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Comparison of fundamental motor skills in children with ADHD and typically developing peers using the TGMD-2

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HIGHLIGHTS

- Children with ADHD show lower performance in fundamental motor skills.
- ADHD children often classified as poor or very poor in motor tasks.
- Motor skill deficits may affect school and daily life activities.
- Physical activity and adapted practice can improve motor and executive skills.
- Inclusion strategies in schools are crucial for motor development.

ABBREVIATIONS

ADHD	Attention-deficit/hyperactivity disorder
CPM	Coloured Progressive Matrices
DCD	Developmental Coordination Disorder
DLPFC	Dorsolateral prefrontal cortex
DSM-5	Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition
DSM-V	Diagnostic and Statistical Manual of Mental Disorders
K-SADS-PL	Schedule for Affective Disorders and Schizophrenia for School-Aged Children—Present and Lifetime Version
MABC	Movement Assessment Battery for Children
MABC-2	Movement Assessment Battery for Children 2
NITIDA	Nucleus of Investigations in Impulsivity and Attention
ODD	Oppositional Defiant Disorder
SNAP-IV	Swanson, Nolan, and Pelham Rating Scale–IV
TDG	Typical development group
TGMD-2	Test of Gross Motor Development–2

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ABSTRACT

BACKGROUND: Fundamental motor skills, developed during childhood, are essential for future participation in sports and physical activities. Children with developmental disorders tend to exhibit reduced motor performance.
AIM: This study aimed to assess these skills in children with ADHD.
METHODS: Forty-four children of both sex aged between 6 and 10 years-old (6 girls and 38 boys with average age of 8.45 ± 1.18 years). The experiment consisted of two groups (n = 22): children diagnosed with ADHD and children of typical development (TDG). Motor performance was evaluated by the Test of Gross Motor Development - 2 (TGMD-2). Descriptive statistics were calculated, and group differences were tested using Student's t-tests and the chi-square test, with an alpha level of .05. Effect sizes were estimated using Cohen's d.
RESULTS: Results showed better performance of TDG than ADHD in locomotor subtest as well as in object control subtest. In a qualitative analysis, all children from ADHD presented low performance as well as 40% of children from TDG.
INTERPRETATION: Discussion reinforces the importance of fundamental motor skills for children with developmental disorders especially to ADHD children and we raise a question if motor performance would be related to the sub-type of the disorder.

KEYWORDS: Motor development | Quotient motor | TGMD-2 | ADHD | Children

INTRODUCTION

The attention-deficit/hyperactivity disorder (ADHD) is characterized by inattention, hyperactivity and impulsivity, and by a heterogeneous clinical behavior. It consists in one of most prevalent and most studied neuropsychiatric disorders in childhood and adolescence [1]. It is estimated that approximately 5% of children worldwide present ADHD, with a higher frequency of diagnosis in boys than in girls [2]. In adolescence, ADHD persists in about 70% of cases, and prevalence in adulthood ranges from 2.9% to 4.4% [3].

Children with ADHD present difficulties in daily activities, which reflects in impaired academic performance and difficulties in social participation. ADHD children are more susceptible to exclusion and frequently show low self-esteem [4]. These behavioral deficits are associated with neuropsychological impairments involving attention regulation, working memory, and executive functions [5]. Executive dysfunctions are associated with difficulties in decision-making, impulse control, sustained attention, and sensitivity to behavioral consequences, which may also compromise motor planning and motor control [6,7].

It is estimated that more than 50% of ADHD children present motor deficits [8]. Deficits have been reported across multiple domains of motor control, such as manual dexterity [9], less force parametrization [10], more reaction time variability [11] and less precision [12] when compared to typical children. In addition, Goulardins et al. [13] observed motor delays in fine and gross motricity, balance, body scheme, and temporal and spatial organization.

Although Attention-Deficit/Hyperactivity Disorder (ADHD) and Developmental Coordination Disorder (DCD) frequently co-occur, reaching comorbidity rates of up to approximately 50% of cases, they are distinct neurodevelopmental disorders with specific diagnostic criteria and clinical manifestations [14]. ADHD is primarily characterized by persistent patterns of inattention, hyperactivity, and impulsivity, whereas DCD involves significant difficulties in the acquisition and execution of motor skills that interfere with functional and academic performance [14]. Distinguishing between these conditions is essential from both clinical and scientific perspectives, as comorbidity may exacerbate functional impairments but does not imply diagnostic overlap, thus requiring differentiated assessment and intervention approaches.

From a neurobiological and neurocognitive perspective, structural and functional alterations in the prefrontal cortex, particularly in the dorsolateral region, appear to be a defining feature of the disorder [15,16]. The dorsolateral prefrontal cortex (DLPFC) is a region of the prefrontal cortex associated with the control of cognitive functions, particularly executive functions. These include a set of abilities such as inhibitory control, working memory, and cognitive flexibility, which serve as the foundation for more complex cognitive processes, including reasoning, planning, and problem solving [17,18,19]. According to Diamond [17], metabolic alterations in prefrontal regions, such as the DLPFC, may initially impact cognitive functions and, over time, lead to motor alterations.

Fundamental motor skills, which constitute the base to more complex skills acquisition of children [20,21] have also presented delays in ADHD children. Harvey e Reid [22] evaluated fundamental skills in ADHD children, and they observed low performance in locomotor and object control skills. However, this study did not include a typically developing comparison group. Pitcher, Piek e Hay [23] have also observed delay in gross motor skills in ADHD boys with inattention, hyperactivity and both combined. Harvey et al. [24] analyzed fundamental motor skills of [22] children with and without ADHD, and they found differences in the 12 motor skills evaluated. They concluded that ADHD children present risks to gross motor skills development. Similar findings were also presented by Pan et al. [25], in which ADHD children showed worse performance in locomotor and object control skills when compared to typical children.

Despite these findings, the literature remains methodologically heterogeneous. Among the aforementioned studies, only Pitcher, Piek, and Hay [23] used the Movement Assessment Battery for Children (MABC) [26], which evaluates movement outcomes (product-oriented approach), assessing performance in fine and gross motor skills [27]. Other studies [23,25,26] used the Test of Gross Motor Development–2 (TGMD-2) [28], which evaluates the quality of fundamental motor skill patterns. This process-oriented approach allows a qualitative analysis of how and why specific motor outcomes occur, offering important insights into motor development mechanisms [29].

Results from a systematic review including 45 studies assessing motor skills in children with ADHD highlighted the scarcity of research focusing specifically on fundamental motor skills in this population [30]. Considering all studies, some researchers used the TGMD test to specific evaluation of the motor patterns of children [24,25,31,32,33].

Based on the existing literature, it was hypothesized that children with ADHD would demonstrate poorer performance in fundamental motor skills, particularly in locomotor and object control domains, when compared to typically developing children, as assessed through a process-oriented approach.

METHODS

Participants

Forty-four children (6 girls and 38 boys) with age between six and 10 years-old (M=8.45 + 1.18 years) took part of this study. All children were students at fundamental school, and they live in a metropolitan region of a Brazilian city (Table 1). The children were divided in two groups (n = 22): ADHD group (ADHD) consisted by ADHD diagnosed children, and the typical development group (TDG).

ADHD diagnoses were established in accordance with the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) criteria, operationalized through standardized clinical interviews and validated assessment instruments. All participants with ADHD were diagnosed at the Núcleo de Investigações sobre Impulsividade e Atenção (NITIDA; Nucleus of Investigations in Impulsivity and Attention), located at the University Clinical Hospital, following a structured three-stage multidisciplinary diagnostic protocol.

In the first stage, children with suspected ADHD, referred by schools or healthcare services, were placed on a waiting list and subsequently invited for a comprehensive clinical evaluation at the psychiatric outpatient clinic. Parents or legal guardians participated in an initial clinical interview conducted by a child psychiatry resident physician, during which the Brazilian version of the Swanson, Nolan, and Pelham Rating Scale–IV (SNAP-IV) [34] was administered. This instrument assesses core ADHD symptoms as well as oppositional defiant behaviors, in accordance with the diagnostic criteria established by the Diagnostic and Statistical Manual of Mental Disorders (DSM-V) [26].

In the second stage, children underwent an independent psychiatric assessment conducted by a child psychiatrist or a supervised psychiatry resident. This evaluation included a structured clinical interview and administration of the Brazilian version of the Schedule for Affective Disorders and Schizophrenia for School-Aged Children—Present and Lifetime Version (K-SADS-PL) [35], which was used to identify ADHD symptoms and determine their severity.

In the third stage, children were evaluated by a neuropsychologist, who administered a comprehensive cognitive assessment battery, including the Brazilian version of Raven's Coloured Progressive Matrices (CPM) [36], a nonverbal measure of general intellectual functioning.

Table 1. Descriptive statistics of age, locomotor skills, object control skills, and motor quotient by group.

Variable	ADHD - Mean (SD)	ADH - 95% CI	TDG - Mean (SD)	TDG - 95% CI
Age (years)	8.27 (1.38)	[7.69, 8.85]	8.45 (1.18)	[7.93, 8.97]
Locomotor	27.50 (7.73)	[24.27, 30.73]	40.18 (3.81)	[38.49, 41.87]
Object Control	25.91 (9.20)	[22.07, 29.75]	38.86 (3.31)	[37.38, 40.34]
Motor Quotient	61.82 (9.50)	[57.85, 65.79]	88.09 (11.94)	[82.81, 93.37]

Note: Values are presented as mean (standard deviation) and 95% confidence intervals.

After these stages, the tests results were analyzed in a multi-professional debate between several specialists, for example: child psychiatrist, pediatric doctor, neuropsychologist, and an assistant doctor, when the ADHD diagnostic might be declared, with or without other comorbidity associated to the disorder. A return to a doctor was then appointed, when the decision of the ADHD diagnostic was informed, and the child was taken to the most appropriate health care center. On the other hand, when no development disorder was diagnosed, the child was discharged.

To the present study, the inclusion criteria for ADHD were to have an ADHD diagnostic that followed these procedures, and to perform the treatment at NITIDA. As exclusion criteria, except ODD, the child cannot present another comorbidity associated to the ADHD. It is important to highlight that ADHD children do not use any medication during the day they were submitted to the motor performance evaluation. As an inclusion criterion in TDG, children who did not present any report from family or school about any disorder were allowed to participate in the experiment. Moreover, groups' participants were counterbalanced in age and sex.

General cognitive functioning was assessed using the Brazilian version of Raven's Coloured Progressive Matrices, allowing the exclusion of children with intellectual disability. However, specific executive functions, adaptive behavior, socioeconomic status, and formal measures of school achievement were not systematically assessed and were therefore not included as covariates in the analyses.

The present study was approved for the Internal Review Board of the University (protocol number 282,013).

Instruments

This study used the Test of Gross Motor Development – 2 (TGMD-2) to evaluate motor performance in children between 3 and 10 years-old. The Test of Gross Motor Development–2 (TGMD-2) is a process-oriented assessment designed to evaluate fundamental motor skills in children. The instrument presents strong psychometric properties, with high internal consistency (Cronbach's alpha values ranging from 0.85 to 0.91), good test–retest reliability (intraclass correlation coefficients [ICC] > 0.85), and excellent inter-rater reliability (ICC > 0.90) as reported in the original validation study [37]. In the Brazilian context, the TGMD-2 demonstrated excellent reliability in its cultural adaptation and validation study, with inter-rater intraclass correlation coefficients (ICC) exceeding 0.90, supporting its adequacy for assessing fundamental motor skills in Brazilian children [37]. These finding support the methodological adequacy of the TGMD-2 for use in the present study.

The TGMD-2 assesses movements used to displace the body from one place to another (locomotion) as well as to project or to manipulate objects (object control), especially balls [28]. Twelve fundamental motor skills are evaluated being six in locomotor subtest (run, gallop, hop, leap, horizontal jump, and slide), and six in object control subtest (striking a stationary ball, stationary dribble, catch, kick, overhand throw, and underhand roll). These skills are performed twice.

According to Ulrich [28], the TGMD-2 may be used to diagnose children that present difficulties in fundamental motor skills, to help planning an intervention program, to evaluate the progress of children performance, as well as a test in research. Each skill present three to five performance criteria. If performance reach a criterion, one point is marked. After analyzing the twelve fundamental skills, all points are summed, which is the value that represents the raw score. From this raw score, it is calculated the standard score for each subtest, using normative tables that involve age (locomotor subtest) and age and sex (object control subtest). The test still gives the motor quotient and descriptive evaluation. In the present study, we used locomotor and object control raw scores, motor quotient, and descriptive evaluation.

Procedures

All children were invited to participate of study through authorization of parents or legal guardian, via signature in a consent form. Then, a schedule was set in order to apply the motor test. The children from ADHD went to the university in a specific date while the children from TDG were evaluated in their own school during the scholar period. The test was applied individually, and it lasted approximately 20 minutes. A demonstration as well as verbal explanation were told to the child before each skill, which was performed three times, being the first one used only as familiarization.

Children with ADHD were assessed at the university clinic on a scheduled date, whereas typically developing children were evaluated in a reserved room within their school during the school period. All assessments were conducted individually in quiet and familiar environments, with environmental conditions standardized as much as possible across settings, including minimal external distractions, similar room size, and standardized testing materials. The assessment session lasted approximately 20 minutes. Before each motor skill, children received a standardized verbal explanation and demonstration, and each skill was performed three times, with the first trial used for familiarization only. To minimize potential confounding effects, standardized verbal encouragement was provided in accordance with TGMD-2 administration guidelines, short rest intervals were allowed when necessary to reduce fatigue, and evaluators maintained a neutral and consistent interaction style to optimize attention and engagement across. Tasks were administered following the standardized order recommended in the TGMD-2 manual. Task order was not randomized across participants.

All movements were video recorded and analyzed according to the TGMD-2 scoring criteria. Two researchers with expertise in TGMD-2 assessment independently analyzed the recordings after receiving standardized training, including manual review and practice with recorded performances. Inter-rater agreement reached 85%, and scoring discrepancies were resolved by consensus to enhance objectivity.

Statistical analysis

Data showed normal distribution according to the Shapiro–Wilk test. Then, a parametric analysis was adopted, in which the Student's t test was applied with a alpha level of $p < 0.05$. Given the sample size and the close matching between groups in age, independent-samples t tests were considered the most appropriate approach for group comparisons. Motor performance of the groups was then compared in the following measures: locomotor raw score, object control raw score, and motor quotient. The descriptive analysis was also presented, and a frequency distribution was performed. In this analysis, a Chi-Square test was used to verify the association of gross motor performance with the profile of each group. The software Statistica™ 10.0 performed all statistical analyses.

RESULTS

Figure 1 illustrates group differences in locomotor and object control raw scores. Children in the TDG group demonstrated significantly higher performance than children with ADHD in the locomotor subtest, $t(42) = 4.95$, $p < .001$, $d = 1.49$, as well as in the object control subtest, $t(42) = 4.72$, $p < .001$, $d = 1.42$.

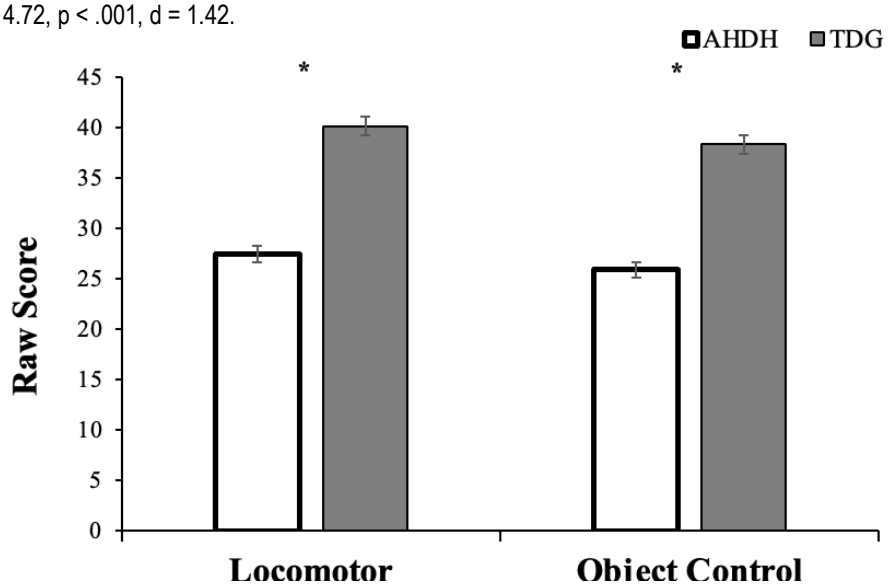

Figure 1. Motor performance fundamental motor skills locomotor and object control.

Figure 2 presents group differences in the motor quotient. The TDG group also showed superior performance compared to the ADHD group, $t(42) = 8.05$, $p < .001$, Cohen's $d = 2.42$.

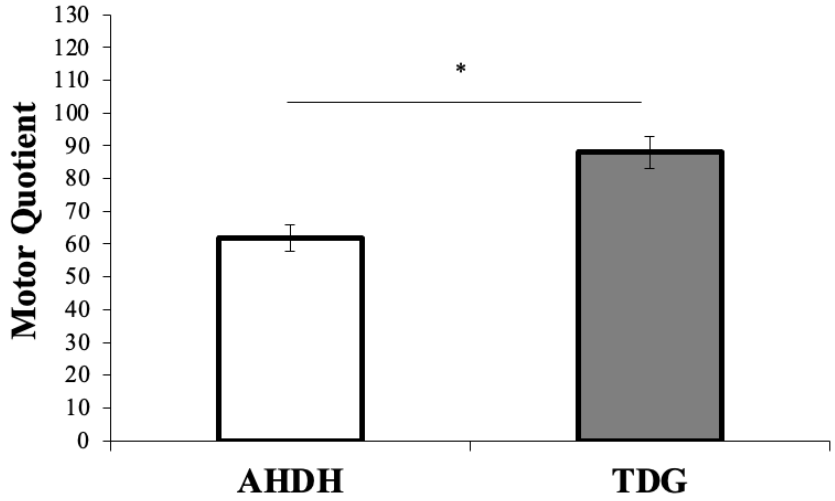

Figure 2. Motor quotient groups AHDH and TDG

Figure 3 show the frequency distribution of qualitative motor performance classifications according to TGMD-2 normative criteria. The chi-square test indicated a significant association between group and motor performance classification, $\chi^2(4, N = 44) = 32.92$, $p < .001$. The ADHD group showed a modal classification of "Very Poor," whereas the TDG group showed a modal classification of "Average," indicating overall better motor performance in typically developing children.

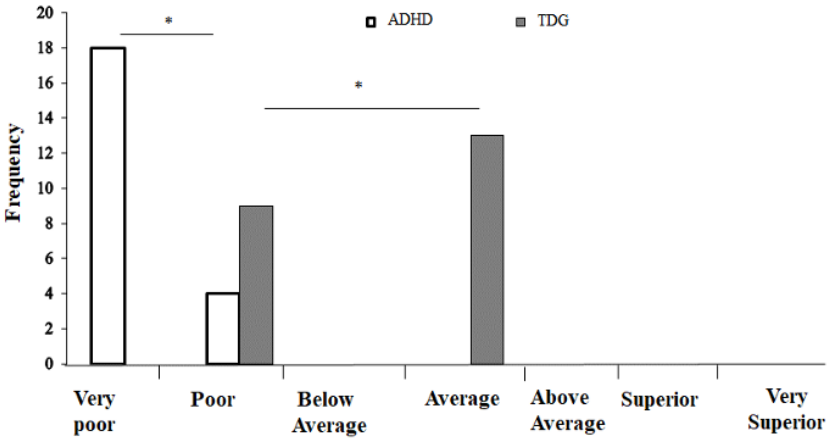

Figure 3. Descriptive classification motor performance groups.

Table 2 presents the frequency distribution of qualitative motor performance classifications according to TGMD-2 normative criteria. The chi-square test indicated a significant association between group and motor performance classification, $\chi^2(4, N = 44) = 32.92$, $p < .001$. Most children in the ADHD group were classified as Very Poor (77.3%), whereas children in the TDG group were predominantly classified as Average (59.1%), indicating overall better motor performance in typically developing children.

Table 2. Frequency distribution of qualitative motor performance classifications according to TGMD-2 normative criteria by group.

Classification	ADHD (n = 22) n (%)	TDG (n = 22) n (%)	Classification	ADHD (n = 22)
Very Poor	17 (77.3%)	0 (0.0%)	Very Poor	17 (77.3%)
Poor	5 (22.7%)	9 (40.9%)	Poor	5 (22.7%)
Average	0 (0.0%)	13 (59.1%)	Average	0 (0.0%)
Below Average	0 (0.0%)	0 (0.0%)	Below Average	0 (0.0%)

Note: Classifications are based on TGMD-2 normative criteria

DISCUSSION

The present study investigated the performance of fundamental motor skills of children with ADHD. Due to the possible limitations that may affect motor behavior of these children [37], we expected a low motor performance of ADHD children when compared to typical development children. For this purpose, we used a motor test that evaluates motor skills performance in children.

Findings were strong in demonstrating that ADHD children were worse when compared to the typical development children. These results confirm our hypothesis, and they are in line with previous studies that also demonstrated low motor performance of atypical children [38,39]. The present study used a specific test that evaluates motor skills in analyzing their pattern of movement. Moreover, children were diagnosed with ADHD, as well as its respective clinical subtypes.

The fundamental motor skills may be considered as base to the development and learning of more complex skills [20,21]. These skills also are strongly associated to the engagement in physical activities in life span [40,41]. Contemporary developmental models propose reciprocal relationships between motor competence, physical activity participation, and physical fitness. Lower fundamental motor skill proficiency, as observed in children with ADHD, may limit engagement in physical activity, although these relationships were not directly examined in the present study.

In this way, the ADHD group presented worse performance than TDG group. Moreover, the ADHD group presented the category "very poor" as central tendency (mode). We may speculate if the ADHD children have been stimulated to the motor activities practice, as well as in physical education classes in school. Are these children included in all activities and programs in schools? The poorer motor performance observed in the ADHD group highlights the importance of considering the contexts in which motor skills are developed and practiced. Rather than suggesting causal explanations, these findings emphasize the need to reflect on how opportunities for motor practice and engagement may differ for children with ADHD. Such considerations should be viewed as hypotheses for future research.

In Brazil, the inclusion of neurodevelopment disorders children in regular schools is warranted by laws, which also recommend support to continuing education to the teachers. Inclusive education is not just about putting students in the classroom, but rather accepting differences and the teacher is a fundamental part of this process of inclusion at school [42] and beyond.

From a practical perspective, the findings highlight the importance of systematically assessing fundamental motor skills in children with ADHD. Identifying motor difficulties may support educational and clinical decision-making, particularly in monitoring development and guiding future intervention planning. However, the present results do not allow inferences regarding the effectiveness of specific educational or therapeutic strategies.

It is also important to highlight that ADHD may be related to a disorder in the pre-frontal cortex neurotransmitter [43], which is the area responsible for executive functions. In addition, regular practice of physical activity may influence in executive functions, for example, in inhibitory control [44]. Thus, it seems important to develop fundamental motor skills in ADHD children, as an aspect that may indirectly help in deal with the daily effects of the disorder. For example, ADHD children that practice physical activities have improved executive functions in a significant way [45]. The evaluation of fundamental motor skills performance is relevant, as strategies of intervention with this population can be proposed in a systematic way.

Results also showed that all ADHD children presented low performance in fundamental motor skills, classified as below average, poor or very poor, as well as 40% (9 children) of participants of TDG. In general, studies have concluded that children in scholar age are delayed in distinct fundamental motor skills [46], what is in accordance with our results. However, when comparing ADHD children with typical development children, our results are distinct from Nascimento et al. [47], which did not find association between ADHD and motor performance, although typical development children have presented superior performance in some skills. They still showed that most children of both groups were classified in a normal category.

The main explanation to this difference in relation to our results may be due to the test used in the experiment. Nascimento et al. [47] evaluated motor behavior through the Movement Assessment Battery for Children 2 (MABC-2), which did not discriminate motor competence when children are positioned above percentile 16. In this test, children classified between percentile 16 and percentile 100 are considered of typical development. In other words, this test is not able to distinguish eventually distinct behavior in typical development children. The purpose of the test is to identify children with DCD as well as other motor impairments [26]. While the Movement Assessment Battery for Children–2 (MABC-2) is designed to identify motor impairment and developmental coordination disorder, the TGMD-2 focuses on the qualitative assessment of fundamental motor skill patterns. These conceptual differences may explain inconsistencies between studies.

It is also important to highlight that ADHD has been associated with dysfunctions in prefrontal cortex neurotransmission, a region responsible for executive functions such as inhibitory control and attentional regulation [43]. Deficits in inhibitory control may increase motor variability and compromise the organization and consistency of movement patterns, particularly in tasks that require sequencing and timing. In addition, regular physical activity has been shown to positively influence executive functions, including inhibitory control [44]. Therefore, difficulties in executive control may partly explain the poorer qualitative motor performance observed in children with ADHD, although these mechanisms were not directly assessed in the present study.

The present experiment investigated eventual differences in motor behavior between typical development and ADHD children. However, more studies are needed in order to have a better understanding of the possibilities and limitations of children with the ADHD.

Indeed, studies that use motor intervention may also contribute to professionals and therapists in developing appropriate programs of motor activities to the needs of children diagnosed with ADHD.

LIMITATION

The present study has several limitations. First, the sample showed an uneven sex distribution, with a predominance of boys. Although this reflects the epidemiological profile of Attention-Deficit/Hyperactivity Disorder (ADHD), the small number of girls prevented sex-stratified analyses, limiting the generalizability of the findings to females with ADHD. Future studies with more balanced samples are needed. Second, habitual physical activity levels were not objectively measured or controlled. Although participants were recruited from similar school contexts, differences in physical activity exposure may have influenced motor performance and should be considered when interpreting the results.

In addition, the study did not include formal screening or exclusion criteria for Developmental Coordination Disorder (DCD). Given the known overlap between ADHD and motor coordination difficulties, subclinical DCD cannot be ruled out and may have influenced motor performance. This limitation should be considered when interpreting the results, and future studies should control for DCD to better disentangle disorder-specific motor profiles.

Finally, comorbid conditions such as Oppositional Defiant Disorder (ODD) were not used as exclusion criteria and were not systematically controlled. Although common in clinical ADHD populations, such comorbidities may influence motor behavior through impaired behavioral regulation and impulsivity, potentially contributing to variability in motor performance. Therefore, this factor should be considered when interpreting the results, and future studies should control for comorbid conditions or examine their effects separately.

CONCLUSION

The analysis of fundamental motor skills in ADHD children allows verifying that their motor behavior is also affected. These findings reveal the actual level of motor development of ADHD children. The fact that children diagnosed with attention deficit and hyperactivity disorder present low motor performance suggests that they should be given specific care, as well as more motor stimulus, they should be included not only in physical education classes, but also in motor activities in general. From the current state of performance, it is important to plan motor activities and actions of intervention, in order to better contribute to the motor development of children.

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REFERENCES

1. Goldman LS, Genel M, Bezman RJ, Slanetz PJ. Diagnosis and treatment of attention deficit/hyperactivity disorder in children and adolescents. *JAMA.* 1998;279(14):1100-1107. doi: 10.1001/jama.279.14.1100.
2. Polanczyk G, Rohde LA. Epidemiology of attention deficit/hyperactivity disorder across the lifespan. *Curr Opin Psychiatry*. 2007;20(4):386-392. doi: 10.1097/YCO.0b013e3281568d7a.
3. Biederman J, Faraone SV. Attention deficit hyperactivity disorder. *Lancet.* 2005;366:237-248. doi: 10.1016/S0140-6736(05)66915-2.
4. Harpin VA. The effect of ADHD on the life of an individual, their family, and community from preschool to adult life. *Arch Dis Child*. 2005;90(1):i2-7. doi: http://dx.doi.org/10.1136/adc.2004.059006.
5. Malloy Diniz LF, Leite WB, Moraes PHP, Correa H, Bechara A, Fuentes D. Brazilian Portuguese version of the Iowa Gambling Task: Transcultural adaptation and discriminant validity. *Rev Bras Psiquiatr*. 2008;30(2):144-148. doi: 10.1590/S1516-44462008005000009.
6. Cantin N, Polatajko HJ, Thach T, Jaglal S. Developmental coordination disorder: Exploration of a cerebellar hypothesis. *Hum Mov Sci*. 2007;26(3):491-509. doi: 10.1016/j.humov.2007.03.004.
7. Castelnau P, Albaret JM, Chaix Y, Zanone PG. Developmental coordination disorder pertains to a deficit in perceptuo motor synchronization independent of attentional capacities. *Hum Mov Sci.* 2007;26(3):477-490. doi: 10.1016/j.humov.2007.03.001.
8. Barkley RA. Behavioral inhibition, sustained attention, and executive functions: constructing a unifying theory of ADHD. *Psychol Bull*. 1997;121:65-94. doi: 10.1037/0033 2909.121.1.65.
9. Wang H, Huang T, Lo S. Motor ability and adaptive function in children with attention deficit hyperactivity disorder. *Kaohsiung J Med Sci.* 2011;27(10):446-452. doi: 10.1016/j.kjms.2011.06.004.
10. Pitcher MT, Piek JP, Barrett NC. Timing and force control in boys with attention deficit hyperactivity disorder: subtype differences and the effect of comorbid developmental coordination disorder. *Hum Mov Sci*. 2002;21(5 6):919-945. doi: 10.1016/S0167 9457(02)00167 7.
11.Van Der Meere J, Sergeant J. Acquisition of attention skill in pervasively hyperactive children. *J Child Psychol Psychiatry*. 1988;29:301-310. doi: 10.1111/j.1469-7610.1988.tb00718.x.

12. Johnson S, Hollis C, Kochhar P, Hennessy E, Wolke D, Marlow N. Psychiatric disorders in extremely preterm children: longitudinal findings at age 11 years in the EPICure study. *J Am Acad Child Adolesc Psychiatry*. 2010;49(5):453-463. doi: 10.1016/j.jaac.2010.02.002.
13. Goulardins JB, Marques JCB, Casella EB, Nascimento RO, Oliveira JA. Motor profile of children with attention deficit hyperactivity disorder, combined type. *Res Dev Disabil*. 2013;34(1):40-45. doi: http://dx.doi.org/10.1016/j.ridd.2012.07.014.
14. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM 5). Washington (DC)/London (England): American Psychiatric Association; 2014. 992 p.
15. Agoalikum E, Klugah-Brown B, Wu H, Hu P, Jing J, Biswal B. structural differences among children, adolescents, and adults with attention-deficit/hyperactivity disorder and abnormal granger causality of the right pallidum and whole-brain. *Front Hum Neurosci*. 2023;17:1076873. doi:10.3389/fnhum.2023.1076873
16. Soman SM, Vijayakumar N, Thomson P, Ball G, Hyde C, Silk TJ. Cortical structural and functional coupling during development and implications for attention deficit hyperactivity disorder. *Transl Psychiatry*. 2023;13(1):252. doi:10.1038/s41398-023-02460-6.
17. Diamond A, Executive functions. *Annu Rev Psychol*. 2013;64:135–168. doi:10.1146/annurev-psych-113011-143750.
18. Westwood SJ, Nunes C, Pereira M. Transcranial direct current stimulation (tDCS) combined with cognitive training in adolescent boys with ADHD: a double-blind, randomised, sham-controlled trial. *Psychol Med*. 2023;53(2):497–512. doi:10.1017/S0033291721004603.
19. Salehinejad MA, Ghanavati E, Glinski B, Hallajian AH, Azarkolah AA. A systematic review of randomized controlled trials on efficacy and safety of transcranial direct current stimulation in major neurodevelopmental disorders: ADHD, autism, and dyslexia. *Brain Behav*. 2022;12(9):e2724. doi:10.1002/brb3.2724.
20. Benda RN, Marinho NFS, Duarte MG, Ribeiro Silva PC, Ortigas PR, Machado CF, Gomes TVB. A brief review on motor development: Fundamental motor skills as a basis for motor skill learning. *Braz J Mot Behav*. 2021;15(5):342-355. doi: 10.20338/bjmb.v15i5.257.
21. Tani G, Júnior CMM, Ugrinowitsch H, Benda RN, Chiviacowsky S, Corrêa UC. Research in motor behavior area: Theoretical models, methods of investigation, instruments of analysis, challenges, tendencies and perspectives. *J Phys Educ*. 2010;21(3):329-380. doi: 10.4025/reveducfis.v21i3.9254.
22. Harvey WJ, Reid G. Motor performance of children with attention deficit hyperactivity disorder: A preliminary investigation. *Adapt Phys Act Q*. 1997;14(3):189-202. doi: 10.1123/apaq.14.3.189.
23. Pitcher TM, Piek JP, Hay DA. Fine and gross motor ability in males with ADHD. *Dev Med Child Neurol*. 2003;45(8):525-535. doi: 10.1111/j.1469 8749.2003.tb00952.x.
24. Harvey WJ, Reid G, Grizenko N, Mbekou V, Ter Stepanian M, Joober R. Fundamental movement skills and children with attention deficit hyperactivity disorder: Peer comparisons and stimulant effects. *J Abnorm Child Psychol*. 2007;35(5):871-882. doi: 10.1007/s10802 007 9140 5.
25. Pan CY, Tsai CL, Chu CH. Fundamental movement skills in children diagnosed with autism spectrum disorders and attention deficit hyperactivity disorder. *J Autism Dev Disord*. 2009;39(12):1694-1705. doi: 10.1007/s10803 009 0813 5.
26. Henderson S, Sugden D. The Movement Assessment Battery for Children. Austin (TX): The Psychological Corporation; 1992. 84 p.
27. Palmer KK, Pennell A, Terlizzi B, Nunu MA, Stodden DF, Robinson LE. Performance metrics from product oriented measures of fundamental motor skills - a comparison and developmental perspective. *J Mot Learn Dev*. 2023;11(3):401-423. doi: 10.1123/jmld.2022 0074.
28. Ulrich DA. Test of gross motor development 2. Austin (TX): PRO ED; 2000. 65 p.
29. Clark JE, Whitall J. What is motor development? The lessons of history. *Quest*. 1989;41(3):183-202. doi: 10.1080/00336297.1989.10483969.
30. Kaiser ML, Schoemaker MM, Albaret JM, Geuze RH. What is the evidence of impaired motor skills and motor control among children with attention deficit hyperactivity disorder (ADHD)? *Res Dev Disabil*. 2015;36:338-357. doi: 10.1016/j.ridd.2014.09.023.
31. Pan CY, Tsai C-L, Chu C-H, Sung M-C, Huang C-Y, Ma W-Y. Effects of physical exercise intervention on motor skills and executive functions in children with ADHD: a pilot study. *J Atten Disord*. 2016;23(4): 384-397. doi:10.1177/10870547155692.
32. Liang X, Qiu H, Tsai C-L, Li C, Sit CHP. MVPA and motor proficiency between children with ADHD and typical development: associations with sleep quality. *Med Sci Sports Exerc*. 2023;55(10):1886–1893. doi:10.1249/MSS.0000000000003223
33. D'Anna C, Carlevaro F, Magno F, Vagnetti R, Limone P, Magistro D. Gross motor skills are associated with symptoms of attention deficit hyperactivity disorder in school-aged children. *Children (Basel)*. 2024;11(7):757. doi:10.3390/children11070757
34. Mattos P, Serra Pinheiro MA, Rohde LA, Pinto D. Apresentação de uma versão em português para uso no Brasil do instrumento MTA SNAP IV de avaliação de sintomas de transtorno do déficit de atenção/hiperatividade e sintomas de transtorno desafiador e de oposição. *Rev Bras Psiquiatr*. 2006;28(3):290-297. doi: 10.1590/S0101 81082006000300008.
35. Kaufman J, Birmaher B, Brent D, Roa U, Flynn C, Moreci P, Ryan N. Schedule for affective disorders and schizophrenia for school age children present and lifetime version (K SADS PL): initial reliability and validity data. *J Am Acad Child Adolesc Psychiatry*. 1997;36(7):980-988. doi: 10.1097/00004583 199707000 00021.
36. Raven JC, Teste das matrizes progressivas escala geral – manual. Rio de Janeiro: Centro Editor de Psicologia Aplicada; 2008. 48 p.
37. Valentini NC, Validity and reliability of the TGMD 2 for brazilian children. *J Mot Behav*. 2012;44(4):275-280. doi: 10.1080/00222895.2012.700967.
38. Neto FR, Goulardins JB, Rigoli D, Piek JP, Oliveira JA. Motor development of children with attention deficit hyperactivity disorder. *Braz J Psychiatry*. 2015;37(3):228-234. doi: 10.1590/1516 4446 2014 1533.

39. Toniolo CS, Santos LCA, Lourenceti MD, Padula NAMR, Capellini SA. Caracterization of motor performance in scholars with attention deficit hyperactivity disorder. *J Bras Assoc Psychopedagog*. 2009;26(79):33-40.
40. Barnett LM, Van Beurden E, Morgan PJ, Brooks LO, Beard JR. Childhood motor skill proficiency as a predictor of adolescent physical activity. *J Adolesc Health*. 2009;44(3):252-259. doi: 10.1016/j.jadohealth.2008.07.004.
41. Stodden DF, Goodway JD, Langendorfer SJ, Roberton MA, Rudisill ME, Garcia C, Garcia LE. A developmental perspective on the role of motor skill competence in physical activity: an emergent relationship. *Quest.* 2008;60(2):290-306. doi: 10.1080/00336297.2008.10483582.
42. Silva NC, Carvalho BGE. Compreendendo o processo de inclusão escolar no Brasil na perspectiva dos professores: uma revisão integrativa. *Rev Bras Educ Espec*. 2017;23(2):293-308. doi: 10.1590/S1413 65382317000200010.
43. Ernst M, Zametkin AJ, Matochik JA, Jons PH, Cohen RM. DOPA decarboxylase activity in attention deficit hyperactivity disorder adults: A [Fluorine 18] fluorodopa positron emission tomographic study. *J Neurosci*. 1998;18(15):5901-5907. doi: 10.1523/JNEUROSCI.18 15 05901.1998.
44. Drollette ES, Scudder MR, Raine LB, Moorea RD, Salibaa BJ, Pontifex MB, Hillman CH. Acute exercise facilitates brain function and cognition in children who need it most: an ERP study of individual differences in inhibitory control capacity. *Dev Cogn Neurosci*. 2014;7:53-64. doi: 10.1016/j.dcn.2013.11.001.
45. Pontifex MB, Saliba BJ, Raine LB, Picchietti DL, Hillman CH. Exercise improves behavioral, neurocognitive, and scholastic performance in children with attention deficit/hyperactivity disorder. *J Pediatr*. 2013;162(3):543-551. doi: 10.1016/j.jpeds.2012.08.036.
46. Hardy LL, Barnett L, Espinel P, Okely AD. Thirteen year trends in child and adolescent fundamental movement skills: 1997–2010. *Med Sci Sports Exerc*. 2013;45(10):1965-1970. doi: 10.1249/MSS.0b013e318295a9fc.
47. Nascimento EMF, Contreira AR, Silva EVA, Souza LP, Beltrame TS. Motor performance and nutritional status in students with attention deficit hyperactivity disorder. *J Hum Growth Dev*. 2013;23(3):358-364. doi: 10.7322/jhgd.69514.

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