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Review Article

Brazilian research on the development of coordination development: a review in the light of bioecological theory

Pesquisas brasileiras sobre o transtorno do desenvolvimento da coordenação: uma revisão à luz da teoria bioecológica

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Abstract

Introduction: Children with Developmental Coordination Disorder (DCD) present motor disorders that compromise their engagement in occupations. **Objective:** Adopting the Bioecological Theory of Human Development (BTHD) as a basis for examining the productions of DCD, this study aimed to identify and discuss the elements of the Process-Person-Context-Time model (PPCT) in the national scientific production about children with DCD. **Method:** The first phase of the study consisted of an integrative review of the national scientific literature on DCD in journals indexed in Virtual Health Library and SciELO, based on health descriptors. The second phase consisted of collating the elements of the PPCT model in the selected literature. **Results:** The sample, composed of 19 studies, showed a predominance of quantitative methodology and cross-sectional studies. Elements of the core *Person* were present in all searches. Motor performance was the central condition for the identification of DCD and correlation with other clinical, health and social variables. In the proximal processes, the family and school microsystem prevailed. In the core *Time,* the importance of diagnosis and early intervention, and specificities of normative life events of the child were highlighted. The review revealed the intense use of the Movement Assessment Battery for Children (MABC) as an instrument of identification and the importance of broader measures for the development of children with DCD. **Conclusion:** The analysis of research in the light of the bioecological theory made us think about important aspects of child development

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and there is a gap in the literature in relation to studies on DCD that contemplate the macrosystem with emphasis in the national health and education policies.

Keywords: Motor Skills Disorders, Human Development, Child.

Resumo

Introdução: Crianças com Transtorno do Desenvolvimento da Coordenação (TDC) apresentam desordens motoras que comprometem seu engajamento em ocupações. **Objetivo:** Adotando-se a Teoria Bioecológica do Desenvolvimento Humano (TBDH) como base para o exame das produções sobre o TDC, este estudo objetivou identificar e discutir os elementos do modelo Processo-Pessoa-Contexto-Tempo (PPCT) na produção científica nacional sobre crianças com TDC. **Método:** A primeira fase do estudo consistiu na revisão integrativa da literatura científica nacional sobre o TDC em periódicos indexados na Biblioteca Virtual em Saúde e SciELO, a partir de descritores em saúde. A segunda fase consistiu no cotejamento dos elementos do modelo PPCT na literatura selecionada. **Resultados:** A amostra, composta por 19 estudos, apresentou predomínio da metodologia quantitativa e estudos transversais. Os elementos do núcleo *Pessoa* estiveram presentes em todas as pesquisas. O desempenho motor foi a condição central para a identificação do TDC e correlação com outras variáveis clínicas, de saúde e sociais. Nos processos proximais prevaleceram o microssistema familiar e escolar. No núcleo *Tempo* destacou-se a importância do diagnóstico e intervenção precoce e especificidades dos eventos de vida normativos da criança. A revisão revelou o intenso uso do *Movement Assessment Battery for Children* (MABC) como instrumento de identificação e a importância de medidas mais amplas do desenvolvimento da criança com TDC. **Conclusão:** A análise das pesquisas à luz da teoria bioecológica traz à reflexão importantes aspectos do desenvolvimento da criança e mostra-se uma lacuna na literatura em relação aos estudos sobre TDC que contemplem o macrossistema com ênfase nas políticas nacionais de saúde e educação.

Palavras-chave: Transtorno do Desenvolvimento da Coordenação, Desenvolvimento Humano, Criança.

1 Introduction

Changes in motor skills of children without specific neurological injuries, "apparently normal", have been called, since the 1980s, Developmental Coordination Disorder (CDC) by the American Psychiatric Association (DSM-III) and Specific Motor Development Disability by the World Health Organization (WHO) in the International Classification of Diseases (ICD-10). This fact represented the recognition that these children had problems in motor development that affected their overall development (Dantas & Manoel, 2009).

According to the recent recommendations of the European Academy for Childhood Disability (Blank et al., 2019), closely related to those established by the

DSM-V (American Psychiatric Association, 2013), for the diagnosis of DCD the following criteria must be met:

(I) the acquisition and performance of coordinated motor skills are substantially lower than expected for chronological age and enough opportunities for age-appropriate skills acquisition; together there may be clumsiness, falls, bumping into things, balance deficit, difficulties on writing, jumping, cutting, coloring, catching and/or kicking the ball;

(II) the impairment in motor skills described in criterion I significantly and persistently interferes with the child's daily activities, such as self-care and mobility, and academic/school productivity, pre-vocational and vocational activities, leisure, games and jokes;

(III) such impairments in motor skills are not better explained by other medical, neurodevelopmental, psychological, social or cultural conditions;

(IV) the onset of symptoms occurs in childhood, although not identified before adolescence or adulthood.

In addition, poor motor behavior can lead to poor postural control and difficulties in motor learning (new skills, motion planning, automation), strategic planning, timing and motion sequencing, and processing visuospatial information (Vaivre-Douret, 2014).

Vaivre-Douret et al. (2016) present three subtypes for DCD; Ideomotor is the rarest and characterized by special difficulty in digital perception, gesture imitation and digital praxis; Visuospatial/Constructional presents dysfunctions in visuomotor integration and tasks involving visuospatial integration; and Mixed type, which presents specific difficulties in motor coordination and poor manual dexterity.

DCD is present in different cultures, races and socioeconomic conditions and considered idiopathic, so far. It is very often in comorbidity with other neurodevelopmental disorders including Attention Deficit Hyperactivity Disorder (ADHD), language disorders, learning disorders, autistic spectrum disorders, dyslexia or other writing disorders. It has a commonly reported prevalence of 5 to 6% in schoolchildren, however, between 2 and 20% in more recent research, and is more common in boys (Blank et al., 2019).

Motor difficulties tend to affect negatively socio-emotional aspects of children with DCD, with secondary damage on self-esteem, self-concept, feeling of competence, anxiety levels, participation in physical and sports activities, and physical conditioning (Ferreira et al., 2015). It also impairs sense of self-efficacy in tasks and facing barriers to physical activity (Batey et al., 2014), perceived efficacy in school activities/productivity, leisure and self-care (Engel-Yeger & Hanna Kasis, 2010). Tal-Saban et al. (2014) identified that these primary and secondary impairments of DCD affect participation in daily activities, quality of life and adult satisfaction.

The ecological theory of human development, conceived by Urie Bronfrenbrenner in the 1970s, explain the relevance of ecological contexts in the process of human development (Bronfenbrenner, 1996). After reformulation by the author himself, the Bioecological Theory of Human Development (BTHD) now includes biological, process and time factors as equally determinant to human development and

interdependent not only in context but also among them. Based on this reformulation, the author systematizes the theory into four cores, namely *process*, *person*, *context* and *time* (PPCT), understanding that human development would be a process of reciprocal interaction between the person and their context through time (Bronfenbrenner, 2011).

That theory has been used in several national studies (Dessen & Polonia, 2007; Alves & Emmel, 2008; Rolfsen & Martinez, 2008; Portes et al., 2013) about childhood problems in both health and education. The study by Custódio et al. (2014) reported a critical review of the literature about social support networks in the context of preterm infants' development. It pointed out that the network approach in the context of prematurity, under the conception of BTHD, allowed us to glimpse the complexity of the various systems involved in this scenario, as well as the interrelationship between them.

With regard to schoolchildren, the studies of Nobre et al. (2014, 2016) and Costa et al. (2014) reveal the contributions of BTHD to both critical analysis and the systematization of public actions related to factors that affect the motor development of socioeconomically disadvantaged Brazilian children. However, among national studies, there is no analysis of the problem of DCD in the light of TBDH.

In the international context, although there is evidence about the biological factors (pre, peri and postnatal) associated with the development of DCD (Hua et al., 2014), there are few studies exploring the reciprocal relationship with sociocultural aspects or using Bronfenbrenner's approach to this kind of investigation.

The fact that there is no construction of knowledge about the nature of children with DCD interaction in their environmental context is a major gap, given the interactional reciprocal nature of development (McQuillan, 2015).

Sugden (2014) points out that BTHD provides a solid theoretical framework for understanding the developmental process of children with DCD, considering that this development occurs as a function of the child's resources and the various environmental influences that occur over time. These influences range from broad social conditions to those present when engaged directly in physical activity. In this sense, this study aimed to identify and discuss the elements of PPCT cores in the national scientific production related to children with DCD. By dimensioning these elements in each study, we expect to discuss the developmental conditions of the Brazilian child with DCD in face of the importance of interactions reciprocity and environmental influences.

2 Method

This research consisted of an integrative review of the national scientific literature on studies on DCD, whose data were analyzed based on the perspective of BTHD elements. The integrative review consists of a method that reviews and systematizes literature data in order to gather and relate empirical and theoretical findings that provide a comprehensive understanding of certain thematic(s) and proposes new research questions (Cecílio & Oliveira, 2017).

Following the steps of an integrative review proposed by Mendes et al. (2008), the guiding question of this integrative literature review is as follows: what do national research on children with DCD reveal when analyzed in the light of BTHD elements?

As inclusion criteria of the studies in this review, we selected articles available in full, which should: 1) constitute research on the topic of DCD; 2) not constitute a theoretical or documentary research; and 3) be national studies.

Data collection occurred in journals indexed in Virtual Health Library (Bireme) databases and in Scielo database. The following search descriptors were selected in English and Portuguese using the Health Science Descriptors (DeCS) and Medical Subjects Headings (Mesh): *motor skills*, *motor skills disorders*, *child*, *Brazil*, *transtorno das habilidades motoras, transtorno do desenvolvimento da coordenação, criança e Brasil*, in a combined way. No time limit has been set for the search period, which occurred until March 2018.

The articles were analyzed using the quantitative and qualitative approach (Turato, 2005). The characterization of the studies regarding quantitative data was tabulated by the following information: author, year, objective, characterization of participants, research location, assessment instruments and outcomes. The information from each article in the light of the four cores of PPCT model of BTHD went through a categorization process, using the characterization of the cores and indicators described in Table 1, which classify the presence of each component according to Bronfenbrenner (2011), Prati et al. (2008) and Narvaz & Koller (2004). Three of the authors independently performed reading of each study and categorization in each core, verifying the agreement between the items.

Table 1. Characterization of cores according to the concept and indicators used in the categorization of studies.

Core	Description
Person	*Individual repertoire of biological, cognitive, emotional and behavioral characteristics.* *Three features:* Dispositions, which can set proximal processes in motion and continue to sustain their operation. Bioecological resources of skill, experience and knowledge to make proximal processes effective in a given phase of development. Demand, which invite or discourage social context reactions that may nurture or disrupt the operation of proximal processes. **Examples of Indicators:** gender or skin color; genetic factors; values and expectations that have in the social relation; performance and skills.
Process	*Fusion and the relationship dynamics between the individual and the context.* Proximal process of the individual with active interaction participation, progressively more complex and reciprocal with people, objects and symbols in the immediate environment, on a fairly regular basis over extended periods of time. **Examples of Indicators:** parent-child relationship; teacher-child relationship; activities among children; group or solitaire games; learning new skills; sport activities; family and school daily activities.

Core	Description
Context	*Levels or developmental systems that influence and are influenced by the individual's developmental processes, and where they may or may not be inserted.* Microsystem: characterized as the context in which there is a pattern of activities, social roles and interpersonal relationships experienced face to face by the individual in an immediate context. The microsystem has physical, social, and symbolic characteristics that invite, allow, or inhibit individual engagement. Mesosystem: consists of the interaction between the microsystems of the individual. Exosystem: involves the environments that influence the development of the individual, but in which they are not necessarily present. Macrosystem: composed of a set of ideologies, values and beliefs, religions, culture, subcultures, forms of government that can influence the development of the individual. **Examples of Indicators:** *microsystems*: family, school, therapies; *exosystem*: parents' job, institutional support and other types of social support; *macrosystem*: Brazil region, socioeconomic status, public policies
Time	*Development in the historical sense, with changes in events over time and due to pressures on the developing person.* Micro time: related to continuities and discontinuities in proximal processes; Meso-time: comprises broad time intervals such as days, weeks, months in which episodes occur; Macro time: changing expectations and events within the broader society, within or across generations, with a focus on normative or non-normative ecological transitions. **Examples of Indicators:** child entry into school; birth of a sibling; parents' change of work; get married; have children; diseases; affective losses; natural or social disasters.

Source: Bronfenbrenner (2011), Prati et al. (2008) and Narvaz & Koller (2004).

Based on the search criteria, 268 articles were found. After reading titles and abstracts, we excluded duplicate articles and those that did not mention DCD. Thus, the sample consisted of 30 articles read in full. After the complete reading, the selection was refined according to the objectives of this research and we excluded other studies that did not mention or were not directly related to children with DCD or that conceptually discussed DCD. The final sample for descriptive analysis consisted of 19 articles.

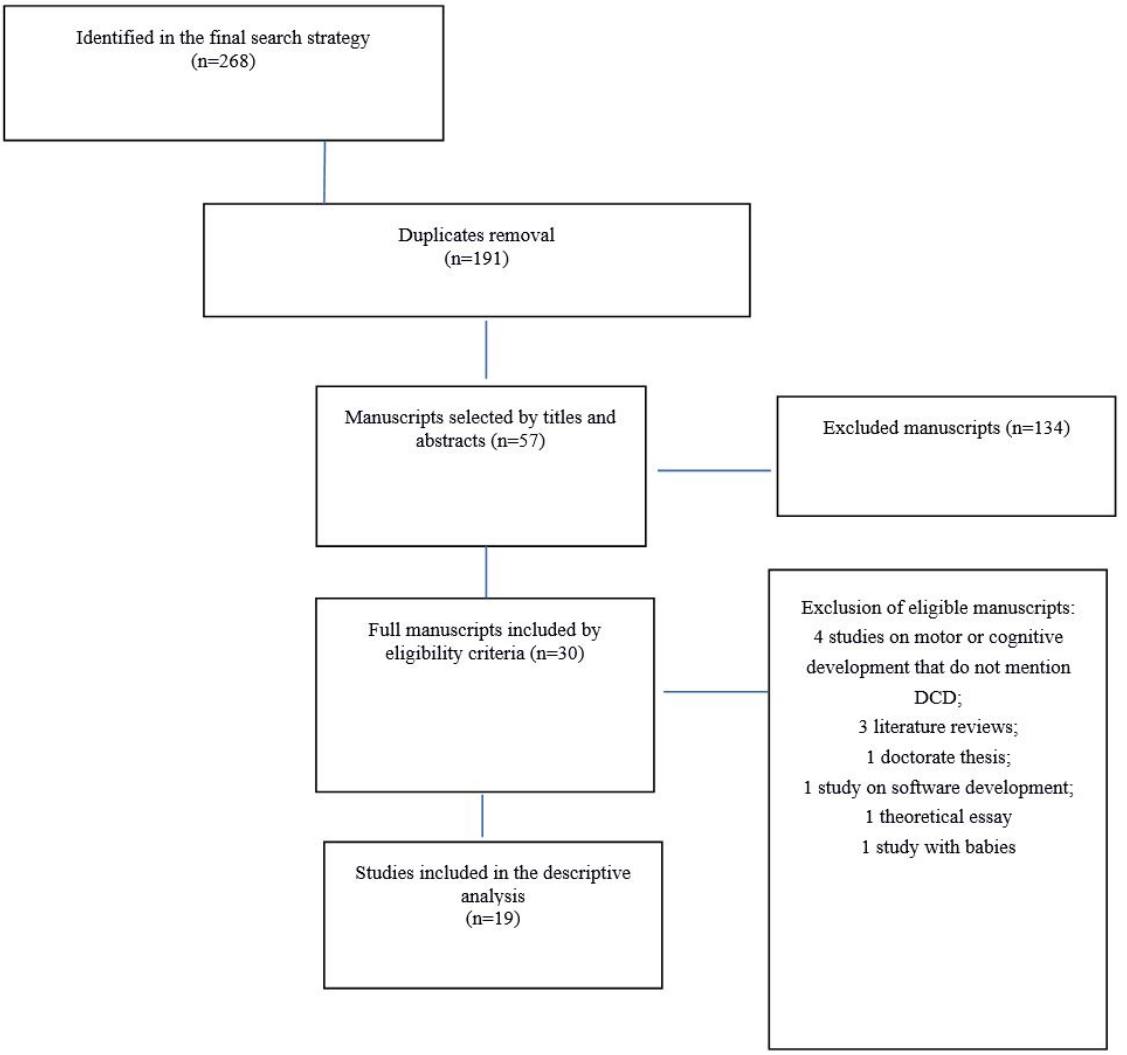

Figure 1. Articles Search and Selection Flow Diagram (Moher et al., 2009).

Figure 1 shows the diagram with the search and selection procedures of the articles for analysis.

3 Results

3.1 Characterization of the articles sample

Table 2 shows the characteristics of the 19 studies according to authors, year, objective, participants, research region and instruments or measures used. The articles of this review were published between 2009 and 2017.

Table 2. Studies characterization.

Author/year	Objective	Sample size and age (years old)	Region	Instruments/Measures
Beltrame et al. (2017)	Identify the prevalence of DCD	787 (7 to 10)	Florianópolis – Santa Catarina	MABC-2
Della Barba et al. (2017)	Identify the prevalence of DCD	130 (5 to 14)	São Carlos – São Paulo	DCDQ – Brazil Brazil Economic Classification Criteria Sample Characterization Questionnaire
Rocha et al. (2016)	Analyze motor performance and cognitive maturity of preschoolers	89 (4 to 5)	Maringá – Paraná	MABC-2 EMMC
Capistrano et al. (2016)	Analyze the relationship between motor performance and physical ability of students	98 (7 to 10)	Florianópolis – Santa Catarina	MABC-2 PROESP-BR
Santos et al. (2015)	Analyze the nutritional status and socioeconomic level of students with probable DCD, risk of DCD and typical development.	581 (7 to 10)	A municipality of northwestern Paraná	MABC 1 Body mass index. Brazil Economic Classification Criteria.
Valentini et al. (2015)	Identify the prevalence of DCD	1056 (4 to 10)	12 Brazilian cities	MABC 1
Galvão et al. (2014)	Investigate the perception of Brazilian mothers about the daily performance of children with DCD	5 guardians (between 32 and 60 years old) per children with DCD indicative (8 and 9 years old)	Belo Horizonte – Minas Gerais	Semi structured interview
Contreira et al. (2014)	Investigate the lifestyle of students with and without DCD	108 (11 to 13)	Florianópolis – Santa Catarina	MABC-2 EVIA
Moreira et al. (2014)	Analyze the factors that influence the motor development of premature Brazilian students	100 (8-10)	Belo Horizonte – Minas Gerais	MABC-2. Token Test School Performance Test Skills and Difficulties Questionnaire RAF Sample Characterization Questionnaire
Cardoso et al. (2014)	Estimate the frequency of DCD and the relationships with ADHD, age, gender,	181 (7 and 8)	Belo Horizonte – Minas Gerais	AMCD MABC-2 RPCM DCDQ-Brazil

Author/year	Objective	Sample size and age (years old)	Region	Instruments/Measures
	type of school and the different dimensions of DCD.			SNAP-IV Brazil Economic Classification Criteria.
Nascimento et al. (2013)	Analyze physical ability of children with DCD	180 (6 to 10)	Manaus	DSM IV TR Fitnessgram
Valentini et al. (2012)	Investigate DCD Prevalence	1587 (4 to 12)	14 cities of Rio Grande do Sul, Paraná and Santa Catarina	MABC 1
Silva et al. (2012)	Verify motor and learning difficulties in underperforming students	19 (9 to 11)	São José – Santa Catarina	School Performance TestMABC 1
King et al. (2012)	Compare the developmental trajectory of maximum torque output and finger torque control in children with and without DCD.	72 (6 to 12)	Porto Alegre – Rio Grande do Sul	MABC 1 force identification sensor and software-associated oscilloscope
Miranda et al. (2011)	Investigate motor performance and nutritional status of students with and without DCD	380 (7 to 10)	Florianópolis – Santa Catarina	MABC-2 Body mass index
Araújo et al. (2011)	Explore the use of CO-OP in Brazilian children with DCD	3 (9 to 10)	Belo Horizonte – Minas Gerais	DCDQ-Brazil MABC 1 PEGS COPM PQRS
Mazer & Barba (2010)	Detect signs of DCD in children at risk for development	10 (3 to 6)	Interior of the state of Sao Paulo.	DCD Signal Evaluation Protocol
Magalhães et al. (2009a)	Compare motor development of term and preterm students	70 (7)	Belo Horizonte – Minas Gerais	MABC 1
Magalhães et al. (2009b)	Identification coordination problems through teachers	288 teachers of children from 4 to 8 years old	Belo Horizonte Metropolitan Region - Minas Gerais	Semi structured interview

Caption: MABC-1 or 2: Movement Assessment Batery Children 1st and 2nd editions; DCDQ – Brazil: Developmental Coordination Disorder Questionaire Brazilian version; EMMC: Escala de Maturidade Mental Colúmbia; PROESP-BR: Physical Fitness Tests of the Measurement, Testing, Standards and Evaluation Application Manual of Projeto Esporte Brasil; EVIA: Inventary of Estilo de Vida na Infância e Adolescência; RAF: Inventary of Recursos do Ambiente Familiar; AMCD: Assesment of Motor Coordination and Dexterity; RPCM: Raven's Progressive Coloured Matrices – Brazilian version. SNAP-IV: Swanson, Nolan and Pelham IV Scale; DSM IV TR: Diagnostic and statistical manual of mental disorders – 4th ed., text revision (American Psychiatric Association, 2000); PEGS: Perceived Efficacy and Goal Setting System; COPM: Canadian Occupational Performance Measure; PQRS: Performance Quality Rating Scale; CO-OP: Cognitive orientation to daily occupational performance.

Regarding the objectives of the studies, eleven of them correlated motor performance with other motor, physical, cognitive health, school performance aspects and the presence of risk factors such as prematurity and related to social context. Five studies sought to establish the prevalence of DCD in Brazilian children and three aimed, respectively, to analyze mothers' perceptions of their children's difficulties, teachers' identification of DCD and to test the effectiveness of CO-OP in improving motor performance and perceived efficacy of children with DCD.

The sample size of children was between 3 and 1587, between 4 and 14 years old. The most frequent research region was the metropolitan area of Belo Horizonte, following the southern, northern and other cities of southeastern Brazil. Noteworthy is the work of Valentini et al. (2015), which included children from 12 Brazilian cities.

Most studies (n=16) have a cross-sectional descriptive quantitative methodological design, one of them is quasi-experimental (Araújo et al., 2011) and two are qualitative (Galvão et al., 2014; Magalhães et al., 2009b). The Movement Assessment Battery for Children (MABC) instrument, in its first and second editions (Henderson et al., 2007), was the most used as a direct measure of motor performance and the score obtained by the child was the reference for analysis of its relationship with other variables in several of the studies analyzed.

3.2 Categorization of studies according to PPCT cores

Table 3 shows the categorization of the studies according to the presence of the core elements of the PPCT Model.

Table 3. Categorization of studies according to PPCT cores.

AUTHOR/YEAR	PERSON	CONTEXT	PROCESS	TIME
Beltrame et al. (2017)	Motor performance Gender Age range	School microsystem. Public schools.	Girls had more difficulty in throwing and receiving skills, and boys in manual dexterity skills. The ages of 7 and 8 years had higher prevalence of DCD, compared to other age groups.	They suggested studies with longitudinal delineation and intervention with perinatal risk factor and socioeconomic status control.
Della Barba et al. (2017)	Gender Age range DCD Signals	Microsystem: School Macro system: socioeconomic condition.	Heterogeneous disorder hinders DCD identification and treatment. Negative reflexes in the consolidation of self-esteem and the child's sense of competence.	Early diagnosis of DCD is essential to empower education professionals and to provide guidance to all actors in the daily lives of children, avoiding negative impacts on daily life.

AUTHOR/YEAR	PERSON	CONTEXT	PROCESS	TIME
Rocha et al. (2016)	Motor Performance Cognitive Maturity Age range Motor Classification (risk of DCD, probable DCD and typical development)	Microsystem: Preschool	Five-year-olds scored higher on cognitive maturity than four-year-olds. Weak positive correlation between motor performance and cognitive maturity of preschoolers.	Cognitive development and motor performance are in constant interaction. The maturation of neural control occurs in older children. Early identification of motor difficulties and referral to intervention programs are extremely important in reducing the damage caused by motor delay. The same is true for children's cognitive maturity.
Capistrano et al. (2016)	Motor performance Gender Age Range Physical aptitude	Microsystem: School	Boys had superior results of inadequacy in physical fitness tests compared to girls. Force and abdominal endurance, and agility contributed to motor performance.	Gender-related activities direct the relationship of different dimensions of physical fitness and motor performance over time.
Valentini et al. (2015)	Age groups Gender Race Motor and school performance	Macro system: socioeconomic status of families.	The prevalence in gender and age groups may be influenced by sociocultural factors.	Need for greater sensitivity for the diagnosis of DCD in cases of children who had few opportunities to develop their motor skills over time, within their socio-cultural context.
Santos et al. (2015)	Nutritional status Anthropometric measurements: weight and height Motor performance	Microsystems; Family and School Macro system: socioeconomic status of families.	Association between socioeconomic status and motor performance.	Need to identify children with DCD before school years.
Cardoso et al. (2014)	Age Gender Attention deficit hyperactivity symptoms	School Microsystem: public and private schools.	Important relationship between DCD and signals of attention deficit hyperactivity / impulsivity or combined ADHD.	The combination of DCD and ADHD deserves greater attention as it seems to have important long-term implications.

AUTHOR/YEAR	PERSON	CONTEXT	PROCESS	TIME
Moreira et al. (2014)	Motor, neuropsychological and academic performance Clinical history and behavior of the child; Resources present in the family environment	Family Microsystem - factors related to children's home environment from their parents' perspective. Exosystem: relationship between motor performance and unemployed mother. Macro system: association between maternal age at birth and greater deficit in motor performance.	Relationship of family environment factors and social variables with motor performance.	The results demonstrate the importance of the time involved in different activities of the family environment.
Contreira et al. (2014)	Schoolchildren's lifestyle	Family Microsystem - Habits in activities indoors and out - and in PE classes.	Significant association between probable DCD and video game, to the detriment of more active physical activity.	Data provide support for the design of future healthy habits incentive programs.
Galvão et al. (2014)	Motor performance in ADLs, school activities and playing	Family Microsystem - perception of Brazilian mothers about the performance in daily activities of children with DCD.	Ignorance of motor coordination problems by family and teachers.	Difficulties in daily activities and relationship with peers, accentuated by entry into school.
Nascimento et al. (2013)	Motor performance Physical aptitude	School Microsystem: Manaus public schools.	Children with DCD with two different degrees of severity are not different from health-related physical fitness.	They suggest further research that looks at the interactions between motor performance and physical fitness over time.
Valentini et al. (2012)	Motor performance Gender Age	School microsystem. Macro system: public policies for preventive and compensatory care.	Higher prevalence of DCD in girls and problems related to manual dexterity. Reflection on the high prevalence of DCD and concern about the limited resources available in Brazil to take care of these children.	The results regarding the difficulties in manual dexterity emphasize the need to identify this disorder before these children enter school.

AUTHOR/YEAR	PERSON	CONTEXT	PROCESS	TIME
Silva et al. (2012)	School performance Gender	Microsystem: School	Teachers in the indication process pointed out students with low school performance that actually showed signs of learning disabilities, especially in reading and writing. There was no relationship with motor performance.	They indicated research for diagnosis and implementation of intervention programs in the early school phases to favor the well-being, quality of life and health of children with learning and motor disabilities.
King et al. (2012)	Production development trajectory and finger torque control	-	Difficulty controlling digital torque, which affects the acquisition of writing skills.	The development trajectory is similar, however, delayed in DCD.
Miranda et al. (2011)	Motor performance Nutritional status	School microsystem. Public schools.	Schoolchildren with DCD had lower performance in all motor skills compared to students without the disorder. Similar nutritional status between groups.	They recommend longitudinal studies of intervention to minimize motor difficulties.
Araújo et al. (2011)	Occupational performance Functional performance on tasks	Family, School, and Therapeutic Microsystems.	Intervention process (CO-OP) contributes to performance functional in chosen tasks. Learning in the chosen tasks generalized to other environments, according to reports of the mother. The proximal process structure between therapist and child proposed by CO-OP was efficient.	Data demonstrate the importance of qualified relationship between therapist and child to obtain results over time.
Mazer & Barba (2010)	Main aspects of DCD Risk Signs	School microsystem: kindergartens and municipal preschools.	Importance of Therapy Occupational in working with children and their family members.	Importance of Detecting DCD signals in preschool phase to minimize future consequences of the disorder in school performance.

AUTHOR/YEAR	PERSON	CONTEXT	PROCESS	TIME
Magalhães et al. (2009a)	Motor performance of school children and prematurity	School and family microsystem. Macro system: socioeconomic condition.	Writing processes and performance in ADLs are compromised by difficulties in manual dexterity according to mothers' complaints.	Children with a history of prematurity when they reach school age have worse motor performance compared to those born at term.
Magalhães et al. (2009b)	Motor coordination in children	School microsystem: teachers from the municipal network and from private schools. Macro system: Brazilian public service policies.	The teachers observe coordination problems. Higher prevalence in municipal schools. The attitude of teachers is to report to the pedagogical guidance sector, pay more attention to the student, talk to parents and, in the minority, refer for treatment.	Importance of careful teacher observation in the time of proximal school process. It is important to invest in future epidemiological studies and correct identification of DCD in Brazilian children.

Caption: DCD: Developmental Coordination Disorder; ADHD: Attention Deficit Hyperactivity Disorder; ADLs: activities of daily living; CO-OP: *Cognitive Orientation To Daily Occupational Performance*.

The studies reported a considerable set of elements of the core *Person*, in which motor performance is the central condition of studies on DCD, used to identify the disorder and correlate it with other variables of clinical history (gestational age and birth weight) and biological aspects of the child (gender, age, nutritional status, physical aptitude, digital torque control, cognitive performance).

The analysis in the light of BTHD identified how these characteristics of children with DCD influence their dispositions to support the proximal processes, especially in family and school microsystems, through differences between age groups, gender, its impact on academic or school performance, lifestyle and relationships with peers, family and teachers. In addition, some studies show characteristics of the demands that these motor difficulties bring to the family and school microsystem, based on the perception and reports of parents and teachers, analyzed through interviews and questionnaires. The influence of the exosystem and macro system on child development was also identified, considering relevant data on the association between motor difficulties and unfavorable socioeconomic status (economic level, mother's age at birth, maternal unemployment).

The core *Time* was identified, especially in relation to the importance of early diagnosis and intervention, locating normative life events related to DCD and the proposition of studies on DCD in the longitudinal perspective.

Table 4. Categorization of instruments and measures in PPCT cores.

Elements of PPCT cores	Variable of study	Instruments
PERSON Biologic individuals' resources	Motor performance	MABC 1 or 2 DCDQ – Brazil Skills and Difficulties Questionnaire AMCD COPM PQRS DCD Signal Evaluation Protocol
	Neuropsychological performance	Maturity Scale Mental Columbia – EMMC Token Test RPCM SNAP-IV PEGS
	Nutritional status	Body Mass Index
	Physical aptitude	PROESP-BR DSM IV TR Fitnessgram
Dispositions	Lifestyle	EVIA
	Academic achievement	School Performance Test
Demand	Perception of parents and teachers	Semi-structured Interviews
	Family life	EVIA RAF
CONTEXT	Home environment resources	RAF
	Involvement in indoor and outdoor activities	EVIA RAF
	Teacher-child relationship; family-school-child	Semi-structured Interviews RAF
	Social risk conditions	Skills and Difficulties Questionnaire
	Socioeconomic condition	Brazil Economic Classification Criteria
	Actions in the school environment for children with motor difficulties at school age	Semi-structured Interviews
PROXIMAL PROCESSES	Family relationship	RAF
	Relations of the child outside the school environment	EVIA RAF
	School relationship with teachers and peers	Semi-structured Interviews
TIME	Time to engage in indoors and outdoor activities	EVIA RAF
	Age and motor performance ratio	MABC 1 or 2

Caption: MABC-1 or 2: *Movement Assessment Batery Children* 1st and 2nd editions; DCDQ – Brasil: *Developmental Coordination Disorder Questionaire* Brazilian version; AMCD: *Assesment of Motor Coordination and Dexterity*; COPM: *Canadian Occupational Performance Measure*; PQRS: *Performance Quality Rating Scale*; DCD: *Developmental Coordination Disorder*; RPCM: Raven's Progressive Coloured Matrices – Brazilian version; SNAP-IV: *Swanson, Nolan and Pelham IV Scale*; PEGS: *Perceived Efficacy and Goal Setting System*; PROESP-BR: *Physical Fitness Tests of the Measurement, Testing, Standards and Evaluation Application Manual* of *Projeto Esporte Brasil*; DSM IV TR: *Diagnostic and statistical manual of mental disorders* – 4th ed., *text revision* (American Psychiatric Association, 2000); EVIA: Inventary of *Estilo de Vida na Infância e Adolescência*; RAF: Inventary of *Recursos do Ambiente Familiar*.

Due to the greater occurrence of quantitative approach studies that included instruments or measures, it was considered relevant to verify which elements of the PPCT cores such instruments make it possible to collect (Table 4).

4 Discussion

The current study aimed to perform an integrative review of the national literature on DCD and to relate the contents of the studies with the elements of PPCT cores of the TBCTH. The studies revealed the presence of the four elements based on their objectives, method and outcomes. There is a predominance of the core *Person* in research, as they evaluate the individual repertoire of biological, cognitive, emotional and behavioral characteristics of children with DCD, which influence their development. Elements of the other cores (*process*, *context* and *time*) were identifiable, denoting the association between all of them.

Considering the prevalence of DCD, which ranged from 4.3% (Cardoso et al., 2014) to 19.9% (Valentini et al., 2012) for children with probable DCD and 5.9% (Capistrano et al., 2016) to 22.2% (Contreira et al., 2014) for risk of DCD, there is a need to know the risk factors that influence the development and manifestation of DCD and the characteristics of the *Person* regarding sensorimotor difficulties present in the development of skills. Equally important is the recognition of DCD influence in different ecological contexts present in the child's daily life and the best therapeutic, family, educational and cultural practices about the problem.

The highest prevalence of DCD was found in premature infants, with rates of 39% (Moreira et al., 2014) and 57% (Magalhães et al., 2009a). The lower the birth weight and maternal age at delivery, the greater the chance of impairment in the result MABC-2 motor performance test (Moreira et al., 2014).

The study by Rocha et al. (2016) found a correlation impairment of cognitive development of children with DCD when compared to children with typical development (Rocha et al., 2016). Although Silva et al. (2012) found no significant relationship between learning disabilities and motor problems (with a sample size of only 19 children), there was significant comorbidity with ADHD (41.2% of children with DCD) in the study by Cardoso et al. (2014).

Three studies on the prevalence of DCD in Brazilian children found manual dexterity as the most impaired motor dimension (Beltrame et al., 2017; Valentini et al., 2012, 2015). According to King et al. (2012), children with DCD have less digital torque control, and delayed development of production and torque control. There is difficulty in the production of force, high variability and regularity in motor response, with difficulty in adapting to the demand for task modifications in fine motor skills (Oliveira et al., 2005). The study by Valentini et al. (2015) also found significant impairments in balance, and Valentini et al. (2012) observed worse ability to throw/receive in girls.

In this way, it is identified the remarkable presence of the core *Person* when addressing the impairments in the performance of children with DCD. This impairment in the individual skills repertoire characterizes the child's biopsychological resources for their development. According to Bronfenbrenner (1999), the

consequences of this limited repertoire are also built in relation to the environment, and can, in a reciprocal way, be a generator or disorganizer for development processes. Some examples of this relationship are shown in the following lines, such as the child with DCD engagement in physical activity, their weight gain, autonomy in family or school daily life, interaction with objects and symbols, and social peer comparison.

Although there is a discussion about greater weight gain in the presence of DCD (Goulardins et al., 2016), studies with Brazilian children have found a higher eutrophic index (Santos et al., 2015; Miranda et al., 2011), with levels of physical aptitude (Nascimento et al., 2013) similar to children without DCD. Nevertheless, Contreira et al. (2014), when using EVIA with children from 11 to 13 years old, observed a significant association between probable DCD and higher frequency of playing video games, to the detriment of more active physical activities.

When parents and teachers are asked about the main difficulties of children with DCD, they are perceived in different ecological contexts, whether in daily living activities, playing and school activities (Galvão et al., 2014), more specifically in the difficulties handling scissors and a frequent report of a "clumsy" child (Magalhães et al., 2009b).

In 14 of 19 studies, MABC was used to assess the child's motor performance and DCD screening. This is currently the reference tool for identifying DCD, both for its extensive presence in research on the subject and because the European Commission recommends its use (Blank et al., 2013). Already validated for the Brazilian population, MABC consists of a battery of motor tests (Valentini et al., 2014) and the motor difficulties check test (Ramalho et al., 2013) answered by adults who deal with the child in their daily life. However, it is observed that MABC motor test battery is commonly used for screening DCD in isolation. According to the DCD diagnostic guidelines, it is important, in the diagnostic process, that motor difficulties have repercussions on autonomy in daily activities and school skills, which would also justify the use of instruments that identify this impact, such as MABC checking test and the Brazilian version of *Developmental Coordination Disorder Questionaire* (DCDQ) DCDQ-Brasil (Prado et al., 2009; Magalhães & Wilson, 2017), for example.

Vaivre-Douret (2014) calls the attention for the need to associate with motor performance tests the evaluation of aspects related to the child's neurological development (such as tone, visuomotor perception, praxis, laterality, digital perception, integration between rhythm and notion of the body in space), as well as neuropsychological tests, especially executive functions. This is important both for a differential diagnosis process and to elucidate better intervention strategies.

Considering all these aspects, the Cognitive Orientation to Daily Occupational Performance (CO-OP) seems to be a reference for DCD intervention, as it associates cognitive development or executive function strategies with task-oriented motor skills training (Zwicker et al., 2015). As shown by Sangster Jokić & Whitebread (2016), self-regulatory skills in children with DCD are impaired in such a way that they are inefficient or require a lot of instructor or therapist mediation for the learning process of a motor skill. In the CO-OP strategy, the therapist mediates the process, with the

child's very active participation in choosing the goal, setting strategies to achieve it, and self-assessment (Zwicker et al., 2015). The CO-OP was effective in reaching motor goals, transferring learning to extra goals and increasing satisfaction in a group of Brazilian children (Araújo et al., 2011, 2019). Parental involvement in the therapeutic process contributed to the success of the intervention. This occurred through their participation in the intervention sessions, production of printed material with information on the overall CO-OP strategies to use for homework, and an extra session only with parents for guidance (Araújo et al., 2019).

Relations with the core *Context* are shown in those studies that associate the child's biological conditions with those found in the micro, meso and exosystem. Moreira et al. (2014) identified that, in relation to maternal age at delivery, for each additional year at mother's age, there is a 12% reduction in the chance of the child having an abnormal MABC-2 score. Children whose mother was employed at the time of the interview were four times less likely to have a poor MABC-2 score.

Studies identify the relationship between DCD and socioeconomic status (Della Barba et al., 2017; Santos et al., 2015). Children from private schools performed better on the motor test (Cardoso et al., 2014), as well as having fewer reports of motor coordination problems by teachers compared to those from public schools (Magalhães et al., 2009b). Valentini et al. (2015) pointed out one of the highest rates (18% of children with probable DCD and more than 15% for DCD risk) when investigating the prevalence of DCD in socially disadvantaged children in Brazil, and the socioeconomic status is determinant in 21% in MABC percentile variation.

Considering the biological, cognitive and emotional impairments of children with DCD, it is important to look at the developmental opportunities given to them in a social structure and in the processes established in different contexts. Nobre et al. (2014), in a study on the motor development ecology of extremely poor students in northeastern Brazil, identified delays in fundamental motor skills in 95% of the children evaluated. Regarding the structure in which these children lived, they pointed out the lack of physical space for the practice of guided motor activities, since the vast majority of schools do not have spaces for physical education classes and physical education professionals. The teachers reported the lack of material resources and didactic-pedagogical proposal to promote children's motor proficiency, revealing lack of commitment from the local government. In the community, there was heterogeneity of opportunities, with more than one social support unit in some neighborhoods, with music, dance and school reinforcement, to the detriment of no unit in most of them. In the case of children with DCD, teachers reports show the lack of a structured policy for children care and monitoring, leaving only the school and the family to offer the conditions that they think are important for their development (Magalhães et al., 2009b).

On the other hand, mothers' reports identify an over-protection and "doing for the child" behavior, much present in the home system, when faced with the difficulties of the child in their school activities and daily life (Galvão et al., 2014). The greatest concern of mothers is their children socialization, because of their difficulties in

participating in motor games at school, clumsiness, slow behavior and stigmatization by peers. As Nobre et al. (2014, p. 271)

> […] it is explicit that the child's MP [motor proficiency] guides their goals and dispositions and provokes the demand of their peers, affecting the way they deal with the developing child and with the goals, values and expectations they have about it.

The qualitative methodological approach, as used by Galvão et al. (2014) and Magalhães et al. (2009b), is able to abstract from the participants very relevant information for analysis under the PPCT model. The study by Nobre et al. (2014) specifically delineated under the bioecological model, also brings data richness acquired with the ethnographic method, inserting the researcher in the natural environment of phenomena. However, Prati et al. (2008) states that there is no rigid proposal of a research method in Bronfenbrenner's approach, being fundamental that the research model in this theory systematizes its design and analyzes the cores based on the model elements.

Considering that 16 studies from the sample of this review used the quantitative methodological approach, two instruments stand out in the possibility of broadening the perspective on child development through the PPCT model: RAF and EVIA. The *Recursos do Ambiente Familiar* Inventory (RAF), used by Moreira et al. (2014), was created in the Brazilian context by researcher Edna Marturano (2006), with an emphasis on resources that promote proximal processes, ie, parenting practices that promote family-school connection and activities that signal stability in family life. EVIA was also able to collect some data related to the proximal process between child and family in the home environment by identifying aspects of this relationship, such as frequency of going out and helping with housework, for example (Contreira et al., 2014). The use of this instrument identified that children with DCD play more video games than those without DCD, but no other significant differences were found between the lifestyle of parents and children with probable DCD and typical development (Contreira et al., 2014). The correlation between RAF score and an abnormal MABC-2 score was the strongest in the study by Moreira et al. (2014). For each 10-point increase in RAF score (environment with more development-friendly processes) there was a 36.5% observed reduction in the chance that the premature child would have an abnormal MABC-2 score, compatible with DCD, showing the importance of stimulating environment.

Both RAF and EVIA also allow the researcher a direct analysis of the core *Time*, as they characterize the child's routine in relation to the time spent playing, in other leisure activities, indoors and outdoors, or in direct process of contact with parents, all very important aspects for child development (Marturano, 2006; Moreira et al., 2014). It is understood that elements of the core *Time* were intrinsic in all these studies, as they evaluate the performance of children in preschool or school, an important moment of ecological transition for children (Bronfenbrenner, 2011). The analysis of the study sample of this review shows how early detection and intervention of DCD, both in children and in the contexts in which they are inserted,

can make a difference in their learning experience, performance and the demands that their difficulties place in the family and school context. Tal-Saban et al. (2014) identified that, in adulthood, people with DCD continue to have lower levels of participation in daily activities, as well as life quality and satisfaction. Therefore, the dimension *Time* appears in studies generally pointing to preventive and other actions that can promote the improvement of life quality of these people in the medium and long term.

5 Final Considerations

In this review, there was a predominance of cross-sectional studies with quantitative methodology. The elements of the core *Person* were present in all analyzed articles, and motor performance was the central condition in the identification of DCD and correlation with other clinical, health and social variables. In the core *Time*, the importance of diagnosis, early intervention and specificities of the normative life events of the child were highlighted. There was an intense use of MABC as an identification instrument, as well as the importance of establishing broader measures for analyzing the development of children with DCD.

Based on these results, we identify the need for continuing investigations on the prevalence of DCD in Brazil. In addition, it was evident that instruments for DCD early detection and characterization of difficulties require improvement. There is also demand for the development of interventions that address the family, school contexts and foster strategies for the empowerment of these family members and professionals about DCD. Finally, there is the need for studies that address the dimension of the macro system, which dialogue with the development of health and education policies in Brazil, in order to consider the impacts of DCD on the developmental course of these children and the demands of different contexts.

This review limitation is the performing search only in certain databases by indexed journals, related only to searches in Brazilian context and without including theses and dissertations. However, it presents an original look at the research carried out with DCD, since it proposes to conduct a dialogue with the cores PPCT of the Bioecological Theory of Human Development.

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Author's Contributions
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