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BADS-C INSTRUMENT: AN ECOLOGICAL PERSPECTIVE OF THE EXECUTIVE FUNCTIONS IN CHILDREN WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER

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SUMMARY

Background: Attention-Deficit/Hyperactivity Disorder (ADHD) is nowadays one of the most studied neurobehavioral disturbance. This pathology affects about 5.3% of children worldwide, while there has been registered a significant increase in the rate of prevalence over the last decade. Recent studies have revealed that alongside some characteristic symptoms of this pathology, it also affects the executive functioning. This investigation has as its purpose the studying of the executive functioning in ADHD, through the Behavioral Assessment of the Dysexecutive Syndrome for Children (BADS-C). Designed to evaluate the executive dysfunction in children, this battery is based on a strong ecological validity, making possible a more sensible analysis and obtaining more valid and trustworthy results.

Material/ Methods: 50 patients with ADHD (mean age= 8.79, SD= 1.706) and 50 patients belonging to the control group (mean age= 9.86, SD= 1.678), each group was evaluated with the neuropsychological battery BADS-C.

Results: The group of children with ADHD showed a significant lower performance, not only in the final score, but also in the total amount of time used to complete the battery, in comparison to the control group.

Conclusions: The presence of cognitive impairment in this context stresses the importance of investigative studies into neuropsychological assessment because through the selection of suitable tests to evaluate the executive functioning in a specific way it becomes relevant to the determination of accurate profile data on the functioning and child behavior, allowing for specific and effective therapeutic planning in each case.

Keywords: neurodevelopment, dysexecutive syndrome, behavioral assessment

BACKGROUND

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most studied disturbances nowadays, and at the same time, one of the most controversial. This pathology reflects the most frequent neuropsychological disturbances in childhood and adolescence, as well as one of the major causes when looking for assistance in Mental Health Clinics (Guilherme, Mattos, Serra-Pinheiro & Regalla, 2011). It affects up to 5.3% of children worldwide, and, according to recent studies, a significant increase in the prevailing rate has been recorded during the last decade (Polanczyk, De Lima, Horta Biederman & Rohde, 2007). This prevalence appears to be higher in lower ages, in 75% of the cases ADHD happens before the age of 5 or between the ages of 6 and 9 (Ramalho, 2009).

This disturbance involves heavy individual and social costs, humanly and economically speaking, and could result in significant incapacitating states in adult age (Pardilhão, Marques & Marques, 2009). According to the World Health Organization (WHO), the symptoms of ADHD continue in adult age in about 50% of the affected children (Lara, Fayyad, De Graaf, Kessler, Aguilar-Gaxiola & Angermeyer, 2009). Widely studied at age, investigations estimate that between 3 and 7% of children at this age fulfill the diagnose criteria for ADHD, relating that it exists in a higher prevalence in the male sex of 2:1 in community studies, and 9:1 in clinical studies. However, during development this prevalence has a tendency to decrease (American Psychiatry Association [APA], 2002).

ADHD consists of a neurodevelopmental pathology that affects the behavioral and attention control. It corresponds to a persistent pattern in the subjects' conduct, frequently observed in a more intense severe degree than the one presented by individuals in the same development stage (APA, 2000). This results in a disturbance that shows signs of inadequate development in the child according to its mental and chronological age, regarding the self-control development, expressed by deficits in the attention periods, impulse manipulation and motor activity (Barkley, 2002).

The diagnostic criteria specifies that this disturbance has to generate a serious malfunction in two or more of the child's life contexts (home and school), there existing, by consequence, an interference of these symptoms in their life quality, in both social and academic performance (APA, 2000); the symptoms should persist for at least six months, and occur before the age of 7 (DSM-IV-TR, 2011).

The damages caused are numerous, in this way it is possible to detect deficits in the emotional and academic development which can manifest itself through a low scholar productivity, injuries resulting from distraction, low self-esteem and difficulties in problem resolution. According to Rohde, Eurípedes, Benetti, Gallois and Kieling (2004), over 50% of the ADHD cases, present comorbidities with other clinical boards, among which prominent are learning difficulties, mood and anxiety issues, disruptive behavioral disturbances, as well as, abusive use of drugs and alcohol.

Current studies of ADHD show a multifactorial etiology, and though there does not exist absolutely conclusive evidence as to its specific cause (Rohde, 2003), researches correlate the disturbance with biological, pre and perinatal, genetic and psychosocial factors (Ramalho, 2009).

The ADHD is one of the most investigated disturbances in neuropsychology – researches and studies of meta-analysis summarize the main neuropsychological characteristics of the pathology, investigating this structure field and the cerebral function.

There has been reported the presence of a slight reduction in the total cerebral volume, particularly expressive at the pre-frontal region, caudate nucleus and cerebellum vermin (Shaw, Lerch, Greenstein, Sharp, Clasen, Evans, Giedd, Castllanos & Rapoport, 2006).

Neuroimages obtained through the functional magnetic resonance, showed anomalies that portray the existence of a neuropsychological dysfunction in children with ADHD, showing a lower sustention of the cognitive control (Durston, 2008).

Noted is a lower activation in the interconnected regions between the prefrontal cortex and the corpus striatum during the realization of tasks that demand the inhibition of an automatic and predominant response. Differences in the temporal and parietal regions are equally known in tasks that embrace the use of attentional capacity (Steinhausen, 2009). Neurobiological studies revealed significant alterations in the dopamine distribution, where the decrease of this neurotransmitter affects various executive functions (Selikowitz, 2010). Thus these alterations determine that besides the general symptoms (attention deficit, hyperactivity and impulsiveness), there occurs simultaneously disturbances of more complex functions, such as the executive functions. Recent neuropsychological theories have detected deficits in the executive functions as the main characteristic of ADHD (Di Trani, Casini, Capuzzo,Gentile, Bianco, Menghini, 2010).

The term 'executive function' is not a simple one to define. Lezak in 1982 describes the executive processes as the mental capacities necessary for the elaboration of objectives, effective planning capacity, suggesting that they are equally the center of all social activities and creative and constructive personal effort.

In 2004 he adds to his original definition capacities that allow the individual to successfully participate in independent objectives with self-directed behaviors.

Baron (2004), on the other hand, defines executive functions as a set of metacognitive capacities that allow individuals to realize the stimulus of the environment, to respond adequately, to have the flexibility for change, to anticipate future objectives and to consider the consequences of their actions. The executive functioning shows itself as a neuropsychological construct that includes higher levels of cognitive functioning such as: inhibition and alternation, working memory, sustained and selective attention, impulse control, self-regulation, initiative, mental flexibility, feed-back use, planning, organization and problem solving strategies. The executive functions consist in the cognitive and emotional processes responsible for the dynamic adjustment between reason, behavior and environment. The deterioration of these functions, mainly in the early stages

of development, relates with adaptation difficulties and associates itself to multiple neurodevelopmental disturbances, such as ADHD.

Hence the existence of evaluation instruments for the assessment of the executive functions that are adapted to the development level, interests and culture origin of the child, applied to all their needs becomes a crucial element (Mesquita, 2001). The characterization and measuring of the executive alterations is one of the most challenging aspects for modern neuropsychology.

The neuropsychological sets of instruments that appear to be effective in the evaluation of the executive functioning are relatively limited when dealing with the assessment of children, as different investigators and professionals go chiefly for the same instruments, such as: the Wisconsin Card Sorting Test (WCST), Trail Making Test, STROOP, Wechsler Intelligence Scale for Children (WISC III), among others, originally designed to evaluate other constructs, and proving themselves to be less sensitive to frontal dysfunctions in children.

For the evaluation of this construct it is crucial to create a situation in which the patients expose how and where they self-structure their behavior (Tirapu-Ustárroz, Muñoz-Céspedes & Pelegrín-Valero, 2002), which becomes another problem in the election of an evaluation battery, because instruments requiring the subject to organize and plan their behavior for a long period of time or to establish priorities when confronted with two or more activities are of a limited number (Emslie, Wilson, Burden, Nimmo-Smith, & Wilson, 2003). Therefore the search for new solutions and evaluation batteries reflects an added value to the whole evaluation process, as well as more precise diagnostics.

The choosing of the BADS-C battery for the realization of this study resulted from the notorious advantages it brings when compared to the other batteries, its much higher ecological value: something of crucial importance not only to the investigation but also to the clinical practice. This summarizes the use of day-to-day tasks as a way of evaluation, obtaining more sensible, valid and trustworthy results (Barbosa, 2003), overcoming the handicaps related to the conventional tests.

Although it is relatively recent, according to some authors (Norris & Tate, 2000) the BADS-C has proven itself to be very promising and with a high response potential. Various studies affirm that the battery is sensitive to the combined deficits, usually accepted as being associated with the pre-frontal lobes dysfunctions, by which it constitutes an appropriate tool for t executive dysfunction evaluation (Burgess, Alderman, Evans, Emslie, & Wilson, 1998).

Participants

100 children of both sexes, participated in this study. The experimental group was composed of 50 patients who were diagnosed with ADHD, aged between 7 and 12 (M = 8.79, SD = 1.706). The control group was formed by the same number of subjects, also of the same ages (M = 9.86, SD = 1.678).

For the selection of the participants, we defined the inclusion and non-inclusion criteria for both groups. In the experimental group only children with a positive diagnostic of ADHD were included. These came from the Alto Ave Hospital

Center and were confirmed to be registered in the Mental Health and Psychiatry Department – excluding all of children that were mentally unstable in a psychopathological way at the moment of data retrieval as well as children with diseases related to psychological conditions or late psychomotor development.

In turn, the control group was formed of children who did not have any history of neurological, behavioral or psychiatric problems, who were not under psychopharmacological treatment, and similarly were gathered at the same institution. All participants and their caregivers were informed of the nature and objectives of the study and their participation in the neuropsychological evaluation was voluntary.

MATERIALS AND METHOD

To evaluate the executive function of children a neuropsychological battery, considered to be pertinent and effective for the study, was used: BADS-C.

The Behavioral Assessment of the Dysexecutive Syndrome for Children (BADS-C), as the name implies, is designed to evaluate the syndrome, more specifically, it evaluates the frontal lobe executive function in children and teenagers, between the ages of 7 and 16, using a sub-set of tests covering different executive functions. One of the advantages that this test has is its ecological validity (Wilson, Alderman, Burgess, Esmelie & Evans, 1996), one superior to others tests, since the sub-tests that are a part of the battery are very similar to the participants' daily activities.

So, according to Emslie, Wilson, Burden, Nimmo-Smith & Wilson (2003) the BADS-C comprises 6 sub-tests, of which a standardized result is obtained, it being also possible to obtain information as to the time the child took to perform each task, also allowing one to verify the existence of a slowing down in the executive process velocity. The 'Rules Change' test verifies the ability of the child to alter a pre-established standard response for a new pattern response, providing a cognitive flexible measurement unit of the child, using familiar materials. This task divides itself into two parts, in the first a standard response is established according to a simple rule and in the second one the rule is changed: the subjects must change and adapt their behavioral responses, thereby inhibiting the original pattern response. The 'Action Programme' has as its purpose the solving of practical problems, analyzing the child's capacity to develop an action plan for the resolution of a problem, another feature of this test is the forcing from the subject of a physical manipulation of different materials, in order to solve the practical exercise through the use of reasoning and planning strategies. The 'Key Search' test is a design test of an effective, systematic and deployable action strategy, in which the child has the possibility of monitoring their own performance accordingly to their functionality and probability of success. This test is an analogy to real life situations, just like looking for a lost object. The 'Zoo Map' test evaluates the action planning in selecting a labyrinth course, according to the instruction of various rules which inhibit the selection. First, an open situ-

ation, of undetermined purpose, in which a lower external structuring of behavior is provided, and then, at a second stage that involves simply the following of a concrete behavioral strategy, externally imposed. Finally, the 'Six Elements' test (modified) is used to the process of attentional shifting and maintained attention, which implies that the child – for 5 minutes, organizes and programs their execution time in the realization of 3 sets of tasks.

Procedures

The data gathering and the respective neuropsychological evaluations were carried out, as previously mentioned, in the Alto Ave Mental Health and Psychiatry Hospital Center in Guimarães. Through the hospital ethics commission, which allowed the study to be carried out in the Center, as well as the informed consent granted by the children's legal guardians, since the study participants were minors. Prior to the battery application, we performed a clinical process analysis of all the selected children, with the aim of assuring that each criteria of inclusion and non-inclusion was strictly enforced; following this verification we then proceeded to the evaluation of the executive functions.

The neuropsychological battery used in this study was administered transversally, in the case of being a single assessment, with a duration of approximately 45 minutes depending on the individual performance of the child; each evaluation consisted of a total of 3 sessions, to assemble the medical history, neuropsychological evaluation and finally, the return of the results.

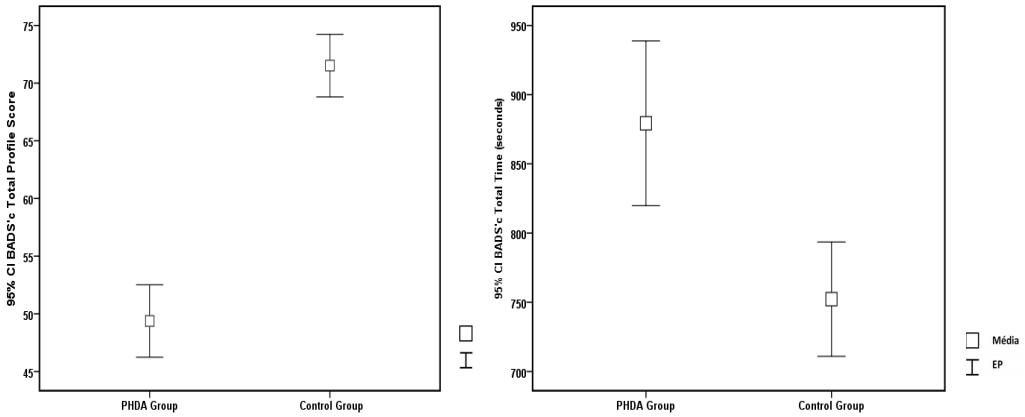
Analysis and Data Handling

For the statistical analysis of the results obtained in the study, we used the statistical analysis computer program SPSS -Statistical Package for the Social Sciences, version 22.0., in which univariate descriptive analysis procedures, namely the measurement of the central tendency and dispersion were taken (averages and standard deviations). Afterwards a univariate descriptive analysis, using the 'Student's T test' for independent samples, was performed. Differences of $p < .05$ were considered to be significant.

RESULTS

In the analysis of the results obtained from the two groups in the implementation of the BADS-C regarding the total score, it can be observed that the experimental group had significantly lower scores (M = 49.38, SD = 11.045) than the control group (M = 71.52, DP = 9543) displaying a substantial and significant difference (t = -10 725), $p < .001$, CI 95% [-26 237, -18 043] (see Figure 1).

Similarly, analysis of the time taken for the full realization of the battery showed a significant difference (t = 3.537, $p < .001$, CI 95% [55 758, 198 334], in relation to the control group (M = 752.26, SD = 145.39) which showed itself to be faster for the execution of the minor test, when compared to the experimental group (M = 879.31, SD = 207 208) (see Figure 2).



Figures 1 and 2. Averages and standard error of the total score obtained and total amount of time taken (in seconds) by the Experimental and Control group in the realization of the BADS-C

Table 1. Averages, Standard Deviations, T Values, P Values and Confidence Breaks of the Experimental and Control groups of the results obtained in each sub-test of the BADS-C

BADS-C Subscales	Experimental Group		Control Goup				95% CI	
	M	*SD*	*M*	*SD*	*t*	*P*	*LL*	*UL*
Rule Shift	5.28	3.654	10.48	3.170	-7.601	<.001	-6.558	-3.842
Action Program	7.04	3.769	12.18	.570	-8.231	<.001	-6.379	-.3901
Key Search	7.84	3.383	11.18	2.939	-5.270	<.001	-4.598	-2.082
Zoo Map 1	11.20	2.642	14.06	2.527	-5.532	<.001	-3.886	-1.834
Zoo Map 2	11.34	3.941	12.46	1.798	-1.828	.071	-2.336	0.96
Modified Six Elements	6.70	2.697	11.16	3.222	-7.505	<.001	-5.639	-3.281

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

Table 2. Averages, Standard Deviations, T Values, P Values and Confidence Breaks in the total amount of time used (in seconds) by the Experimental and Control groups in the performance of the BADS-C sub-tests

Timed BADS -C subscales (seconds)	Experimental Group		Control Goup				95% CI	
	M	*SD*	*M*	*SD*	*t*	*P*	*LL*	*UL*
Rule Shift	31.60	24.620	20.32	15.969	2.718	.008	3.044	19.516
Action Program	175.42	89.731	146.04	84.073	1.690	.094	-5.129	63.889
Key Search	77.42	69.042	59.86	48.997	1.690	.146	-6.200	41.320
Zoo Map 1	164.84	85.094	124.18	53.815	4.604	.005	16.628	42.262
Zoo Map 2	86.32	54.741	68.84	43.806	1.763	.081	-2.196	37.156

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

With regard to the results obtained in each sub-test in the BADS-C, we can observe a substantial difference between the two groups, that is, the group of children with ADHD achieved lower scores than the control group, which in turn demonstrated greater success in concluding the sub-tests in general (see Table 1). The performance differences appear to be statistically significant in all sub-

tests ($p < .05$), with the exception of the 'Zoo Map 2' test, where there were not significant statistical differences ($p < .05$).

In relation to the total amount of time used to complete the battery, in which the conclusion time window is taken into account (sub-testes 1,2,3 and 4), the children group with ADHD showed a need for a larger period of time to complete the tasks, when compared to the control group, which showed itself to be faster; however, in analyzing the results obtained in each sub-test there was no obtainment of significant scores in the following tests: 'Action Program', 'Key Search' and 'Zoo Map 2'.

DISCUSSION AND CONCLUSIONS

The objective of the investigation was to study the executive function in ADHD children, when their performance was compared to children without this disturbance. In this way it was possible to simultaneously verify the sensibility and specificness of the neuropsychological evaluation instrument, BADS-C.

In response to the experimental hypothesis, which was based on the presentation of the lack of executive performance in children with ADHD when compared with the control group, the results of this investigation have demonstrated its validity.

Thus, the results obtained by BADS-C allow one to observe a distinct performance between both of the groups studied in the investigation. We observed that children with ADHD display pressing difficulties in the planning capacity, sustained attention, resistance to interference (inhibition), action strategy planning, temporal organization and the use of feedback.

In general, the scores obtained in the battery showed that the children group with ADHD has a compromising executive function when compared with the control group, presenting more failure in the general completion of the BADS-C, and needing a superior temporal window for the full execution of the battery, in comparison with the children group without the pathology. It is noted that, the children group with ADHD took more time to conclude the battery, obtaining lower scores, unlike the control group that showed itself to be faster and effective.

Through further analysis of the performance in the different sub-tests, we can conclude that the group performance of the children with ADHD was significantly lower in all the battery sub-tests, with the exception of the 'Zoo Map 2' where a significant statistical difference was not observed.

Equally regarding the time taken to complete each task of the battery, where the total time spent is taken into account, the group of children with ADHD turned out to require a larger period of time to complete the tasks, yet this condition did not show itself in all the sub-tests. In the tests: 'Action Programming', 'Key Search' and 'Zoo Map 2', although the completion of the tests also turned out to be slower, this was not reflected in statistically significant results.

With regard to the 'Rules Change' test, children with ADHD showed poor resistance to interference (inhibition), failing to change the default response set for

a new standard of response and demonstrating cognitive inflexibility. With respect to the 'Action Programming' test, although children with ADHD did not demonstrate any physical difficulties in handling the different materials, they showed an inability to plan a set of steps and actions in order to achieve a practical target resolution. In implementing the 'Key Search' test, children with ADHD showed an impulsive pattern without systematic behavior, displaying an inability to construct strategies for efficient and implementable action, as well as the absence of criticism of its implementation, the probability of success and functionality action. In the 'Zoo Map' test, children with ADHD demonstrated impaired judgment and a low action organization, noting again an impulsive pattern. With respect to the 'Zoo Map 2' test, there is a decrease in the number of errors. Finally, in the 'Six Elements' test, we can observe in children with ADHD, difficulties in working memory, attentional shift, sustained attention and time management.

Although the ADHD is a pathology characterized essentially by a lack of attention, hyper kinetic activity and impulsiveness, it is transmitted, has a heterogenic pathology that causes a significant compromise in the cognitive function, including mainly deficits in the attentional capacities and executive functions, alterations originated by the dopaminergic system, causing a hypo function of the frontal cortical and subcortical (Clark, Prior & Kinsella, 2000; Lipowska & Sajewicz-Radtke 2012; Marcinkowska et al. 2012; Tomaszewski et al. 2014).

The low performance displayed by the children with ADHD in BADS-C underlines the seriousness of some cognitive losses, such as the executive function (Charach, 2010). These children displayed difficulties in new situations that demand decision making and self-monitoring, compatible with the conditions in which the cerebral executive function is, theoretical, activated (Oliveira, 2007).

The low performance reflects a reduced mental flexibility capacity on the part of the hyperactive children in planning effective strategies, performance monitoring to solve a problem, capacity to judge and compromised abstract thinking as well as organization and behavioral monitoring (Spreen & Strauss, 1998); these factors suggest that changes underlying these losses may be related to the damage observed daily in children afflicted with the pathology.

A comparison of the results obtained in this study with previous empirical evidence, is difficult because those studies conducted that include the assessment of executive functioning in ADHD, through the neuropsychological assessment battery BADS-C, are extremely few and far between with there being only one study that relates to the subject discussed, namely the study of Shimoni, Engel-Yeger & Tirosh, conducted in 2011. However, the authors only evaluated the construct in a total of 25 male children, aged 8 to 11 . Consequently the current research demonstrates its unique and innovative nature, through its application of a solid battery, with a good theoretical foundation, good psychometric properties and a significant ecological validity, reflecting the everyday problems of executive dysfunction displayed by children with ADHD.

The presence of cognitive impairment in this context stresses the importance of the investigative studies of neuropsychological assessment. As a result of the

selection of suitable tests to evaluate the executive functioning in a specific way, it becomes relevant to the determination of an accurate profile data on the child's functioning and behavior, allowing for a specific and effective therapeutic planning in each case.

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