

Original Article

Relationship between visual-motor integration and manual dexterity in children with developmental coordination disorder

Relação entre integração visomotora e destreza manual em crianças com transtorno do desenvolvimento da coordenação

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Abstract

This study aimed to examine the visual-motor integration and manual dexterity skills in children with Developmental Coordination Disorder (DCD). A cross-sectional descriptive study of 22 children aged 7 to 11 years old with DCD, assessed with the Brazilian version of the Developmental Coordination Disorder Questionnaire (DCDQ-Brazil), Movement Assessment Battery for Children Second Edition (MABC-2) and Beery-Buktenica Developmental Test of Visual-Motor Integration Sixth Edition (VMI). Four girls and 18 boys participated. Considering the 25th percentile in VMI as the cutoff point, 12 children presented a below-average performance in the visual-motor integration domain, 13 in the visual domain, and 19 in the motor coordination domain. We observed a statistically significant correlation between the motor dexterity and the total MABC-2 percentiles, but not between the MABC-2 percentiles and the different domains evaluated with the VMI. The results suggest that the combined use of tests for better assessment of children with DCD is needed and important to detect their real difficulties in both visuomotor integration and manual dexterity and their implications on the performance of children's daily activities.

Keywords: Child, Motor Skill Disorders, Motor Skills, Handwriting, Occupational Therapy.

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Resumo

O objetivo deste estudo foi examinar as habilidades de integração visomotora e destreza manual em crianças com Transtorno do Desenvolvimento da Coordenação (TDC). Estudo descritivo transversal com 22 crianças de 7 a 11 anos com TDC, avaliadas com o *Developmental Coordination Disorder Questionnaire* (DCDQ-Brasil), *Movement Assessment Battery for Children Second Edition* (MABC-2) e *Beery-Buktenica Developmental Test of Visual-Motor Integration Sixth Edition* (VMI). A amostra contou com 4 meninas e 18 meninos. Considerando o percentil 25 no VMI como ponto de corte, 12 crianças apresentaram desempenho abaixo da média no domínio integração visomotora, 13 no domínio visual e 19 no domínio de coordenação motora. Foi observada correlação significativa entre o percentil de destreza motora e o percentil total do MABC-2, mas não entre os escores do MABC-2 e os diferentes domínios avaliados com o VMI. Os resultados sugerem que é necessário e importante o uso combinado de testes para melhor avaliação das crianças com TDC, a fim de detectar suas possíveis dificuldades na integração visomotora e destreza manual e suas implicações no desempenho de tarefas funcionais das crianças no dia a dia.

Palavras-chave: Criança, Transtorno do Desenvolvimento da Coordenação, Destreza Motora, Escrita Manual, Terapia Ocupacional.

1 Introduction

The individual constantly interacts with the environment and with some task, often resulting in the acquisition and improvement of different skills. To succeed in performing movements in each task, the individual needs precision and effectiveness during the process, with several daily tasks requiring basic motor skills (Coutinho et al., 2011). If the motor demand of the task is met, new motor achievements can be triggered through necessary adaptations to the task, but if the skills are flawed, the task may not be completed or completed in an unsatisfactory way for the individual and/or the context (Coutinho et al., 2011). In the children's daily lives, this demand usually appears strongly at school, and the skills required in the classroom directly influence academic performance, in addition to other motor and social interaction skills that are also necessary for the child to play during the break and physical education.

The routine activities such as dressing, eating, self-care, playing and writing are often hampered by the difficulties that children with Developmental Coordination Disorder (DCD) face because they have not learned fundamental motor skills necessary for their performance tasks, even with the presence of a good cognitive level and the absence of other health conditions such as cerebral palsy, hemiplegia or muscular dystrophy, for example (Ibana & Caçola, 2016). These difficulties are often related to deficits in visual-motor coordination and manual dexterity. Manual dexterity is related to the agility and precision of the movements of the hands and fingers (Magalhães et al., 2011), that is, it is the base for handling objects through global hand movements (Bazo, 2014). On the other hand, visual-motor coordination or integration is the degree of coordination

between visual perception and hand and finger movements when performing a task (Magalhães et al., 2011; Beery & Beery, 2010).

Developmental Coordination Disorder is a neurodevelopmental disorder that affects about 5% to 6% of school-age children (Blank et al., 2019; Harris et al., 2015). However, this estimate varies according to the culture and the cutting criteria used for the motor test. In Brazil, it is estimated that this disease affects 4.3% of children between 7 and 8 years old (Blank et al., 2019; Cardoso & Magalhães, 2012). Epidemiological studies estimate that the prevalence of the disorder is higher in boys than in girls, and in premature children with no relation to socioeconomic or educational factors (Blank et al., 2019). DCD is characterized by motor impairment that interferes with the performance of the child's activities of daily life (ADL), considered as one of the most common difficulties affecting school-age children.

The DCD diagnosis is usually made between 6 to 12 years old, following specific criteria defined by the American Psychiatry Association - APA (2014) that consider the diagnosis performance when the acquisition and execution of coordinated motor skills are substantially below the expected for the individual's chronological age, observing the opportunity of the individual to learn and use the skill. The deficit in motor skills significantly interferes with the performance of daily activities appropriate to the chronological age, generating an impact on school productivity, leisure, and games. Also, DCD symptoms appear early in childhood, and deficits in motor skills are not explained by intellectual disability (intellectual development disorder) or by visual impairment and they are not attributable to neurological conditions that affect movements (American Psychiatry Association, 2014).

Children with DCD have difficulties coordinating their movements, slowness, and imprecision in the performance of motor skills and, generally, they have inferior performance in tasks that require skills of manual dexterity and visual-motor coordination when compared to children with typical development (Coutinho et al., 2011). Also, children with DCD may find it more difficult to perform self-care activities, use of tools in academic activities such as writing, coloring, tracing, organizing numbers on the notebook sheet, leisure activities, and sports. Considering these aspects, this study aimed to examine the skills of visual-motor integration and manual dexterity in children with DCD.

2 Method

This is a descriptive cross-sectional study including participants in a randomized clinical trial with the main objective of analyzing the effectiveness of two occupational therapy protocols in occupational performance and with children with DCD. The Research Ethics Committee of the Federal University of Minas Gerais - COEP/UFMG approved the study (Opinion 1.520.296) with a study protocol registered by the United States Institutes of Health, on the ClinicalTrials.gov platform. The children's parents or guardians were informed about the objectives of the study and authorized their participation by signing the Informed Consent Form (ICF). As the research was aimed at children aged 7 to 12 years old, they also had clarifications and signed the Informed Assent Form (IAF).

2.1 Participants

The selection of the participants for the research was carried out through an active search on the waiting list of the *IDEIA* Laboratories - Investigation and Intervention in the Development in Childhood and Adolescence, from UFMG, reports published on social media, contact with other public service and research laboratories inside the university, contact with occupational therapists working in the children's area and an invitation to elementary schools in the city. The inclusion criteria of the study were defined according to the four diagnostic criteria for DCD described in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (American Psychiatry Association, 2014). The children were evaluated in this sequence according to the inclusion criteria: (1) children aged 7 to 12 years old; (2) without a diagnosis of autism spectrum disorder or signs of neurological injury or neuromuscular diseases that affect movements; (3) with a score below the expected for the age in a standardized motor coordination test and a performance below the expected for the chronological age in the ADLs that require motor coordination, considering the learning opportunities, selected through the motor coordination assessments and learning skills; and (4) children enrolled in regular education and without evidence of a highlighted delay according to the report of parents and teachers, and with cognitive development within the expected for the chronological age.

The exclusion criteria were children who do not complete the baseline assessment process for entry into the randomized division for the clinical trial, and with a combined diagnosis of challenging oppositional disorder. Children who started the selection process but did not meet all the inclusion criteria were referred to other health services more adequate to their needs.

2.2 Data collection procedures and instruments used

For the screening and characterization of the sample, we conducted an initial interview with those responsible for the child, mostly mothers, with a questionnaire developed by the authors, collecting information on the child's developmental history, the child's clinical and occupational history and of the family, and investigating the impacts of motor issues daily such as difficulties in dressing, using tools, problems with writing and difficulties in carrying out games and leisure activities such as playing with the ball, jumping rope and riding a bicycle.

After the initial interview, we invited the parents again for a new interview to answer questionnaires for the sample characterization: (1) the Developmental Coordination Disorder Questionnaire, Brazilian version (DCDQ-Brazil) (Prado et al., 2009) traces the child's performance profile in daily tasks based on the parents' perception, helping to identify signs of DCD in their children; and (2) the Brazilian Economic Classification Criterion of the Brazilian Association of Research Companies (Associação Brasileira de Empresas de Pesquisa, 2014) estimates the economic class of the participating families.

To identify signs of DCD and to assess children's motor performance, we used two assessment instruments. The first instrument was the Movement Assessment Battery for Children – Second Edition (MABC-2) (Henderson et al., 2007) as it is one of the most tests

used in research to identify DCD, and professionals from different areas use it for this purpose (Santos et al., 2017). Recently, this test was translated and used in children from the southern region of Brazil in an initial validation study for our population (Valentini et al., 2014). MABC-2 has two protocols, the “motor test” and the “checklist”. In this study, we used only the motor test to assess the motor performance of the sample. MABC-2 is useful to inform if the child reaches criterion “A” for the identification of DCD (American Psychiatry Association, 2014). It performs a direct observation of the children aged 3 to 16 years old in 8 tasks in the areas of manual dexterity, ball skills, and dynamic and static balance. The higher the total score on the test, the better the level of performance (Henderson et al., 2007). The cut-off points for the child's inclusion in this study were severe DCD when the score was less than or equal to the fifth percentile, and moderate DCD when the scores were from the sixth to the 15th percentile (Smits-Engelsman et al., 2015). Considering the recommendations of Smits-Engelsman et al. (2015) in the diagnosis of DCD, the child should be scored below the cutoff point of the DCDQ combined with the MABC-2 percentile.

After that, the children carried out the Beery-Buktenica Developmental Test of Visual-Motor Integration, 6th edition (VMI) (Beery & Beery, 2010). It is a standardized test of copying geometric shapes, using paper and pencil, to verify the level of integration of visual and motor systems. The VMI has good indexes of reproducibility of measurements and inter-rater reliability, which for the normative child group is 0.93 (Pfeiffer et al., 2015). The test consists of three parts: visual-motor integration, visual perception, and motor coordination. The test in the child takes 15 to 25 minutes and their score is based on the correction of each figure, according to the established pass or fails criteria (Beery & Beery, 2010). Occupational therapists commonly used VMI in the process of assessing writing legibility and performance in school activities, assessing the individual's ability to coordinate vision with the hand and finger motor skills (Pfeiffer et al., 2015). VMI can be used in any country because it is relatively independent of cultural issues (Pereira et al., 2011). The current version can be used from 2 years old in groups or individually (Beery & Beery, 2010).

Examiners external to the study previously trained in the application of motor tests evaluated the children, considering the methodological rigor that clinical trial studies require. The evaluation data were recorded in a database accessed by a password (Microsoft Excel spreadsheet)., the database contained only the registration number of each participant to guarantee their confidentiality, without a name or any other identifying information.

2.3 Data analysis

Data analysis was performed using the SPSS version 19.0 statistical package. Descriptive statistics (mean, standard deviation, and frequency) were performed to characterize the sample and the children's performance in the test items. As the data did not have a normal distribution, Spearman's correlation coefficient analyzed the association between MABC-2 and VMI items, with interpretation according to the recommendations of Portney & Watkins (2015) to analyze the strength of the association (0.00 to 0.25 = little or no relation; 0.25 to 0.50 = weak relation; 0.50 to 0.75 = moderate to good relation, and above 0.75 = good to strong relation). For all analyzes, we considered a significance level ≤ 0.05 .

3 Results

Twenty-two children participated in the study as a convenience sample, with 4 (18.2%) being female and 18 (81.8%) being male. The children's age ranged from 7 to 11 years old, with a mean age of 8.95 (\pm 1.09). Regarding economic status, 3 children (13.6%) were classified in Class A, 5 (22.7%) in Class B1, 8 (36.4%) in Class B2, 5 (22.7%) in Class C1 and only 1 (4.5%) in Class C2, with "Class A" as the higher economic level and "Class C" as the lower middle class.

Table 1 shows the average performance of children in items of manual dexterity and the total score of MABC-2 and VMI.

Table 1. Children's performance (n = 22) in MABC-2 and VMI. Belo Horizonte, 2017.

Test	Item	Average \pm Standard deviation
MABC-2	Placing pins (preferred hand)*	29.32 \pm 10.48
	Placing pins (not preferred hand)*	32.35 \pm 14.44
	Alignment*	35.76 \pm 15.58
	Trail Drawing [‡]	1.67 \pm 2.08
	Manual dexterity score	18.88 \pm 6.08
	Percentile Manual Dexterity	12.41 \pm 14.35
	MABC-2 total percentile	3.64 \pm 2.57
VMI	Gross visual-motor [£]	16.32 \pm 2.93
	Percentile visual-motor	27.00 \pm 23.03
	Gross Visual Perception [£]	18.41 \pm 2.65
	Visual percentile perception	32.50 \pm 26.48
	Gross Motor Coordination [£]	14.68 \pm 3.12
	Motor coordination percentile	11.23 \pm 12,68

Note: * Time to complete the task, in seconds; [‡] number of errors; [£] number of hits.

Considering the 25th percentile in the VMI as a cutoff point for below-average performance (Beery & Beery, 2010), we observed that in the visual-motor integration section, 12 children (54.5%) performed below average, in the visual perception, 13 children (59.1%), and the 19 children (86.4%) in the motor coordination section.

Table 2 shows the analysis of the association between the MABC-2 and the VMI sections. There was a single significant association between the MABC-2 total percentile and the MABC-2 manual dexterity percentile.

Table 2. Correlation between the scores on the MABC-2 and VMI items. Belo Horizonte, 2017.

	MABC – total percentil	VMI – visual- motor percentil	VMI – visual percentil	VMI – motor percentile
MABC –dexterity percentile	0.735**	0.139	-0.174	0.035
MABC-2 – total percentile		0.239	-0.047	-0.125
VMI – visual-motor percentil			0.174	0.384
VMI – visual percentile				0.219

Note: ** p<0.001.

4 Discussion

In this study, we examined the skills of visual-motor integration, visual perception, motor coordination, and manual dexterity in children with Developmental Coordination Disorder using MABC-2 (Henderson et al., 2007) and VMI 6th edition as assessment tools (Beery & Beery, 2010). The strength of the association between MABC-2 and VMI was considered weak or non-existent in all areas assessed, despite both analyzing the same construct, the child's fine motor coordination.

Considering the percentile of the different areas assessed by the VMI, the average performance of the children in the sample was below the average (25th percentile) in all areas of the instrument, suggesting that, in general, children with DCD have low visual-motor performance. This data is consistent with Waelvelde et al. (2004) who reported that poor performance in the VMI copy task is quite common in children with DCD. According to Prunty et al. (2016), children diagnosed with DCD have significant difficulties in performing tasks that require this type of skill, and performance problems are more visible when faced with tasks that require speed, such as writing. Valentini et al. (2012) comment that, regardless of gender and age, the greatest difficulties presented by children with DCD assessed in their study were in tasks that involved manual dexterity, a difficulty that tends to worsen during the school period (Valentini et al., 2012).

A significant correlation was observed between the percentile of motor dexterity and the total percentile of MABC-2, which it was expected since manual dexterity represents an aspect of the motor coordination construct measured by MABC-2, and also confirms the construct's validity test. When considering the correlation between MABC-2 scores and the different areas of VMI, no significant correlation was observed. This suggests that the tests assess different aspects of motor function and they should be used in a complementary way in the evaluation of children with DCD. According to Prunty et al. (2016), the tests of visual-motor integration and visual perception do not seem to be sensitive to low performance in tasks that require fine motor coordination, such as writing, in children with DCD. The VMI test aims to identify difficulties with visual-motor integration, indicating the need for treatment, evaluating the effectiveness of the adopted intervention and assisting as a research tool, but it is not known whether the test predicts writing difficulties in children with DCD, which should be the focus of future research with this population (Prunty et al., 2016). Despite its limitations, VMI is still a useful test for this population since there are no standardized instruments for assessing writing difficulties in Brazil.

Kaiser et al. (2009) discuss that the screening quality of MABC-2 for fine motor coordination problems is inferior to other existing tests, such as the Developmental Test of Visual Perception - 2nd ed. (DTVP-2) (Hammill et al., 1993), which has four tasks to assess the hand-eye coordination skill, while MABC-2 has only one task. Therefore, it is necessary and important to use combined tests to better analyze the performance of children with DCD to detect their possible difficulties in visual-motor integration and manual dexterity. Although there was no significant correlation between the VMI and MABC-2 scores, children with DCD performed below average in all areas of the VMI,

which suggests that such children have difficulties in visual-motor integration, and both instruments can be used in a complementary way in the evaluation process.

Several authors show that male children are more affected by DCD than female children (Blank et al., 2019; Coutinho et al., 2011), and the results found in this study corroborate this statement. The literature highlights that boys have greater difficulties with skills that involve fine motor coordination (manual dexterity) and girls have greater difficulties in tasks with the ball (Coutinho et al., 2011). This information may be related to the cultural context. In Brazil, for example, it is common for girls to be encouraged to play with calmer games, with smaller objects that demand more manual dexterity and visual-motor integration (Guerra et al., 2014), while boys are encouraged to play running, jumping, climbing, playing ball, which demands more gross motor skills (Coutinho et al., 2011), favoring the development of these motor skills.

The economic conditions of the children in this study ranged from upper class (A) to lower middle class (C), which supports evidence that the prevalence of DCD is not related to socioeconomic status (Blank et al., 2019; Camacho, 2011). However, the influence of socioeconomic status on clinical outcomes and opportunities for access to services for children with DCD is one of the environmental factors that should be further investigated, and it is important to assess whether these children receive due attention at school and in the community.

Despite presenting relevant information for professionals who work with children with DCD, this study has some limitations such as the sample size, which implies little variability and limits the generalization of the results, with restricted power of the correlation analysis. Another limitation was the use of VMI, which is not the most appropriate instrument to assess writing difficulties. However, as there is no other standardized instrument available in Brazil for this purpose, the use of VMI was important to emphasize the need to assess both global motor coordination and more specific aspects, of visual-motor integration and spatial perception.

5 Conclusion

The results of this study indicated that there was no correlation between MABC-2 and VMI, pointing out the need to assess both global motor coordination, including manual dexterity, visual-motor integration, and visual perception. Visual-motor integration may not be the main component associated with difficulties with manual dexterity in some children. Therefore, it is important to consider a multidimensional assessment since the VMI considers the analysis of a performance component, while the MABC- 2 assesses the child's performance in tasks that require manual dexterity and agility in execution. Children with DCD form a heterogeneous group, with difficulties in activities and tasks that require global motor skills to difficulties with fine motor activities such as writing, scissors clipping, and others that are part of their repertoire, becoming important to assess the different skills needed to perform these tasks.

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Author's Contributions

Amanda Aguiar Valverde and Clarice Ribeiro Soares Araújo were responsible for data collection and writing of the article. Amanda Aguiar and Ana Amélia Cardoso were responsible for organizing and reviewing the text. Clarice Ribeiro Soares Araújo and Lívia de Castro Magalhães were responsible for the textual review and final criticism. All authors approved the final version of the text.

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