

Bibliographical Review on Rehabilitation of Executive Functions in Patients With Developmental Coordination Disorder (DCD)

Keiko da Costa Oikawa Faculdade Censupeg, Joinville, Brazil

Fabr Éio Bruno Cardoso Faculdade Censupeg, Joinville, Brazil Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil

Filipe M. Bonone, Samuel Pereira de Souza, Vitor da Silva Loureiro Faculdade Censupeg, Joinville, Brazil

Alfred Sholl-Franco

Faculdade Censupeg, Joinville, Brazil Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil

The present study aims to establish a literature review on intervention programs for executive functions (EFs) through the use of fundamental motor skills, from a neuropsychopedagogical perspective in subjects with Developmental Coordination Disorder (DCD). An exploratory study was carried out through an integrative literature review. The research was carried out in the Scientific databases Electronic Library Online (SciELO), Latin American and Caribbean Literature in Health Sciences (LILACS), Virtual Health Library-Psychology Brazil (BVSPSI), Electronic Journals of Psychology (PePSIC), in the periodicals available in the Brazilian Digital Library of Theses and Dissertations (BDTD) and on the website of the Coordination for the Improvement of Higher Education Personnel

Keiko da Costa Oikawa, academic degree in Bachelor in Clinical Psychology, academic title Specialized in Behavioral and Cognitive Therapy and Specialized in Clinical Neuropsychology, Laboratory of Educational Innovations and Neuropsychopedagogical Studies (LIEENP), Faculdade CENSUPEG, Joinville, Brazil.

Fabr tio Bruno Cardoso, Ph.D. in Biological Sciences, Laboratory of Educational Innovations and Neuropsychopedagogical Studies (LIEENP), Faculdade CENSUPEG, Joinville, Brazil; Núcleo de Divulgação Cient fica e Ensino de Neurociâncias (NuDCEN), Instituto de Biof tica Carlos Chagas Filho (IBCCF), Programa de Neurobiologia, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil.

Filipe M. Bonone, PhD in Neurosciences, Laboratory of Educational Innovations and Neuropsychopedagogical Studies (LIEENP), Faculdade CENSUPEG, Joinville, Brazil.

Samuel Pereira de Souza, Licensed in Letters, Laboratory of Educational Innovations and Neuropsychopedagogical Studies (LIEENP), Faculdade CENSUPEG, Joinville, Brazil.

Vitor da Silva Loureiro, Master's Degree in Educational Manager Training, Laboratory of Educational Innovations and Neuropsychopedagogical Studies (LIEENP), Faculdade CENSUPEG, Joinville, Brazil.

Alfred Sholl-Franco, Ph.D. in Biological Sciences, Laboratory of Educational Innovations and Neuropsychopedagogical Studies (LIEENP), Faculdade CENSUPEG, Joinville, Brazil; Núcleo de Divulgação Cient fica e Ensino de Neuroci ências (NuDCEN), Instituto de Biof sica Carlos Chagas Filho (IBCCF), Programa de Neurobiologia, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil.

BIBLIOGRAPHICAL REVIEW ON REHABILITATION OF EXECUTIVE FUNCTIONS

(CAPES). The covering publications took place from 2018 to 2023, 14 articles were selected for analysis. This literature review made it possible to create strategies for stimulating EF and Visuomotor Functions so that educators and other professionals can better deal with students with DCD. It was perceived the need to carry out and develop more empirical research regarding the intervention of EFs and Visuomotor Functions by educators and professionals, with a greater sampling amplitude, to increase the number of studies that enable interventions both in children and in teenagers with DCD.

Keywords: developmental coordination disorder, executive functions, school neuropsychology, stimulation of executive functions

Introduction

Individuals with developmental coordination disorder (DCD) have motor coordination disabilities that interfere with the child's daily life, and the diagnosis involves screening instruments, assessment of motor condition based on performance, providing intervention to improve compromised skills and allow a new assessment of motor competence (Crippa, Os ório, & Souza, 2023; Farias, Maia, Morais, & Ferreira, 2022). However, these impairments cannot be explained by medical, neurodevelopmental, psychological, social, or cultural conditions, and occur at the beginning of development (Van Dyck, Baijot, Aeby, De Tiège, & Deconinck, 2022). TDC affects 5% to 6% of school-age children (Crippa et al., 2023). This disorder lasts into adolescence and adulthood and is linked to difficulties in academic behavior, psychosocial adjustment, physical health, and well-being (Subara-Zukic et al., 2022). Other research added that 2% to 20% of students are affected by the disorder, appearing more in boys (Oliveira, 2019), however, girls are affected (Rodrigues, 2019). Subjects with DCD also present impairment in organization, planning, time management, memory, and decision making, and these skills are related to executive functions (EFs) (Oliveira, 2019; Rodrigues, 2019).

Research has highlighted differences in neuronal structure and function, which impair planning and learning through observation, reducing the automation of movement, leading to greater dependence on slower control, based on feedback, and strategies compensatory (Oliveira, 2019). Secondary impairments linked to the child's behavior, emotions, and socialization were identified. Therefore, studies highlight the role of the cerebellum in the executive control of behavior, as they believe that motor development plays a role in predicting the development of EFs and academic skills. From this perspective, initial difficulties in motor coordination represent challenges related to the ability to anticipate, simulate, and regulate action, being considered initial forms of EFs (Oliveira, 2019; Rodrigues, 2019; Meachon, Zemp, & Alpers, 2022).

Research show that children diagnosed with DCD often present a lower level of performance in EFs when compared to their peers with typical development, this becomes evident in working memory, visuospatial functions, inhibitory control, and the ability to switch between tasks, with correlations between these different domains. Evidence points to atypical characteristics in the functioning of brain regions and circuits in children with DCD, suggesting that deficits in EFs may be related to a delay in the development of the frontoparietal and frontocerebellar networks (Bernardi, Leonard, Hill, Botting, & Henry, 2018; Fogel, Stuart, Joyce, & Barnett, 2023).

Therefore, understanding FEs in DCD is fundamental to improving the quality of life of these individuals. For that reason, the present study aims to establish a literature review on intervention programs in executive functions through the use of fundamental motor skills, from a neuropsychopedagogical perspective.

Methodology

To contribute to and ensure the achievement of its objective, this study used an exploratory study that allows the researcher to increase their specific experience, seeking background, and then planning descriptive or experimental research.

To technically and instrumentally operationalize this study, we chose to carry out an integrative literature review, using on the seven stages of planning a meta-analysis. The search and analysis of studies were carried out by pairs, taking into account the recommendation that each article be reviewed independently by more than one reviewer.

In the months of August and September of the year 2023, searches were carried out by texts that addressed the theme "Bibliographical review on Rehabilitation of Executive Functions in patients with Developmental Coordination Disorder-DCD", in the Scientific Electronic Library databases Online (SciELO), Latin American and Caribbean Literature in Health Sciences (LILACS), Virtual Health Library-Psychology Brazil (BVSPSI), Electronic Journals of Psychology (PePSIC), in the periodicals available in the Brazilian Digital Library of Theses and Dissertations (BDTD) and on the website of the Coordination for the Improvement of Higher Education Personnel (CAPES). The following descriptors were used: Developmental Coordination Disorder, Executive Functions, Visuomotor Functions, School Neuropsychology, Neuropsychology, Stimulation of Executive Functions and Visuomotor Stimulation.

The inclusion criteria used for selection were texts that: (1) present direct reference to the topic "Bibliographical review on Rehabilitation of Executive Functions in patients with Developmental Coordination Disorder-DCD"; (2) articles published between 2018 and 2023; (3) available in Portuguese and English; (4) present the Brazilian reality; (5) have theoretical references in the area related to Developmental Coordination Disorder and stimulation of Executive Functions and Visuomotor Functions; and (6) work on the process of Stimulating Executive Functions and Visuomotor Functions.

Studies done before 2018, studies that did not present the researched variables, articles unavailable on the Internet, and texts that did not present the complete and available study were disregarded. And coinciding studies in two or more sources were considered only once.

Result

18 articles related to DCD were identified, of which14 articles were selected that described interventions in Cognitive Functions, being more focused on stimulating EFs and Visuomotor Functions in children and teenagers with DCD in the school context, of which seven articles are in Portuguese and seven articles in English language. Eight articles used control groups, one article used a group of children with TD, and five articles carried out studies through bibliographic review. The main information regarding the 14 selected articles is described in Table 1.

Table 1 Table for Description of Studies for Complex Out a Systematical Literature Parian

Magazine/edition/year	Authors	Sample	Study description	Results
School Performance in Reading, Writing and Arithmetic Skills of Adolescents with Probable Developmental Coordination Disorder. <i>European Academic</i> <i>Research</i> Vol. X, issue 6, September 2022	Farias, L. R. L. C., Maia, S. D. B., Morais, L. C., Ferreira, L. F. (2022)	26 teenagers aged between 11 and 14 years and 11 months old from three schools in the State Network of the Municipality of Manaus/Amazonas participated. They used the TDE-II for data collection.	The objective of this research was to outline the improvement of adolescents at school with probable Developmental Coordination Disorder (pDCD) in Amazonian society, to identify performance levels in writing, reading, and arithmetic.	The assessment of the school performance of teenagers with pDCD presented characteristics that formed four different levels, which showed researchers that adolescents with pDCD can perform well in school skills. However, adolescents with severe difficulties are unable to achieve above-average levels of performance and have presented school difficulties, either alone or together, requiring pedagogical and motor intervention.
Developmental Coordination Disorder (DCD): Relevance for Clinical Psychologists in Europe. <i>Clinical psychology in Europe</i> , v. 4, no. 2, 2022.	Meachon, E. J., Zemp, M., Alpers, G. W. (2022)	Articles published in the last decade about DCD were reviewed; aspects of DCD were considered, such as EFs, psychological consequences, and DCD in adults.	European clinical psychologists and psychotherapists have gained new knowledge about DCD from the last decade of research.	Evidence pointed to impairments in EF at all ages and patients reported secondary psychological difficulties, being questioned about the effectiveness of psychotherapy in the disorder.
Executive Functions in Children with Developmental Coordination Disorder: A 2-Year Follow-Up Study. <i>Developmental Medicine</i> & <i>Child Neurology</i> , vol. 60, n. 3, pp. 306-313, 2018.	Bernardi, M., Leonard, H. C., Hill, E. L., Botting, N., Henry, L. A. (2018)	Children aged 7 to 11 years were assessed twice, two years apart, and evaluated verbal and non-verbal measures of executive functions: working memory (ELWM); fluency; inhibitory control; planning; and mental flexibility. Children with typical development were compared with subjects with DCD and subjects with motor impairments but without a formal diagnosis of DCD.	Deficits in executive functions have been observed in children with motor impairments, with and without a diagnosis of DCD.	Between the groups there were improvements in EFs, even with a gap between children with motor impairments and those with typical development in non-verbal EFs. It was observed that children with DCD had more losses than children with TD in all non-verbal EF tasks and in verbal fluency tasks in both stages; and children with motor impairments, but without a diagnosis of DCD, showed difficulties in EFs in non-verbal ELWM and fluency tasks.
Relationships between Motor Skills and Executive Functions in Developmental Coordination Disorder (DCD): A Systematic Review. <i>Scandinavian Journal of</i> <i>occupational Therapy</i> , vol. 30, no. 3, pp. 344-356, 2023.	Fogel, Y., Stuart, N., Joyce, T., Barnett, A. L. (2023)	There was a systematic search for articles published between 1994 and 2021, in eight electronic databases that addressed quantitative studies that showed relationships between motor skills and EFs when evaluating children, adolescents, and adults with DCD. The quality of the selected articles was analyzed, as well as the evaluation methodology.	This review analyzed the relationships between motor skills and EFs in studies among individuals with DCD.	Eleven articles presented the inclusion criteria and were reviewed. Results from nine studies showed weak to strong correlations between aspects of motor skills and EFs.

Table for Description of Studies for Carrying Out a Systematized Literature Review

Table 1 to be continued				
Behavioral and Neuroimaging Research on Developmental Coordination Disorder (DCD): A Combined Systematic Review and Meta-Analysis of Recent Findings. <i>Frontiers in</i> <i>Psychology</i> , v. 13, p. 809455, 2022.	Subara-Zukic, E., Cole, M. H., McGuckian, T. B., Steenbergen, B., Green, D., Smits- Engelsman, B. C., et al. (2022)	This review included publications carried out between September 2016 and April 2021. One hundred study articles on the DCD Control comparison were included.	This article showed the experimental studies carried out during this period on motor control, the cognitive and neural foundations of DCD.	The most pronounced difficulties were in voluntary control of gaze in movement; cognitive-motor integration; practice/context- dependent motor learning; internal modeling; more variable kinematics/movement kinetics.
Cognitive, Perceptual, and Motor Profiles of School-Aged Children with Developmental Coordination Disorder. F <i>ront Psychol.</i> , Aug 3, 2022; 13: 860766.	Van Dyck, D., Baijot, S., Aeby, A., De Tiège, X., Deconinck, N. (2022)	Fifty children with DCD and 31 peers with TD (7-11 years old) participated, who underwent neuropsychological (15 tests) and motor assessments (three subscales of the Movement Assessment Battery for Children-2).	The motor, perceptual and cognitive profiles of children with DCD at the group level and in terms of subtypes were highlighted.	Moderate percentages of children with DCD detected impairment in: executive functions (92%), praxis (68%), attention (52%), visual perception (46%), and visuomotor (36%). Five subtypes were identified, four of which included children with DCD and one with children with TD.
International Clinical Practice Recommendations on the Definition, Diagnosis, Assessment, Intervention, and Psychosocial Aspects of Developmental Coordination Disorder. <i>Dev Med Child Neurol.</i> , 2019 Mar; 61(3):242-285.	Blank, R., Barnett, A. L., Cairney, J., Green, D., Kirby, A., Polatajko, H., et al. (2019)	Five areas were considered, and bibliographical researches on "mechanisms", "evaluation", and "intervention" were updated following recommendations made in 2012.	The objective was to address the definition, diagnosis, assessment, intervention, and psychosocial aspects relevant to clinical practice in DCD.	Thirty five recommendations were suggested. Three discussed evaluation and five talked about intervention through literature review. 22 were updated following the 2012 guidelines.
Attentional and Executive Functions in Children and Adolescents with Developmental Coordination Disorder and the Influence of Comorbid Disorders: A Systematic Review of the Literature. Rodr guez C, organizer. <i>PLOS ONE</i> . June 4, 2021; 16(6): e 0252043.	Lachambre, C., Proteau- Lemieux, M., Lepage, J. F., Bussi ères, E. L., Lipp é, S. (2021)	41 studies were selected from the PubMed/Medline and PsycINFO databases.	The objective was to verify whether deficiencies can be found in other attentional and executive functions.	Impairments in general EF were detected in children with DCD. The presence of comorbidity apparently helped to find verbal working memory difficulties.
Level Cognitive and Developmental Coordination Disorder: Study with Schoolchildren Aged 7 to 10 Years. <i>Cad Bras Ter</i> <i>Ocupacional</i> , 12 Sep. 2019; 27:534-544.	Barbacena, M. M., Van Petten, A. M. V. N., Ferreira, D. L., Magalh æs, L. de C. (2019)	402 children from public schools participated and used the MABC-2 motor coordination test and the Raven cognitive test. Parents filled out DCDQ-Brazil.	This article verified the relationship between cognitive level and motor performance in children aged 7 to 10 years old with and without DCD.	Of the 402 children analyzed, 35 were diagnosed with DCD. No differences were found in cognitive percentiles between children with and without DCD, but there was an association between motor performance and cognitive level in the DCD group, with higher cognitive percentiles being possible in the group without DCD.

Table 1 to	be co	ntınu	ed
------------	-------	-------	----

Researches Brazilian about Developmental Coordination Disorder: A Review in Light of Theory Bioecological. <i>Cad Bras</i> <i>Ter Ocupacional</i> , 2020 Feb. 17; 28: 246-270.	Oliveira, S. F. de, Martinez, C. M. S., Fernandes, A. D. S. A., Figueiredo, M. de O. (2020)	The first part of the research involved an integrative review of the Brazilian scientific literature on DCD. The second stage compared the elements of the PPCT model. There were 19 studies with quantitative methodology and cross-sectional studies.	The research used the Bioecological Theory of Human Development (TBDH) to examine productions on DCD, and identified and discussed the elements of the PPCT model.	The Person nucleus was present in all research. Motor performance was the main condition for identifying DCD and linking it with other clinical, health, and social variables. In proximal processes, family and school contexts prevailed. In the Time section, the relevance of early diagnosis and intervention in children was highlighted.
Individual Program Interv to Develop Motive and Self- Regulatory Skills in Children with Disorder Coord. 2019.	Oliveira, Sabrina Ferreira de (2019)	A literature review was carried out on the various strategies used in research. The program presented three stages: evaluative, accompanied, and guided interventions, applied to a seven-year- old participant, with qualitative and quantitative analysis of the results. The MABC-2, the DCD identification questionnaire (DCDQ-Brazil) and the EDM, Perceived Efficacy and Goal Setting System (PEGS) (2nd edition), Analogue Verbal Scale for each Learning Goal.	This research related motor training with strategies for developing self-regulation and self-efficacy to obtain motor refinements in children with DCD.	Using the strategies, there was an improvement in performance in motor activities; the effectiveness was noticed in other motor activities. Improvement was observed in both the child and their families.
Characterization of the Academic Performance of Children with Probable Developmental Coordination Disorder. 2019.	Rodrigues, R. dos S. (2019)	Fifty-four children with pDCD participated, 24 girls and 30 boys, between 8 and 12 years old, from nineteen elementary schools I and II of basic education in the municipal and state education network in the city of Manaus/AM.	pDCD was verified in the Amazonian context and from the perspective of inclusive education.	In the Reading subtest, 38 children performed at or below the average and 16 performed at or above the average. In Writing, 45 children had lower performance and only seven had performance equal to or above average. In Arithmetic, 27 children had performance equal to or below the average and 27 children were average to above. In general performance, 37 children performed below the average for the school year, 13 children with average performance, and only four with above average performance.
Characterization of the Academic Performance of Adolescents with Probable Developmental Coordination Disorder. 2020.	Farias, L. R.L. C. (2020.)	26 teenagers participated, 16 girls and 10 boys, aged between 11 and 14 years and 11 months, previously identified with probable DCD, and studying in three schools from the 6th to the 9th year of Elementary School II of the State Education Network of the Municipality of Manaus /Amazonas. The TDE-II was used to collect data.	The study characterized the academic performance of adolescents with DCD in the Amazonian context.	Four levels of performance were identified (1) Severe deficit; (2) Alert/Moderate; (3) Average performance and (4) Good performance, which showed the variability of the pTDC condition, which called for pedagogical and motor intervention actions.

Table	1 to	be	continued

Developmental Coordination Disorder in Adolescents and Its Bonten Relationship with Reading and (2020) Writing Performance. 2020.	It co se mpo, K. D. S. Th an ad pe an	t was a descriptive, exploratory, and orrelational research, of a cross- ectional nature that carried out uantitative and qualitative analyses. The DCDQ-BR instrument was nswered by the parents of 23 dolescents, evaluated by the motor erformance instruments, DCDQ-BR, nd MABC-2.	Indicative signs of DCD in adolescents were identified and were correlated with reading and writing skills.	The majority of adolescents assessed by parents using the DCDQ-BR instrument were identified as having DCD. In relation to MABC-2, five were identified with pTDC. The final sample included three adolescents, identified as having DCD in both instruments. All participants had impairments in reading and writing, according to the results of the TDE and TCLPP. All participants recognized impaired academic performance in reading and writing; and good motor and social performance at school.
--	---	--	--	---

BIBLIOGRAPHICAL REVIEW ON REHABILITATION OF EXECUTIVE FUNCTIONS

During the bibliographic survey, research on DCD related to EF and Visuomotor Function is essential, as it alerts educators to stimulate these functions. However, there is still little research related to this topic.

In the article "School Performance in Reading, Writing and Arithmetic Skills of Adolescents with Probable Developmental Coordination Disorder" (Farias et al., 2022), the school performance of adolescents with pDCD in the Amazonian context was analyzed, to analyze writing, reading and arithmetic. 26 teenagers from three schools of the State Elementary School II participated. The School Academic Performance II-TDE II: Writing, Arithmetic, and Reading, was selected for data collection, with four different levels: first level Deficit serious; second level Alert/Moderate; third level performance Medium, and fourth level Good performance. Each level showed the diversity from the condition in pDCD, that's why adolescents tend to present good performance in school skills. For levels in performance above from the average, teenagers with pTDC presented serious deficits in the three skills schoolchildren, in shape isolated or in together, requiring both pedagogical intervention and how much engine. In this way, monitoring and analysis of behavioral deficits during activities were carried out to be able to intervene to minimize students' difficulties; subsequently the students were referred for multidisciplinary assessment; pedagogical support was necessary for students to adapt to the activities; creating a welcoming atmosphere in the room and encouraging new methodologies in teaching is among other needs.

In the research "Developmental coordination disorder (DCD): relevance for clinical psychologists in Europe" (Meachon et al., 2022), the DCD was revised to assist clinical psychologists and psychotherapists in Europe and this alerted European psychology scholars and professionals for further clarification and to carry out motor skills examinations whenever possible. This inclusion was feasible for more precise symptoms, improving the differential diagnosis, effectively treating DCD symptoms in all age groups.

The research "Executive functions in children with developmental coordination disorder: The two-year follow-up study" (Bernardi et al., 2018), analyzed the development of EF. in children with motor deficits for two years, with and without a diagnosis of DCD, and found difficulties in EF that affected non-verbal domains and were short-lived in the development of children with motor deficits without a diagnosis of DCD. Both the groups with motor difficulties and the groups with DCD showed significant gains in EFs during middle childhood, which corresponded to those of the TD group, showing that the progression of EF over time was at the expected level.

In "Relationships between motor skills and executive functions in development coordination disorder (DCD): A systematic review" (Fogel et al., 2023), PICO (population, intervention, comparison, results) was used, in which they observed the relationships between motor impairments and EF components through analysis of motor assessment and EF with tools used in studies of individuals with TDC. No comparison intervention group was included. Although the studies that were included presented weak to strong correlations, the development of EF, the types of assessment used, and their cognitive demands were considered, as well as the issues of comorbidities in each study. The authors suggested that they continue to analyze EFs and motor deficits to better understand the theory and clinical nature of the relationships between them and their effects on the daily lives of individuals with DCD.

In the article "Behavioral and neuroimaging research on developmental coordination disorder (DCD): A combined systematic review and meta- analysis of recent findings" (Subara-Zukic et al., 2022), a combined systematic review and meta-analysis was carried out to clarify: (1) the profile of motor control and learning deficits in DCD in different domains; (2) the profile of deficits in domains of cognitive control and cognitive-motor integration, and (3) disturbances in brain structure, function, and/or maturation and their relationship with the motor skills of individuals with DCD compared to individuals with typical development (TD). The continuous

progression of DCD and its comorbidity with other neurodevelopmental disorders and, likely, "executive dysfunction" were highlighted, requiring professionals to check comorbidity during diagnosis and intervention. Impairments in EF and cognitive-motor integration were noted, considering the apparently weak link between cognition and movement in the performance of children with DCD, and suggested addressing this issue in the contexts of assessment, rehabilitation, and education. Executive dysfunction was found in learning, academic performance, psychosocial adjustment, and well-being in DCD, requiring adjustments in the classroom and at home. The third point analyzed learning and focus on attention, using methods based on instruction principles and skills practice. The techniques stood out: guided instruction to direct the focus of attention, increased visual feedback, and long learning periods. Active computer games and group-based interventions were also used, which were promising in improving motor performance; therefore, the gains acquired reinforced the motivation of these children. Evidence showed that gains in motor performance following a Cognitive Orientation for Occupational Performance (CO-OP) intervention were accompanied by a sustained increase in white matter microstructure and functional connectivity between brain networks linked to emotional regulation, inhibitory control, and attention for those with DCD.

In the article "Cognitive, perceptual, and motor profiles of school-aged children with developmental coordination disorder" (Van Dyck et al., 2022), the motor, perceptual and cognitive profile of school children with DCD was outlined at the group level and in terms of subtypes. Therefore, a large group of children with DCD and peers with TD of the same age were selected, who participated in fine and gross motor and neuropsychological activities. Five groups were formed, based on motor, perceptual and cognitive measures that were characterized by (1) generalized deficiencies, (2) impaired manual dexterity, balance, planning, and impaired attention functions, (3) impaired manual dexterity, cognitive inhibition, and poor visual perception skills, (4) impaired manual dexterity and cognitive inhibition, and (5) no impairment. Reduced EFs were present across groups of children with DCD, but the nature and severity of these impairments differed between subtypes. The importance of evaluating the perceptual and cognitive abilities of children with suspected DCD was verified.

In the article "International clinical practice recommendations on the definition, diagnosis, assessment, intervention, and psychosocial aspects of developmental coordination disorder" (Blank et al., 2019), the authors aimed to: (1) determine and prioritize the cause, diagnosis, and intervention; (2) question high priority practices; (3) provide knowledge of evidence-based practices; (4) point out deficits in research; (5) define individual diagnostic and intervention strategies based on clinical decision and knowledge of the evidence; (6) recommend different disciplines and define their roles in clinical practice; (7) recognize the interdisciplinary value between doctors and therapists from different disciplines; (8) implement the recommendations, involving medical and paramedical organizations in assessment and treatment; (9) identify barriers to implementation; (10) provide tools for clinical training and the implementation of quality management systems. 35 recommendations were made, eight of which were based on evidence from literature reviews, and 22 were updated through the 2012 recommendations. The new recommendations were for diagnosis, assessment, and psychosocial issues. Another recommendation (LOE) used active video games as complements to interventions, and two new recommendations (one GCP, one LOE) were made for adolescents and adults with DCD. In this way the CPR-DCD presented a comprehensive overview of TDC and current understanding that was based on research evidence and expert consensus.

In the study carried out in "Attentional and executive functions in children and teenagers with developmental coordination disorder and the influence of comorbid disorders: A systematic review of the literature" (Lachambre, Proteau-Lemieux, Lepage, Bussi res, & Lipp & 2021), the losses were clarified linked to DCD, which instead of

being explained by comorbid disorders, identified the needs of children with DCD, considering their clinical condition, to optimize their assessment and the interventions carried out. It was found that children and adolescents with DCD showed impairments in EF in general. Alertness, sustained attention, selective and divided attention, and verbal fluency capabilities remained unchanged, while results in mental flexibility were divided. Deficits were evident in non-verbal executive tasks. Concomitant disorders could influence the impairments found in verbal working memory capabilities in children with DCD. These results made it possible to understand the cognitive profile linked to DCD. At the conceptual level, impairments in EFs are common in DCD, even though they are partially explained by underlying visuospatial and motor deficits. Although it is important that children benefit from appropriate interventions to help with their difficulties, professionals must be careful in diagnosing concurrent illnesses, assisting professionals in their interventions to avoid overloading working memory and supporting them in developing their communication skills planning.

In the article "Cognitive level and developmental coordination disorder: study with schoolchildren aged 7 to 10 years" (Barbacena, Van Petten, Ferreira, & Magalh ães, 2019), the relationship between cognitive level and motor performance in public school children with different levels of motor performance, with and without DCD was investigated. It was a descriptive, cross-sectional study, recruiting schoolchildren from the extra-day physical activity program—Program/Second/Time (PST) of the municipal network, and all children performed physical activities. Students aged seven to 10 years and 11 months old participated in the study, from 21 municipal schools, located in six administrative regions in the city of Belo Horizonte, MG. The results showed that children with DCD, even with marked motor impairment, had a cognitive level similar to their peers with TD. Cognitive and functional assessments need to be included in the diagnosis of DCD, needing to be objective or combining information from different sources about functional performance. The authors suggested that future research carry out more in-depth studies on the relationship between different cognitive abilities and motor and functional performance at different ages.

In the article "Brazilian research on developmental coordination disorder: a review in light of bioecological theory" (Oliveira, Martinez, Fernandes, & Figueiredo, 2020), they adopted the Bioecological Theory of Human Development (TBDH) to guide studies on DCD, and identified and discussed the elements of the nuclei Process-PersonContext-Time (PPCT) in national scientific production. In this review, cross-sectional studies with quantitative methodology predominated. The Person nucleus was present in all the articles analyzed. In the Time nucleus, agility in diagnosis, early intervention, and specificities of the child's life events was observed. The use of MABC as an identification instrument was essential, as well as adopting broader measures to analyze the development of children with DCD. There was a need to continue investigations into the prevalence of DCD in Brazil, and instruments for early detection and characterization of difficulties require improvement. Interventions were required in family and school contexts to better deal with DCD.

In the research "Individualized intervention program for the development of motor and self-regulatory skills in children with developmental coordination disorder" (Oliveira, 2019), a motor intervention program was developed to work on self-regulatory and self-efficacy skills in children with DCD. The study data suggested that exercises for body structure and function had an impact on the child's global performance, while activity-oriented training modified the specificity of the activity in the child's motor performance. This emphasized the relevance of structuring the practice of this Intervention Program for both the structure and the activity, as it can increase possibilities of participation in motor activities, leading to satisfaction and involvement in occupations for children with DCD. In the dissertation "Characterization of the School Performance of children with probable Developmental Coordination Disorder" (Rodrigues, 2019), the school performance of children with pDCD was characterized. Retrospective descriptive research was carried out with cross-sectional characteristics. The academic performance of 54 children with pDCD, aged 8 to 12 years, were identified, known, and described. The following were studied: academic performance, Reading, Writing, and Arithmetic. The variables were measured using the TDE. The results showed that almost three quarters of the children performed below the expected average and that a large proportion were in the lower performance group. The research demonstrated that lack of knowledge and negligence in caring for this population leads to exclusion and self-exclusion from school activities that are crucial for full development. Considering the Amazonian reality, the need to include children with pDCD was emphasized, providing an environment that meets their educational needs.

In the research "Characterization of the School Performance of Adolescents with probable Developmental Coordination Disorder" (Farias, 2020), the school performance of teenagers with pDCD was evaluated and the characteristics formed four levels: in the first level Severe deficit; at the second level Alert/Moderate; in the third level Medium performance, and in the fourth level Good performance, these differences in performance showed the variability of the pDCD condition , and even adolescents with the disorder perform well in school skills. The weight of the presence of above-average levels of performance highlighted that adolescents with pDCD showed serious deficits in school skills, alone or together, which calls for pedagogical and motor intervention actions.

In the research "Developmental Coordination Disorder in adolescents and its relationship with reading and writing performance" (Bontempo, 2020), signs suggestive of DCD were found in adolescents in the 6th and 7th years of elementary school and correlated them with reading and writing skills. It was found that the majority of adolescents with DCD were identified by their parents, using the DCDQ-BR instrument. Regarding MABC-2, five were identified with pDCD. The final sample consisted of three adolescents with DCD in the two aforementioned instruments. The TDE and Word and Pseudoword Reading Competence Test (TCLPP) showed that all participants were impaired in reading and writing. The teenagers also assessed themselves through the Incomplete Sentences Game and the teachers assessed their motor, academic, and behavioral performance through an interview. All participants recognized their poor academic performance in reading and writing, good motor performance, and good social performance at school.

Conclusion

This literature review helped to develop strategies for stimulating Executive Functions and Visuomotor Functions so that educators and other professionals can work with students with DCD as a result of Neuropsychological Assessment; the research had limitations due to the limited number of articles related to the stimulation of EFs and Visuomotor Functions. There were some bibliographic reviews that talked about the problem and few empirical studies were found, with representative samples that highlighted the aforementioned theme. More in-depth studies were international research; Brazilian research still covers little about the topic. Scholars have emphasized the importance of checking the needs of people with DCD, accompanying them in carrying out their activities, analyzing their performance during the tasks, in order to intervene appropriately. Researchers highlighted that psychologists should pay attention to the psychological issues of sufferers, integrating motor skills into their work whenever necessary. Researchers highlighted the relevance of continuing to examine EFs and motor skills for a better theoretical and clinical understanding of the interconnections between them, analyzing the daily consequences in individuals with DCD. Assessing the perceptual and cognitive abilities

of individuals with the disorder was another recommendation. All researched articles recommended carrying out more in-depth studies on the relationship between the various cognitive abilities and motor and functional performance, investigating the level of cognitive impact in intervention procedures, requiring early intervention instruments and outlining the difficulties that require improvements.

It is recommended that more empirical research needs to be carried out covering interventions in EFs and Visuomotor Functions, but using a greater sampling amplitude, to enable greater interventions in both children and adolescents with DCD. Therefore, it is expected that this bibliographical review will contribute to the dialogue between researchers and developers who accept this challenge, to reduce lack of knowledge and negligence in caring for this public, so that they can achieve their school goals, enabling better educational inclusion.

References

- Barbacena, M. M., Van Petten, A. M. V. N., Ferreira, D. L., & Magalhães, L. de C. (2019). Cognitive level and developmental coordination disorder: Study with schoolchildren aged 7 to 10 years. *Cad Bras Ter Ocupacional*, 27, 534-544.
- Bernardi, M., Leonard, H. C., Hill, E. L., Botting, N., & Henry, L. A. (2018). Executive functions in children with developmental coordination disorder: A 2-year follow-up study. *Dev. Med. Child. Neurol.*, *60*(3), 306-313.
- Blank, R., Barnett, A. L., Cairney, J., Green, D., Kirby, A., Polatajko, H., et al. (2019). International clinical practice recommendations on the definition, diagnosis, assessment, intervention, and psychosocial aspects of developmental coordination disorder. *Dev Med Child Neurol.*, 61(3), 242-285.
- Bontempo, K. D. S. (2020). Developmental coordination disorder in adolescents and its relationship with reading and writing performance. Retrieved from https://repositorio.ufscar.br/bitstream/handle/ufscar/12801/Disserta%C3%A7%C3%A3o_Kaila _bontempo_finalizada%202.pdf?sequence=4
- Crippa, A. de S., Os ório, F. de L., & Souza, J. D. R. De. (2023). *Diagnostic and statistical manual of mental disorders: DSM-5TR* (5th ed.). Porto Alegre: American Psychiatric Association.
- Farias, L. R. L. C. (2020). Characterization of the school performance of adolescents with probable developmental coordination disorder (M.Sc. thesis, Universidade Federal do Amazonas, 2020).
- Farias, L. R. L. C., Maia, S. D. B., Morais, L. C., & Ferreira, L. F. (2022). School performance in reading, writing and arithmetic skills of adolescents with probable developmental coordination disorder. *European Academic Research*, 10(6), 2182-2197.
- Fogel, Y., Stuart, N., Joyce, T., & Barnett, A. L. (2023). Relationships between motor skills and executive functions in development coordination disorder (DCD): A systematic review. Scand J Occup Ther., 30(3), 344-356.
- Lachambre, C., Proteau-Lemieux, M., Lepage, J. F., Bussi ères, E. L., & Lipp é, S. (2021). Attentional and executive functions in children and teenagers with developmental coordination disorder and the influence of comorbid disorders: A systematic review of the literature. *PLOS ONE*, 16(6), e0252043.
- Meachon, E. J., Zemp, M., & Alpers, G. W. (2022). Developmental coordination disorder (DCD): Relevance for clinical psychologists in Europe. *Clin. Psychol. Eur.*, 4(2), e4165.
- Oliveira, S. F. de, Martinez, C. M. S., Fernandes, A. D. S. A., & Figueiredo, M. de O. (2020). Brazilian research on developmental coordination disorder: A review in light of bioecological theory. *Cad Bras Ter Ocupacional*, 28, 246-270.
- Oliveira, S. F. de. (2019). Individual program Interv to develop motive and self-regulatory skills in children with disorder coord.
- Rodrigues, R. dos S. (2019). Characterization of the academic performance of children with probable developmental coordination disorder (M.Sc. thesis, Universidade Federal do Amazonas, 2019).
- Subara-Zukic, E., Cole, M. H., McGuckian, T. B., Steenbergen, B., Green, D., Smits-Engelsman, B. C., et al. (2022). Behavioral and neuroimaging research on developmental coordination disorder (DCD): A combined systematic review and meta- analysis of recent findings. *Front Psychol.*, 13, 809455.
- Van Dyck, D., Baijot, S., Aeby, A., De Tiège, X., & Deconinck, N. (2022). Cognitive, perceptual, and motor profiles of schoolaged children with developmental coordination disorder. *Front Psychol.*, 13, 860766.