p < 0.05$ for comparison between EVA2 × EVA1 and EVA3 × EVA1. Unit of measure-points.

value obtained, the better the individual's performance is considered.

Still looking at Table 1, it is possible to see that in the third evaluation (EVA3) the children who underwent PPN, that is, group B, showed a reduction of ±17% in the signs/symptoms evaluated by the SNAP-IV, which means that the gains obtained are maintained even 04 months after the end of the intervention. Likewise, when establishing an intergroup comparison, GB children performed ±11% better ($p < 0.01$) than GA children.

3.2. Motor Competence

When evaluated in relation to motor competence (Table 2), the children from (GA) showed only an increase of ±5% in the second evaluation, whereas the children from (GB) showed an increase of ±33% ($p < 0.01$) in their average performance after being submitted to PPN, which means that the referred program, most likely, provided positive effects on the motor development of these children.

When establishing a comparison between the groups, it is noted that in EVA2 the children from (GB) showed a superior performance by ±21% compared to children from (GA), a performance that, through the ANOVA, revealed a $p < 0.01$.

Still looking at Table 2, it is possible to see that in (EVA3) the children who underwent NPP, that is, group B, maintained the improvement presented in relation to motor competence, since when comparing with EVA1 an increase was revealed of ±39% ($p < 0.01$). Likewise, when establishing an intergroup comparison, GB children performed ±24% better ($p < 0.01$) than GA children.

3.3. Executive Functions

The results obtained by the children in relation to executive functions (Table 3), show that in AV2, children from GA showed an increase of ±05% and children from GB, of ±19% ($p < 0.01$) in the score obtained in the HFKS in relation to EVA1. When establishing a comparison between the groups, it is noted that in

Table 2. Description of the results of children in Group A and B in Supine-to Stand.

Categories	GA (EVA1)	GA (EVA2)	GA (EVA3)	GB (EVA1)	GB (EVA2)	GB (AV3)
Minimum	6.000	7.000	7.000	5.000	7.000	7.000
Maximum	11.00	11.00	11.00	11.00	12.00	13.00
Average	7.906	8.313	8.406	7.531	10.09**	10.47**
Standard deviation	1.329	1.230	1.160	1.218	1.353	1.481

EVA, Evaluation; GA—Group A; GB—Group B; **$p < 0.01$ for comparison between EVA2 × EVA1 and EVA3 × EVA1. Unit of measure-points.

EVA2, children from (GB) presented a superior performance by ±17% compared to children from (GA), with regard to their executive functioning. When establishing an analysis through the ANOVA, such superiority was indeed significant ($p < 0.01$).

Still looking at Table 3, it is possible to see that in (EVA3) the children who underwent PPN, that is, group B, managed to maintain the highest levels in relation to executive functioning. When comparing the performance of EVA3 with the performance obtained in EVA1, an increase of ±28% ($p < 0.01$) was revealed. Likewise, when establishing an intergroup comparison, GB children performed ±23% better ($p < 0.01$) than GA children.

3.4. Reading Comprehension

When looking at Table 4, it can be seen that children from GA showed an increase of ±2% in the average number of words read correctly in one minute, while children who underwent NPP (GB) obtained an increase of ±10% ($p < 0.05$) in the average number of words read correctly in the same time.

When establishing a comparison between the groups, it is noted that in EVA2 the children from (GB) presented a superior performance by ±7% compared to children from (GA), a performance that through the ANOVA revealed a $p < 0.05$.

Table 3. Description of the results of children in Group A and B in HFKS.

Categories	GA (EVA1)	GA (EVA2)	GA (EVA3)	GB (EVA1)	GB (EVA2)	GB (AV3)
Minimum	19.00	20.00	21.00	24.00	30.00	33.00
Maximum	44.00	47.00	46.00	45.00	50.00	51.00
Average	32.19	33.94	34.91	33.41	40.00**	42.96**
Standard deviation	6.884	7.229	7.050	5.841	4.938	4.546

EVA, Evaluation; GA—Group A; GB—Group B; **$p < 0.01$ for comparison between EVA2 × EVA1 and EVA3 × EVA1. Unit of measure-points.

Table 4. Description of the results of children in group A and B in HFKS.

Categories	GA (EVA1)	GA (EVA2)	GA (EVA3)	GB (EVA1)	GB (EVA2)	GB (AV3)
Minimum	43.00	43.00	44.00	41.00	49.00	49.00
Maximum	66.00	66.00	66.00	67.00	69.00	71.00
Average	54.34	55.03	55.00	53.47	58.56*	59.84*
Standard deviation	5.649	5.539	5.465	6.136	5.781	5.513

EVA, Evaluation; GA—Group A; GB—Group B; *$p < 0.05$ for comparison between EVA2 × EVA1 and EVA3 × EVA1. Unit of measure-points.

Still looking at Table 4, it is possible to see that in (EVA3) the children who underwent the PPN, obtained a positive increase ($p < 0.05$) of ±11% in the average performance of words read correctly per minute. Likewise, when establishing an intergroup comparison, children from (GB) had a superior performance by ±9% ($p < 0.05$) in relation to children from (GA).

4. Discussion

Certainly, the impact and effect of the parental program on children can be seen as the results of the SNAP-IV after the application of the NPP and especially after 4 months of the aforementioned program are promising because there are proven decreases in the signs/symptoms of ADHD. This is supported by studies that highlight that in addition to conventional treatments [38] [39], parent-based interventions have been effective in improving signs/symptoms of children with ADHD [40]. Protocols based on knowledge from neurosciences, in addition to cognitive behavioral psychology, showed improvement in signs/symptoms of children with ADHD, mainly in tasks of daily living [41] [42] [43] [44].

Regarding activities of daily living, in general, the results of this study found strong evidence in support of the benefits after a program of cognitive-motor activities structured in more or less six weeks, which revealed significant improvements in the motor competence of children with ADHD. Therefore, it is noteworthy that the structured activities prescribed in this study proved to be effective in stimulating the development of fundamental motor skills in children with ADHD [45] [46]. These findings are similar to those of previous studies, where short- and long-term improvements in motor skills were also reported after exercise programs through recreational activities as proposed in the NPP developed in the present study. [45] [46] [47]. Thus, it is suggested that ludomotor exercises be incorporated into parenting programs for children with ADHD.

Another finding of this study that showed a significant difference between the experimental and control groups after NPP was the score on executive functions, which significantly increased in the experimental group compared to the control group. The benefits of systematic activities with playful and motor aspects that improve performance in tasks that require inhibitory control and cognitive flexibility in children with ADHD are well documented [48] [49] [50], thus corroborating the results found in our study.

Regarding the number of words read correctly per minute on the Reading Comprehension test, we observed significant improvement between pre- and post-intervention, which has a particularly close association with the ADHD core factor of inhibitory control [51] [52]. In light of these results, we assume that interference control, as a core factor in ADHD, improved as a result of the intervention. Taylor *et al.* [47] reported similar improvements in classroom performance in children with ADHD after a mixed exercise and activity program. Thus, structured exercises should be considered as an essential treatment for reducing disruptive behavior in the classroom.

Although this research was carried out with only a small group of children with ADHD, it seems that the NPP can be useful in clinical practice, it is believed that the NPP has an important role in the treatment of ADHD, but it is of paramount importance to carry out research in which a larger sample of participants and more ADHD tests are investigated.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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