Neuropsychological differences between attention deficit hyperactivity disorder and control children and adolescents referred for academic impairment

Diferenças neuropsicológicas entre crianças e adolescentes portadores de transtorno da falta de atenção com hiperatividade e controles encaminhados por comprometimento acadêmico

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Abstract

Objective: To compare the performances of children and adolescents with attention deficit hyperactivity disorder with a group of control comparison subjects, both taken from a large clinical sample, using some of the most widely employed attention-based Brazilian tests. *Method: The performances of 186 children and adolescents with attention deficit hyperactivity disorder were compared to that of 80 control individuals based on attention and working memory scores. Both groups had been referred due to academic impairment. All individuals were submitted to the TAVIS-3 sustained, shifted and focused attention tests, as well as to the working memory tests that make up the WISC-III Freedom from Distractibility Index (Digit Span and Arithmetic).* *Results: The control group was slightly older than the attention deficit hyperactivity disorder group (p = 0.07); IQ and schooling did not differ between groups (p = 0.34 and p = 0.38, respectively). While performing a test requiring sustained attention for a longer period of time, the attention deficit hyperactivity disorder group showed a significantly higher number of commission errors compared to the controls, thus presenting sustained attention deficits (p = 0.003); when the influence of IQ, age and schooling was reduced, the attention deficit hyperactivity disorder group also made more omission errors during a sustained attention task in comparison to the control group, thus achieving a borderline significance level (p = 0.08); the attention deficit hyperactivity disorder group also performed worse in Digit Span forward and backward (p = 0.013 and p = 0.01, respectively) and in Arithmetic (p = 0.008). Other scores did not achieve significance.* *Conclusion: Our findings suggest that some of the most commonly used Brazilian attention-based tests - especially the sustained attention and working memory tests - may be useful to help distinguish subjects with attention deficit hyperactivity disorder from control subjects.*

Descriptors: Attention deficit disorder with hyperactivity; Attention; Neuropsychological tests; Adolescent development; Educational status

Resumo

Objetivo: Comparar o desempenho de crianças e adolescentes portadores de transtorno da falta de atenção com hiperatividade e controles de amostra clínica ampla utilizando alguns dos testes de atenção brasileiros mais utilizados. *Método: Desempenho de 186 crianças e adolescentes com transtorno da falta de atenção com hiperatividade foi comparado a 80 controles em medidas de atenção e memória operacional. Ambos os grupos foram encaminhados devido ao comprometimento acadêmico. Todos os participantes foram submetidos a testes de sustentação, alternância de conceitos e seletividade da atenção visual (TAVIS-3), além dos testes de memória operacional que compõem o índice de distratibilidade da bateria WISC-III (Span de Dígitos e Cálculos).* *Resultados: O grupo controle era um pouco mais velho que grupo de portadores (p = 0,07); QI e escolaridade não diferiram entre grupos (p = 0,34 e p = 0,38, respectivamente). Controlando as influências do QI, idade e escolaridade, o grupo de portadores apresentou número de erros por ação em tarefa de sustentação da atenção significativamente maior que os controles (p = 0,003); o grupo de portadores também apresentou mais erros por omissão em tarefa de sustentação da atenção, atingindo nível de significância limítrofe (0,08). O grupo transtorno da falta de atenção com hiperatividade também teve desempenho comprometido no Span de Dígitos ordem direta e reversa (p = 0,013 e p = 0,01, respectivamente) e em Cálculos (p = 0,008). Outras medidas não alcançaram significância estatística.* *Conclusão: Nossos achados podem sugerir que alguns dos testes de atenção mais utilizados em nosso meio podem ser úteis na discriminação de portadores de transtorno da falta de atenção com hiperatividade e controles, especialmente tarefas de sustentação da atenção e memória operacional.*

Descritores: Transtorno da falta de atenção com hiperatividade; Atenção; Testes neuropsicológicos; Desenvolvimento do adolescente; Escolaridade

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Introduction

Attention deficit hyperactivity disorder (ADHD) is a highly prevalent mental disorder among children and adolescents, with a worldwide-pooled prevalence of 5.29%.[1] ADHD is characterized by a persistent pattern of severely impaired attention and concentration and/or impulsive, disorganized, and hyperactive behavior occurring to a degree that is developmentally inappropriate in comparison to peers.[2]

DSM-IV criteria are comprised of two distinct but related symptomatic dimensions, i.e., inattention and hyperactivity-impulsivity. This diagnostic system allows ADHD to be classified into three distinct subtypes: predominantly inattentive (ADHD-I), combined (ADHD-C), and predominantly hyperactive-impulsive (ADHD-HI). This classification has been challenged by studies that suggest that subtypes might vary even in the same individual throughout his or her life span.[3]

Neuropsychological deficits are frequently described in ADHD subjects in domains such as attention and Executive Functions (EFs).[4] Visual sustained attention assessment tools such as Conners' Continuous Performance Test (CPT-II) have been frequently used for both research and clinical issues concerning ADHD, despite controversial results about their discriminant validity.[5] Neuropsychological aspects of ADHD have been widely studied in Brazil, and most of these studies aimed at investigating EFs deficits, as proposed by Barkley's theory.[6] Some studies found no significant differences between ADHD and normal subjects in EFs scores,[7] whereas others found only slight differences.[8] However, Schmitz et al. have found impaired performances in working memory (WM) and other EFs tasks in ADHD subjects when compared to a control group.[9] A meta-analytic review has suggested that EFs deficits are neither necessary nor sufficient to predict all cases of ADHD; also, some studies have suggested that neuropsychological deficits of ADHD individuals are not restricted to EFs domains.[4]

One important issue that is often neglected is the paucity of Brazilian attention tasks to evaluate children and adolescents. Our group has previously demonstrated positive and negative predictive value for ADHD diagnosis using the Test of Visual Attention (TAVIS-3),[10] a computerized task developed to assess focused, sustained and shifted attention to visual stimuli. Some important neuropsychological tests designed to evaluate memory and EFs have been recently adapted for use in Brazil.[11,12] However, to the best of our knowledge, efforts to validate and/or develop attention tests for the purpose of ADHD diagnosis are scarce.

The current study aimed at comparing performances of ADHD children and adolescents and control subjects from a large clinical sample using some of the most commonly used Brazilian tests based on attention systems. All individuals had been referred because of academic impairment; the complaint was either reported on the referral document sent by the health professional in charge of the patient and/or made by the parents. All individuals had school reports attesting such impairment. We hypothesized that the ADHD group would perform worse than the control group, despite having been referred for the same reasons.

Method

We performed a retrospective analysis of the database of a private center specialized in ADHD and learning disorders in Rio de Janeiro (*Centro de Neuropsicologia Aplicada*). Children and adolescents aged 8 to 16 years who had been diagnosed with ADHD without any comorbid learning, mood or anxiety disorders between 2003 and 2006 were included in the study. Children and adolescents had been referred to the center by physicians - mainly psychiatrists and psychologists; only a few subjects had been referred to the center by their schools.

Parents were interviewed using a semi-structured interview based on DSM-IV criteria in order to establish the presence of ADHD. Interviews were conducted by a highly trained psychologist (GC). All subjects were treatment-naïve for ADHD. The control comparison group comprised children and adolescents without ADHD, mood, anxiety or learning disorders. Both groups were submitted to the same diagnostic procedures. Our control group differed from those often used in other studies mainly because it comprised individuals who had been referred for neuropsychological evaluation due to significant academic impairment. This aspect is of utmost importance, since the discrimination of ADHD samples from normal controls does not provide relevant data regarding differences between ADHD and non-ADHD related burdens on academic performance.

Individuals with an estimated IQ (WISC-III)[13] lower than 80 in both the ADHD and the control groups were excluded from the analysis. All collected data were studied by a certified board psychiatrist (PM) for purposes of a final diagnosis.

Children were submitted to several tests. TAVIS-3[10] assesses focused, shifted and sustained attention; this task also provides scores on hit reaction time, omission and commission errors for each of the aforementioned features of visual attention. Digit Span (WISC-III) assesses phonological loop (span forward) and central executive (CE) (span backward) abilities. The WISC-III arithmetic subtest was also administered because it requires the subject to mentally solve arithmetic tasks, thus requiring WM (both storage and manipulation) ability; this is also one of the tasks that are included in the WISC-III Freedom from Distractibility Index.

The study was approved by the Ethics Committee of the Psychiatry Institute of the Federal University of Rio de Janeiro (Protocol No. 14liv2/07).

1. Statistical analysis

Since most variables had a non-normal distribution according to the Kolmogorov-Smirnov's test, we used the non parametric Mann-Whitney test to compare the groups' demographic variables (IQ, age and schooling) and neuropsychological scores; a Pearson Chi-Square test was also used to compare gender distribution between groups. Considering the neuropsychological scores presenting statistically significant differences between the groups, we used the Generalized Linear Model with group (ADHD x Control) as a factor, and IQ, age and schooling as covariates. Differences below $p < 0.05$ were considered to be significant.

Results

From an initial sample of 245 ADHD children and adolescents, 59 were excluded for presenting comorbid disorders (26 had learning disorders, 20 had anxiety disorders and 13 filled the criteria for major depression). A total of 186 children and adolescents with ADHD were included in the study. The proportion of ADHD was higher among boys (84.9%), and ADHD-C was more prevalent than ADHD-I (53.76% and 46.2%, respectively). ADHD-HI individuals were not included because the prevalence of this subtype was small (4.62% of the total ADHD sample). Eighty children and adolescents comprised the control comparison group. Boys were the majority of the control group (76.25%). ADHD individuals were somewhat younger than the control subjects (mean: 11.50; SE: 0.17; mean: 12.38; SE: 0.27, respectively) ($p = 0.07$). However, schooling

level (ADHD – mean: 5.16; SE: 0.16; and control – mean: 5.40; SE: 0.26) and IQ (mean: 96.83; SE: 0.74; mean: 98.45; SE: 1.34, for ADHD and control groups, respectively) were similar between groups (p = 0.38 and p = 0.34, respectively). Gender distribution did not differ between groups (p = 0.15).

1. Neuropsychological assessment

The ADHD group showed a worse performance in span forward (p = 0.013), span backward (p = 0.001) and arithmetic (p = 0.008). The ADHD group also performed worse in tasks that demand controlling attention for a longer period of time (TAVIS-3 sustained attention task), with a higher number of commission errors compared to the control group (p = 0.003). Omission errors in the same sustained attention task reached a borderline significance level (p = 0.08). Other scores did not differ between groups (Table 1).

In a Generalized Linear Model, we found an association between IQ and span forward (Wald Chi-Square = 11,164; df = 1 and p = 0.01); IQ, age and span-backward (Wald Chi-Square = 22.834; df = 1 and p < 0.001; Wald Chi-Square = 4.189; df = 1 and p = 0.041, respectively) and in IQ, age and arithmetic (Wald Chi-Square = 17.188; df = 1 and p < 0.001; Wald Chi-Square = 118.478; df = 1 and p < 0.001, respectively). No association was found for the TAVIS-3 sustained attention task.

Discussion

The current paper aimed at investigating how a commonly used Brazilian neuropsychological test battery could help differentiate ADHD from control individuals. Such design mimics what clinicians see in their everyday clinical practice, i.e., individuals with complaints of a low academic performance who are referred for neuropsychological evaluation. The proportion of ADHD was higher among boys, in accordance with other studies with clinical samples.[13]

Our findings showed that ADHD subjects made more omission errors than the control group in a sustained attention task with discrepancies reaching a borderline significance level (p = 0.08); we also found that ADHD individuals were more impulsive than control subjects, with commission errors in the sustained attention task reaching a significant level (p = 0.003). Our results are in accordance with previous findings[4,10] as well as with Barkley's theory,[6] which suggested that ADHD subjects would present significant inhibition deficits.

We found significant differences between the ADHD and control groups in all verbal WM scores (span forward, span backward and arithmetic; p = 0.013, p = 0.01 and p = 0.008, respectively),

and these findings are in accordance to a Brazilian study with a non-clinical sample.[9] Nevertheless, other studies have found no differences between ADHD and control groups on WM scores;[7,8] a meta-analysis conducted by Martinussen et al. has also described controversial results.[15] This is an issue of special interest because WM plays a critical role in guiding a person's everyday behavior which, in turn underlies his or her ability to perform complex tasks such as learning, comprehension, reasoning, and planning. It is noteworthy that behaviors associated with WM deficits are often the main complaints that bring ADHD individuals to seek treatment in specialized centers like ours. We must consider that some of the neuropsychological tasks often used in everyday clinical practice to assess WM such as Digit Span are not sensitive enough to detect deficits faced by individuals, thus compromising the ecological validity of these tools.[15] This being the case, differences found in our study might be associated to our sample size that is larger than that used in other Brazilian studies.[7-9]

Our study did not aim at investigating the impact of comorbidity in ADHD, and patients with comorbid disorders were excluded. However, our findings should be interpreted in light of certain limitations: 1) our sample came from a high socioeconomic background and our findings may therefore not be easily generalized to the overall Brazilian population; and 2) it is possible that different schools use different reasons and standards to identify academic impairment.

Conclusion

Taken together, our findings suggest that tests that demand sustained attention might be useful in discriminating ADHD from control subjects, especially when considering omission and commission errors. These findings are of special interest for clinicians because our study was designed in such a way as to replicate everyday clinical practice. However, clinicians might consider that in spite of the discrepancy seen between the performances of the ADHD and control groups on certain neuropsychological tasks, those deficits are neither necessary nor sufficient to diagnose individuals who seek treatment. It is necessary to associate test performance with information from other sources that are ideally based on the DSM-IV criteria. For the purpose of conducting an ADHD evaluation, additional research is needed to assess differences between ADHD and control individuals using a larger neuropsychological battery to better investigate certain important cognitive abilities, such as decision making and visual-spatial WM, as well as the influence of emotional domain.

Table 1 – Performance of ADHD and control groups in WM and attention tasks

Subtest	ADHD		Control		Mann-Whittney	
	Mean	SD	Mean	SD	Z	p
Digit Span forward	5.73	1.23	6.20	1.34	-2.483	0.013
Digit Span backward	3.90	1.15	4.39	1.22	-3.259	0.01
Arithmetic	17.60	3.03	18.74	3.23	-2.632	0.008
HRT – 1	0.50	0.07	0.49	0.07	-0.896	0.37
HRT – 2	0.59	0.11	0.58	0.13	-0.414	0.68
HRT – 3	0.45	0.11	0.43	0.10	-1.449	0.15
OE – 1	3.05	3.36	3.54	4.37	-0.282	0.78
OE – 2	2.16	2.15	2.32	2.62	-0.013	0.99
OE – 3	0.08	0.33	0.00	0.00	-1.721	0.08
CE – 1	5.73	5.80	5.42	6.32	-0.390	0.70
CE – 2	4.50	4.00	3.36	2.21	-1.426	0.154
CE – 3	4.30	9.61	2.00	3.33	-2.963	0.003

HRT – Hit reaction time; OE – Omission errors; CE – Commission errors; 1 – Task 1; 2 – Task 2; 3 Task 3; TAVIS-3 task 1: focused attention; TAVIS-3 task 2: shifted attention; TAVIS-3 task 3: sustained attention.

Disclosures

Writting group member	Employment	Research grant[1]	Other research grant or medical continuous education[2]	Speaker's honoraria	Ownership interest	Consultant/ Advisory board	Other[3]
Gabriel Coutinho	CNA	-	-	-	-	-	-
Paulo Mattos	UFRJ	Janssen Cilag*	Janssen Cilag*	Janssen Cilag*	-	Janssen Cilag*	-
Leandro Malloy-Diniz	UFMG	-	-	-	-	-	-

Modest
*** Significant*
*** Significant. Amounts given to the author's institution or to a colleague for research in which the author has participation, not directly to the author.*
Note: CNA = Centro de Neuropsicologia Aplicada; UFRJ = Universidade Federal do Rio de Janeiro; UFMG = Universidade Federal de Minas Gerais.
For more information, see Instructions for authors.

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