Original Article

Artigo Original

Fine motor, sensory and perceptive function of students with attention deficit disorder with hyperactivity

Função motora fina, sensorial e perceptiva de escolares com transtorno do déficit de atenção com hiperatividade

Paola Matiko Martins Okuda[1]
Fábio Henrique Pinheiro[2]
Giseli Donadon Germano[1]
Niura Aparecida de Moura Ribeiro Padula[3]
Maria Dalva Lourencetti[4]
Lara Cristina Antunes dos Santos[4]
Simone Aparecida Capellini[5]

Keywords

Motor skills
Attention deficit disorder with hyperactivity
Learning
Evaluation
Handwriting

ABSTRACT

Purpose: To characterize and compare the fine motor, sensory and perceptive functions of students with Attention Deficit Disorder with Hyperactivity (ADHD) and students with good academic performance, without behavior alteration. **Methods:** Participants were 22 male students from Elementary School distributed into: GI – 11 children with ADHD; and GII – 11 students with good academic performance and no behavior alteration. Students were submitted to the Protocol for Evaluation of Fine Motor, Sensory and Perceptual Function, and to the Dysgraphia Scale. **Results:** There were differences between GI and GII in tasks concerning fine motor function, sensory function, and perceptual function, with lower performance from GI. All students in GI presented dysgraphia. **Conclusion:** Students with Attention Deficit Disorder with Hyperactivity present lower performance regarding fine motor, sensory and perception functions in relation to students with good academic performance. These difficulties can cause significant impact on academic performance, impairing the development of written language and causing dysgraphia in these students.

Descritores

Destreza motora
Transtorno do déficit de atenção com hiperatividade
Aprendizagem
Avaliação
Escrita manual

RESUMO

Objetivo: Caracterizar e comparar as funções motoras fina, sensorial e perceptiva de escolares com Transtorno do Déficit de Atenção com Hiperatividade (TDAH) e escolares com bom desempenho escolar sem alterações de comportamento. **Métodos:** Participaram 22 escolares do ensino fundamental, de gênero masculino, distribuídos em: GI – 11 escolares com Transtorno do Déficit de Atenção com Hiperatividade; e GII – 11 escolares com bom desempenho acadêmico e sem alterações de comportamento. Os escolares foram submetidos à aplicação do Protocolo de Avaliação da Função Motora Fina, Sensorial e Perceptiva e da Escala de Disgrafia. **Resultados:** Houve diferença nas tarefas de função motora fina, função sensorial e função perceptiva entre o GI e o GII, com desempenho inferior do GI. Todos os escolares de GI apresentaram disgrafia. **Conclusão:** Escolares com Transtorno do Déficit de Atenção com Hiperatividade apresentam desempenho inferior aos escolares com bom desempenho acadêmico em relação às funções motoras fina, sensorial e perceptiva. Tais dificuldades podem causar impacto significativo sobre o desempenho acadêmico, uma vez que comprometem o desenvolvimento da linguagem escrita, ocasionando disgrafia nesses escolares.

Correspondence address:
Simone Aparecida Capellini
Av. Hygino Muzzy Filho, 737, Campus Universitário, Marília (SP), Brasil, CEP: 17-525-900.
E-mail: sacap@uol.com.br

Received: 3/30/2011

Accepted: 5/24/2011

Study developed at the Department of Speech-Language Pathology and Audiology, School of Philosophy and Sciences, Universidade Estadual Paulista "Júlio de Mesquita Filho" – UNESP – Marília (SP), Brazil.
(1) Investigation Laboratory in Learning Disabilities, School of Philosophy and Sciences, Universidade Estadual Paulista "Júlio de Mesquita Filho" – UNESP – Marília (SP), Brazil.
(2) Graduate Program in Education, School of Philosophy and Sciences, Universidade Estadual Paulista "Júlio de Mesquita Filho" – UNESP – Marília (SP), Brazil.
(3) Department of Neurology e Psychiatry, Medical School, Universidade Estadual Paulista "Júlio de Mesquita Filho" – UNESP – Botucatu (SP), Brazil.
(4) Child Neurology Ambulatory – Learning Disabilities, General Hospital, Medical School, Universidade Estadual Paulista "Júlio de Mesquita Filho" – UNESP – Botucatu (SP), Brazil.
(5) Department of Speech-Language Pathology and Audiology, and Graduate Program in Education, School of Philosophy and Sciences, Universidade Estadual Paulista "Júlio de Mesquita Filho" – UNESP – Marília (SP), Brazil.

INTRODUCTION

The Attention Deficit Disorder with Hyperactivity (ADHD) is a neuropsychiatric disorder frequently diagnosed in childhood and may persist into adulthood in about 60 to 70% of cases, and then become relatively chronic, affecting many areas of the main activities of life since childhood[1].

The principal features of the framework are: inattention, impulsivity and psychomotor agitation, which can vary to a higher or lower degree, according to the subtype, namely: predominantly inattentive, predominantly hyperactive/impulsive or combined[2].

Over the last years, studies[3-6] have shown that students with ADHD have brain dysfunction, particularly in the frontal lobes (frontal-striatal-cerebellar network), which can cause changes in cognitive mechanisms, such as sustained attention, executive functions, deficits in motor inhibition and psychomotor agitation, which impair the acquisition of oral and written language and, therefore, learning.

According to the literature[7-10], students with ADHD have motor disorders related to hyperactivity, lack of attention, executive dysfunction and alterations in working memory and planning, responsible functions for praxis-productive performance of motor skills, which may damage most refined fine motor activities, such as writing.

Considering that one of the motor actions which require a higher degree of integration and adequate functioning of the central nervous system is the fine motor function, which is characterized as the ability to control a set of activities involving the movement of certain body segments, with the use of minimum force, in order to achieve a precise answer to the task[11], the literature[12] suggests that changes related to motor function can cause failures in the adequate development of writing skills.

Thus, changes in fine motor function can affect the performance of children in school in different ways, influencing both the quality and quantity of learning within the classroom, concerning motivation and self-esteem of children, generally causing changes on the fine motor coordination, responsible for the design of writing (graphics), because this is one of the most difficult skills to be learned, as a result of multiple functions that join and coordinate work, since the central nervous system to muscles, joints and tendons[13-16].

The changes at any level of motor function, since the capture of sensory information, its processing and sequencing to the motor act itself, lead to impaired writing ability, which is known as dysgraphia, and can achieve between 10% and 30% of students in the general population, being characterized by difficulty in writing, illegible handwriting, improper shape of the letter and spelling mistakes, hence impeding understanding,[12, 16-17].

Both, the difficulty in fine motor coordination as dysgraphia, can coexist with Attention Deficit with Hyperactivity Disorder (ADHD), being considered as manifestations associated with ADHD, as demonstrated by national[3,18] and international[17-21] studies.

Thus, based on the above, this study aimed to characterize and to compare the fine motor, sensory and perceptive function of students with ADHD with students with Attention Deficit Disorder with Hyperactivity (ADHD) and students with good academic performance and without behavior alteration.

METHODS

This study was approved by the Research Ethics Committee of the School of Philosophy and Science – FFC/UNESP, Marília (SP), Brazil, under protocol number 2004/2009. Before starting the assessments, parents or guardians of selected participants signed the Term of Free and Informed Consent, authorizing the study.

The study included 22 students aged 8 years and 6 months to 11 years and 6 months of age, 100% male, average socioeconomic level. All the students attended public schools, basic education. The classification of socioeconomic status was based on statistical analysis of the Index of Socioeconomic Development – IDESE[22], thereby, ensuring the homogeneity of the sample of average socioeconomic point of view. The children were divided into two groups:

- Group I (GI): 11 students with interdisciplinary diagnosis of attention deficit and hyperactivity disorder (ADHD). The ages of the students in this study ranged from 8 years and 6 months to 11 years and 6 months. All students were selected from the confirmed interdisciplinary diagnosis of ADHD, obtained from neurological, neuropsychological, speech language therapy and occupational therapy assessments in the Investigation Laboratory of Learning Disabilities of the institutions in which the study was conducted.
- Group II (GII): 11 students with good academic performance, selected according to recommendation of their teachers, as satisfactory performance (grade higher than 5.0) in two consecutive grading periods, in tests of Portuguese Language and Mathematics, paired with GI in age and gender. These students did not have any observations concerning pre, peri and post-natal delays in neuropsychomotor and language development or behavioral changes described in the school records, about the students.

For this study, the following procedures were applied:

a) Evaluation of Fine Motor, Sensory and Perceptual Function[23]: This instrument involves areas that represent different subsystems of motor control, providing a means of evaluating the school age child. The assessment is divided into three parts:

- *Fine motor function* (FMF), which includes the following specific tests: Grips (fingertip, pencil grip, grab cylinder, stick with the palm of the hand, hold the key) (FMF1), Put coins into a box (FMF2) , Pegboads (FMF3), Pour water from one glass to another (FMF4), Screw nuts onto a bolt (FMF5), Thread small beads on a string (FMF6) and finger--thumb opposition (FMF7).
- *Sensory function* (SF): Position sense (FS1), Touch (SF2), Pain (SF3), temperature (SF4), Differentiation: sharp object and blunt (SF5); Stereognosis (SF6), Graphesthesia (SF7), Two points Discrimination (SF8) and Extinction (SF9).
- *Perceptual function* (PF): Imitation of postures (PF1), Buttoning five buttons (PF2,) Tie a bow (PF3), Tracing of a flower (PF5) and Cutting a circle (PF6).

The item cooperation (COOP), refers to the cooperation of the students in the realization of assessment tests. The tests were designed[23] to evaluate both hemibody, and the score must be calculated by the simple average between them, that is, the sum of points for each hemibody in certain test, divided by two. Through the individual scores of each test, we get the final classification of the assessment by adding the points from all of them and dividing by the total number of tests, which can demonstrate the following result: severe dysfunction (SD): average between 0.0 and 0.9, moderate dysfunction (MD): average between 1.0 and 1.9, mild (M): average between 2.0 and 2.8, and no dysfunction (ND) average from 2.9 and 3.0.

b) Scale of Dysgraphia[24]: Assessment that allows the analyzes of the following writing aspects: flowing lines, progeny and/or ascending lines, irregular space between words, retouched letters, curvatures and angles of the arches of the letters m, n, u and v, junction points, collisions and adherences, sudden movements, irregular in size and bad forms. The score should be calculated by the total sum of results for each analysis of the spelling, resulting into a classification as non-dysgraphic, when the score was up 8 points and dysgraphia when the score was above eight points.

The students of GI were evaluated at the Investigation Laboratory in Learning Disorders from the Department of Speech-Language Pathology and Audiology of the institutions where the study was carried out, after 30 minutes of drug administration (methylphenidate), whereas in the absence of medication, it was not possible to make the evaluation proposed in this study. These students were drug users for exactly six months before this study. The students of GII were evaluated in a classroom provided by the coordinating education, at a predetermined time by the teacher from each student. The procedures were applied in an evaluation session, 60 minutes long.

The results were analyzed using the Mann-Whitney test, with the purpose of detecting differences in performance on fine motor, sensory and perceptual tests between the groups in this study; Friedman test for detecting differences in performance among groups in the fine motor, sensory and perceptual function compared concurrently, and Wilcoxon Signed-Rank Test, adjusted by Bonferroni correction, to identify which tests differ among themselves, when compared pairwise. The level of significance (p-value), was 5% (0.050).

RESULTS

The performance of GI and GII on fine motor, sensory and perceptual functions was verified (Table 1). It was observed that the students in GI showed differences in relation to GII in four tests of fine motor function, six tests in sensory function, and three tests of perceptual function. These data indicated that the performance of GI in the motor tests assessed were lower than the performance of GII. This result is confirmed by the difference in the total score, obtained in the comparison of performance between GI and GII.

Based on the data that indicated differences in the motor, sensory and perceptual tests between GI and GII, a test was

Table 1. Comparison of the performance of students in GI and GII regarding fine motor function, sensory function and perceptual function

Variables	Group	n	Mean	SD	p-value	Variable	Group	n	Mean	SD	p-value
FMF1	I	11	2.45	0.52	0.005*	SF6	I	11	2.36	0.92	0.013*
	II	11	3.00	0.00			II	11	3.00	0.00	
FMF2	I	11	3.00	0.00	>0.999	SF7	I	11	3.00	0.00	0.031*
	II	11	3.00	0.00			II	11	2.55	0.69	
FMF3	I	11	2.09	0.30	0.003*	SF8	I	11	1.55	0.52	<0.001*
	II	11	2.73	0.47			II	11	2.82	0.41	
FMF4	I	11	3.00	0.00	>0.999	SF9	I	11	1.73	0.79	<0.001*
	II	11	3.00	0.00			II	11	3.00	0.00	
FMF5	I	11	3.00	0.00	0.031*	PF1	I	11	2.45	0.82	0.274
	II	11	2.64	0.51			II	11	2.82	0.41	
FMF6	I	11	2.64	0.51	0.136	PF2	I	11	2.09	0.54	<0.001*
	II	11	2.91	0.30			II	11	3.00	0.00	
FMF7	I	11	1.18	0.41	<0.001*	PF3	I	11	1.64	0.67	<0.001*
	II	11	2.55	0.69			II	11	3.00	0.00	
SF1	I	11	1.82	0.60	<0.001*	PF4	I	11	2.00	0.45	0.003*
	II	11	3.00	0.00			II	11	2.73	0.47	
SF2	I	11	3.00	0.00	>0.999	PF5	I	11	2.64	0.51	0.350
	II	11	3.00	0.00			II	11	2.82	0.41	
SF3	I	11	1.91	0.94	0.002*	COOP	I	11	2.64	0.67	0.261
	II	11	3.00	0.00			II	11	2.91	0.30	
SF4	I	11	2.82	0.41	0.147	Total	I	11	48.18	7.67	<0.001*
	II	11	3.00	0.00			II	11	63.36	1.80	
SF5	I	11	3.00	0.00	0.317	Avarege	I	11	2.32	0.25	<0.001*
	II	11	2.91	0.30			II	11	2.87	0.08	

* Significant values (p≤0.05) – Mann-Whitney test

Note: FMF fine motor function; SF = sensory function; PF = perceptual function; COOP = cooperation; SD = standard deviation

applied to verify differences in the set of tests that allows the analysis of fine, sensory and perceptual motor functions between GI and GII (Table 2). It was observed that GI showed differences in the tests of fine motor function (FMF), sensory function (FS) and Perceptual Function (FP), while the GII showed difference in the tests of fine motor function (FMF) and sensory function (SF). These data demonstrated that the students of GI showed lower performance in than the GII in the tests of fine motor, sensory and perceptual function.

From the examination of differences in the tests assessed, we verified in which tests that compose the assessment of fine motor function the students of GI and GII showed differences in the comparison between them (Table 3).

The results showed that in the tests of sensory function (SF), the group GI showed difference in the test of sensory function 8 (SF8), when compared to the test of sensory function 4 (SF4) (Table 4).

The comparisons between the tests of perceptual function (PF) had similar averages when compared simultaneously and thus, there was no reason for the realization of pairwise comparison.

The results of dysgraphia scale showed variables constant and thus, demonstrated that 100% of the students of the GI had dysgraphia and 100% of the students of GII showed no dysgraphia. The dysgraphia presented by the students of IG was characterized by flowing lines, descended lines, retouched letters, curvatures and angles of the arches of the letters m, n, u, collisions and adherences, sudden movements, irregular in size and incorrect forms.

DISCUSSION

Based on the data obtained, it could be observed that students with ADHD showed delayed development of fine motor, sensory and perceptual skills and dysgraphia, corroborating to the national[13,18,25] and international[8,19-20] literature. The alterations in fine motor, sensory and perceptual functions impair normal development and the refinement of fine motor coordination during the natural sequence of development. Such changes affect the way the improvement of coordination occurs in more complex activities such as using tools like pencils and scissors, or even for simple use, or more independent use of the hands and fingers[13,16,26].

As seen on the results of this study, students with ADHD had difficulty in performing fine motor activities such as: holding pins in the cork, screw and thumb-finger opposition, difficulties in sensory motor functions such as: hand position, touch, sharp differentiation, stereognosis , grafoestesia and two-point discrimination, and difficulty in perceptual motor functions such as: buttoning, drawing and give bond. These fine motor, sensory and perceptual activities require proper grip, strength and graduate pressure and synchronization of movement, requiring a high degree of dexterity and coordination necessary for the acquisition of graphics. In addition, there must be neurop-

Table 2. Peformance of the students of GI and GII on the block of tests of fine motor function, sensory function and perceptual function

Block of variables	n	Group I			Group II		
		Mean	SD	p-value	Mean	SD	p-value
FMF1	11	2.45	0.52	<0.001*	3.00	0.00	0.032*
FMF2	11	3.00	0.00		3.00	0.00	
FMF3	11	2.09	0.30		2.73	0.47	
FMF4	11	3.00	0.00		3.00	0.00	
FMF5	11	3.00	0.00		2.64	0.51	
FMF6	11	2.64	0.51		2.91	0.30	
FMF7	11	1.18	0.41		2.55	0.69	
SF1	11	1.82	0.60	<0.001*	3.00	0.00	0.010*
SF2	11	3.00	0.00		3.00	0.00	
SF3	11	1.91	0.94		3.00	0.00	
SF4	11	2.82	0.41		3.00	0.00	
SF5	11	3.00	0.00		2.91	0.30	
SF6	11	2.36	0.92		3.00	0.00	
SF7	11	3.00	0.00		2.55	0.69	
SF8	11	1.55	0.52		2.82	0.41	
SF9	11	1.73	0.79		3.00	0.00	
PF1	11	2.45	0.82	<0.003*	2.82	0.41	0.199
PF2	11	2.09	0.54		3.00	0.00	
PF3	11	1.64	0.67		3.00	0.00	
PF4	11	2.00	0.45		2.73	0.47	
PF5	11	2.64	0.51		2.82	0.41	

* Significant values (p≤0.05) – Friedman test

Note: FMF fine motor function; SF = sensory function; PF = perceptual function; SD = standard deviation

Table 3. Pairwaise comparison of the performance of the students in GI and GII in the tests of fine motor function

Pair of variables	p-value	
	Group I	Group II
FMF2 – FMF1	0.014	>0.999
FMF3 – FMF1	0.046	0.083
FMF4 – FMF1	0.014	>0.999
FMF5 – FMF1	0.014	>0.999
FMF6 – FMF1	0.414	0.317
FMF7 – FMF1	0.004	0.059
FMF3 – FMF2	0.002*	0.083
FMF4 – FMF2	>0.999	>0.999
FMF5 – FMF2	>0.999	0.046
FMF6 – FMF2	0.046	0.317
FMF7 – FMF2	0.002*	0.059
FMF4 – FMF3	0.002*	0.083
FMF5 – FMF3	0.002*	0.705
FMF6 – FMF3	0.014	0.317
FMF7 – FMF3	0.002*	0.317
FMF5 – FMF4	>0.999	0.046
FMF6 – FMF4	0.046	0.317
FMF7 – FMF4	0.002*	0.059
FMF6 – FMF5	0.046	0.083
FMF7 – FMF5	0.002*	0.763
FMF7 – FMF6	0.003	0.157

* Significant values (p≤0.05) – Wilcoxon Signed-Rank test, adjusted by Bonferroni correction

Note: FMF = fine motor function

sychological integrity, particularly regarding the sensory motor integration necessary for the organization of the information required for the execution of fine movements[8,13,16,26-28].

As described in the literature[5,6], the student with ADHD presents neurological dysfunction in the region of the frontal lobes (frontal-striatal-cerebellar). Therefore, it is expected to present difficulties compatible with those verified during the execution of the tasks proposed in the assessment, i.e., changes related to fine motor, sensory and perceptual function. This same neurological region, which is dysfunctional in students with ADHD, is responsible for planning, organizing and executing the motor act[29].

The difficulties in manual dexterity and sensory-perceptual aspects, as a result of such neurological deficits justify the results of the assessment, of which all students in the ADHD group showed changes in fine motor, sensory and perceptual functions and dysgraphia. These data corroborate to the national[3,18,30] and international[17-20,21,26] literature, indicating that these kinds of manifestations are commonly found in patients with attention deficit with hyperactivity disorder.

Studies have shown that the population with ADHD presents changes in fine motor, sensory and perceptual, difficultind two-hand coordination, manual dexterity, the dissociation and motor precision. Such changes justified the occurrence of dysgraphia in this population[18,26].

The findings of this study suggest that the dysgraphia is a type of common manifestation of being found in students with ADHD. Thus, we must take into account that students with

Table 4. Pairwaise comparison of the performance of students in GI and GII in the tests of sensory function

Pair of variables	p-value		Pair of variables	p-value	
	Group I	Group II		Group I	Group II
SF1 –SF1	0.004	>0.999	SF8 – SF3	0.271	0.157
SF3 –SF1	0.739	>0.999	FS9 – SF3	0.414	>0.999
SF4 –SF1	0.005	>0.999	SF5 –SF4	0.157	0.317
SF5 –SF1	0.004	0.317	SF6 – SF4	0.059	>0.999
SF6 –SF1	0.124	>0.999	SF7 –SF4	0.157	0.059
SF7 –SF1	0.004	0.059	SF8 –SF4	0.002*	0.157
SF8 –SF1	0.180	0.157	SF9 –SF4	0.010	>0.999
SF9 –SF1	0.655	>0.999	SF6 –SF5	0.034	0.317
SF3 –SF2	0.014	>0.999	SF7 –SF5	>0.999	0.157
SF4 –SF2	0.157	>0.999	SF8 –SF5	0.003	0.564
SF5 –SF2	>0.999	0.317	SF9 – SF5	0.006	0.317
SF6 –SF2	0.034	>0.999	SF7 –SF6	0.034	0.059
SF7 –SF2	>0.999	0.059	SF8 –SF6	0.013	0.157
SF8 –SF2	0.003	0.157	SF9 –SF6	0.035	>0.999
SF9 –SF2	0.006	>0.999	SF8 –SF7	0.003	0.317
SF4 –SF3	0.026	>0.999	SF9 –SF7	0.006	0.059
SF5 –SF3	0.014	0.317	SF9 –SF8	0.414	0.157
SF6 –SF3	0.190	>0.999	SF8 –SF3	0.271	0.157
SF7 –SF3	0.014	0.059	SF9 –SF3	0.414	>0.999

* Significant values (p≤0.05) – Wilcoxon Signed-Rank test, adjusted by Bonferroni correction

Note: FS = sensory function

ADHD, for present changes in the functions responsible for praxis-productive performance of fine motor skills, sensory and perceptual, exacerbate by the characteristic neurological deficit of ADHD[7,8], may present a significant loss in their academic performance and social impairment, due to the acquisition and learning of written language[4].

National[3,18] and international[7,8] studies indicate that 10 to 34% of school-age children are not prepared for the use of efficient performance in fine motor, sensory and perceptual function for the development of writing activities in the school context. Thus, it is necessary the development of fine motor and psychomotor activities in these students, in order to minimize the negative impacts of changes in fine motor academic context.

During the study, the found limitation refers to the lack of studies on the subject, which would allow an analysis of the used criteria and the comparison of the obtained results. Allied to this, based on the findings of this research, we suggest that the study of this subject be expanded to a greater number of students, which will enable a better delineation of the description of the change skills and its consequences for the academic and social context.

CONCLUSION

Students with Attention Deficit Disorder with Hyperactivity presented performance below the students with good academic performance regarding the fine motor, sensory and perceptual function. These difficulties can have a significant impact on academic performance, since they can impair the development of written language, resulting in dysgraphia.

The fine motor, sensory and perceptual changes and dysgraphia may not be the only factors responsible for the learning difficulties of children with Attention Deficit with Hyperactivity Disorder. However, it is certainly one of the aspects that may aggravate the academic performance of these children.

REFERENCES

1. Mattos P, Palmini A, Salgado CA, Segenreich D, Grevet, E, Oliveira IR, et al. Painel brasileiro de especialistas sobre diagnóstico do transtorno de déficit de atenção/hiperatividade (TDAH) em adultos. Rev Psiquiatr Rio Gd Sul. 2006;28(1):50-60.
2. Silveira DC, Passos LM, Santos PC, Chiapetta AL. Avaliação da fluência verbal em crianças com transtorno da falta de atenção com hiperatividade: um estudo comparativo. Rev CEFAC. 2009;11(2):208-16.
3. Pinheiro FH, Lourenceti MD, Santos LC. Transtorno do déficit de atenção e hiperatividade: critérios diagnósticos. In: Capellini AS, Germano GD, Cunha VL, organizadores. Transtornos de aprendizagem e transtornos da atenção (da avaliação à intervenção). São José dos Campos: Pulso Editorial; 2010. p. 91-103.
4. Henríquez-Henríquez M, Zamorano-Mendieta F, Rothhammer-Engel F, Aboitiz F. Modelos neurocognitivos para el trastorno por déficit de atención/hiperactividad y sus implicaciones en el reconocimiento de endofenotipos. Rev Neurol. 2010;50(2):109-16.
5. Soliva-Vila JC, Vilarroya-Oliver O. Aportaciones de la resonancia magnética estructural al esclarecimiento de la neurobiología del trastorno por déficit de atención/hiperactividad: hacia la identificación de un fenotipo neuroanatómico. Rev Neurol. 2009;48(11):592-8.
6. Carboni-Román A, Del Río Grande D, Capilla A, Maestú F, Ortiz T. Bases neurobiológicas de las dificultades de aprendizaje. Rev Neurol. 2006;42 (Suppl 2):S171-S175.
7. Vaquerizo-Madrid J, Estévez-Dias F, Díaz-Maíllo I. Revision Del modelo de alerta e intervención psicolinguística em el transtorno por déficit de atención e hiperactividad. Rev Neurol. 2006;42(Supl 2):S53-S61.
8. Meyer A, Sagvolden T. Fine motor skills in South African children with symptoms of ADHD: influence of subtype, gender, age, and hand dominance. Behav Brain Funct. 2006;2:33.
9. Burgess GC, Depue BE, Ruzic L, Willcutt EG, Du YP, Banich MT. Attentional control activation relates to working memory in attention-deficit/hyperactivity disorder. Biol Psychiatry. 2010;67(7):632-40.
10. Alloway TP, Gathercole SE, Elliott J. Examining the link between working memory behavior and academic attainment in children with ADHD. Dev Med Child Neurol. 2010;52(7):632-6.
11. Candido RP, Gobbi LT Silveira CR, Rossi AC, Caetano MJ. Avaliação motora de pré-escolares: relações entre idade motora e idade cronológica. Lecturas: Educación Física y Deportes. 2005;(83):1-5.
12. Feder KP, Majnemer A. Handwriting development, competency, and intervention. Dev Med Child Neurol. 2007;49(4):312–7.
13. Trevisan JG, Coppede AC, Capellini SA. Avaliação da função motora fina, sensorial e perceptiva em escolares com dificuldades de aprendizagem. Temas Desenvol. 2008;16(94):183-7**.**
14. Capellini AS, Souza AV. Avaliação da função motora fina, sensorial e perceptiva em escolares com dislexia do desenvolvimento. In: Sennyey AL, Capovilla FC, Montiel JM, organizadores. Transtornos de aprendizagem: da avaliação à reabilitação. São Paulo: Artes Médicas; 2008. p. 55-64.
15. Vidarte JA, Ezquerro M, Giráldez MA. Perfil psicomotor de niños de 5 a 12 años diagnosticados clínicamente de trastorno por déficit de atención/hiperactividad en Colômbia. Rev Neurol. 2009;49(2):69-75.
16. Fukuda MT, Okuda PM. Avaliação e intervenção na disgrafia. In: Capellini AS, Germano GD, Cunha VL, organizadores. Transtornos de aprendizagem e transtornos da atenção (da avaliação à intervenção). São José dos Campos: Pulso Editorial; 2010. p. 91-103.
17. Adi-Japha E, Landau YE, Frenkel L, Teicher M, Gross-Tsur V, Shalev RS. ADHD and dysgraphia: underlying mechanisms. Cortex. 2007;43(6):700-9.
18. Toniolo CS, Santos LC, Lourenceti MD, Padula, NA, Capellini SA. Caracterização do desempenho motor em escolares com transtorno do déficit de atenção com hiperatividade. Rev Psicopedag. 2009;26(79):33-40.
19. Fliers E, Vermeulen S, Rijsdijk F, Altink M, Buschgens C, Rommelse N, et al. ADHD and poor motor performance from a family genetic perspective. J Am Acad Child Adolesc Psychiatry. 2009;48(1):25-34.
20. Rommelse NN, Altink ME, Fliers EA, Martin NC, Buschgens CJ, Hartman CA, et al. Comorbid problems in ADHD: degree of association, shared endophenotypes, and formation of distinct subtypes. Implications for a future DSM. J Abnorm Child Psychol. 2009;37(6):793-804.
21. Buderath P, Gartner K, Frings M, Christiansen H, Schoch B, Konczak J, et al. Postural and gait performance in children with attention deficit/hyperactivity disorder. Gait Posture. 2009;29(2):249-54.
22. Fundação de Economia e Estatística. Índice de Desenvolvimento Socioeconômico (Idese) [Internet]. Porto Alegre: FEE; 2003.] [citado 2010 Ago 10]. Disponível em: http://www.fee.tche.br/sitefee/pt/content/estatisticas/pg_idese.php
23. Beckung E. Development and validation of a measure of motor and sensory function in children with epilepsy. Pediatr Phys Ther. 2000;12(1):24-35.
24. Lorenzini VL. Uma escala para detectar a disgrafia baseada na escala de Ajuriaguerra [dissertação]. São Carlos: Universidade Federal de São Carlos; 1993.
25. Souza Neto S, Veiga M, Motta AI, Pellegrini AM, Benites LC. O comportamento motor no processo de escolarização e a formação de professores de educação básica. Lecturas: Educación Física y Deportes. 2005;(81):1-10.
26. Summers J, Larkin D, Dewey D. Activities of daily living in children with developmental coordination disorder: dressing, personal hygiene, and eating skills. Hum Mov Sci. 2008;27(2):215-29.

27. Engel-Yeger B, Nagauker-Yanuv L, Rosenblum S. Handwriting performance, self-reports, and perceived self-efficacy among children with dysgraphia. Am J Occup Ther. 2009;63(2):182-92.
28. Kohlmeyer K. Avaliação dos componentes de desempenho. In: Neistadt M, Crepeau EB. Terapia ocupacional. 9ª ed. Rio de Janeiro: Guanabara Koogan; 2003. p. 202-37.
29. Kolb B, Whishaw IQ. Neurociências do comportamento. Barueri: Manole; 2002.
30. Capellini SA, Ferreira TL, Salgado CA, Ciasca SM. Desempenho de escolares bons leitores, com dislexia e com transtorno do déficit de atenção e hiperatividade em nomeação automática rápida. Rev Soc Bras Fonoaudiol. 2007;12(2):114-9.