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Low Motor Competence or Developmental Coordination Disorder? An Overview and Framework to Understand Motor Difficulties in Children

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Abstract

Purpose of review Developmental coordination disorder (DCD) is a condition defined by poor motor proficiency in children in the absence of neurological conditions or other diseases. This review provides an overview of low motor competence (LMC) and DCD in children and a framework to understand the differences and similarities between LMC and DCD.

Recent Findings While the prevalence of DCD is fairly high (up to 5–6% of school-age children), research in the last few decades has documented a significant level of low motor competence (LMC) in the school-age children (~ 30–77%). These numbers represent an epidemic of poor motor skills that need proper assessment, intervention, and sometimes a referral for an investigation of a potential DCD diagnosis.

Summary Low motor competence is typically established after a one-time measurement of motor skills using a standardized assessment. DCD, on the other hand, is a chronic condition—that is, it persists from childhood, through adolescence, and into adulthood.

Keywords Developmental coordination disorder · Low motor competence · Motor skills disorder · Motor development · Children

Introduction

The term "motor competence" is used in the literature to explain a general level of motor skill development in children. It is a global term to reflect various terminologies that have been used in previous literature (i.e., motor proficiency, motor performance, fundamental movement/motor skill, motor ability, and motor coordination) to describe goal-directed human movement [1]. This term has been created in large part to reflect the current, prevalent trend of low motor competence in children. Low motor competence is a generic term defined by having motor skills below what is expected for a child's age [2]. Children with "low motor competence" are those who do not reach adequate (average) levels of motor competence. This is important because a substantial amount of research has recognized the role of motor competence in several key health outcomes, such as physical activity, weight status [3], lower cardiorespiratory fitness [4], obesity [5], and adiposity level [6].

When low motor competence affects daily activities and school achievement, it can be diagnosed as developmental coordination disorder (DCD), a neurodevelopmental disorder with the diagnostic criteria outlined in the DSM-5 [7]. DCD is characterized by a marked impairment of motor coordination that significantly interferes with academic achievement, performance of activities of daily living, and engagement in play [7]. DCD has been the internationally accepted term to use for the condition since 1995 [8]. However, it is important to note that some countries continue to use the outdated term "dyspraxia" (e.g., UK, USA). Since then, thousands of studies investigating mechanisms, assessments, interventions, and consequences of DCD have been published. Nevertheless, the term DCD is still largely underrecognized by health care and educational professionals [9].

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Similarly to LMC, DCD has been linked to several physical and mental health consequences [10]. For example, boys with DCD reported significantly higher loneliness and lower participation rates in group physical activities, whether in structured (e.g., team sports) or unstructured (e.g., informal outdoor play) environments than boys without DCD [11]. Teachers also reported that school-aged children with DCD have fewer friends and are more socially isolated than their peers [12]. It is possible that reduced social contact and friendships observed among children with DCD may lead to lower self-esteem [13]. Several studies have also identified that children with DCD are physically inactive and less fit when compared to their TD peers [14]. In addition, the prevalence of overweight and obesity is higher in children with DCD, according to a recent systematic literature review [15].

In this review, we will explore the characteristics of LMC and DCD in children, review studies associated with each of these groups, and determine the similarities and differences between these concepts. Adequate motor skill development is a critical factor in child development and is foundational to other domains of development, including cognition and social-emotional learning. The measurement and evaluation of motor development can provide practitioners with important cues to a child's overall development. Thus, reviewing important aspects related to LMC and DCD in children is relevant and needed in the literature. We believe that this review will help health professionals, educators, and researchers to understand characteristics associated with DCD and LMC, clearly identify their differences, and understand the better intervention strategies for each.

Low Motor Competence

Motor competence relates to the development and performance of human movement [16]. Childhood is a critical time for the development of motor competence. In early childhood, acquiring fundamental motor skills provides the basis for later building of sport skills and other structured activities. The "overall goal of this period is to build a sufficiently diverse motor repertoire that will allow for later learning of adaptive, skilled actions that can be flexibly tailored to different and specific movement contexts" [17]. If children cannot proficiently run, jump, catch, throw, etc., they will have limited opportunities for engagement in physical activities later in their lives, because they will not have the prerequisite skills to participate and be active. In later childhood and adolescence, there is the emergence of sport/context-specific skills. These are developed if children are able to move from the proficiency barrier (see more about this concept here [18•]) and have extensive practice and instruction on those skills. Interestingly, LMC tends to be associated with low socioeconomic status (SES). In fact, high levels of low motor competence among economically disadvantaged preschool children have been reported in the last decade [19, 20]. A study in Hispanic preschool children from low SES environments found that nearly one-third of the children demonstrated gross and fine-motor delays in motor performance [21]. The trend is also true with older children—lower SES has also been associated with lower motor competence in children aged between 5 and 12 years [22, 23].

Overall, several studies have reported a high prevalence of low motor competence in early childhood [24], school-age children [25], and adolescents [26]. For example, a recent study showed that about 25% of school-aged children between ages of 6 and 10 years score well-below or below average for motor competence levels [23]. But prevalence can be even higher than ¼ of the population. A recent study in the USA showed that approximately 77% of preschoolers scored as "at risk" (below average) for developmental delay in motor skills, scoring below the 25th percentile on the Test of Gross Motor Development, 2nd edition (TMGD-2), with 30% of the sample scoring at or below the 5th percentile [27••]. In addition, a large study from Australia evaluating fundamental motor skills in 6917 children from elementary and high school showed a striking level of low motor competence in all grades, with higher numbers for girls across all ages. The numbers are indeed striking: across all 7 FMS evaluated (4 locomotor skills: sprint run, vertical jump, side gallop, and leap) and 3 object-control skills (catch, over-arm throw, and kick), 92% of boys showed low competence in all FMS in Grade 2 (girls were not tested in this grade), 78% of boys and 98% of girls showed low competence in Grade 4, 65% of boys and 96% of girls showed low competence in Grade 6, and 46% of boys and 93% of girls showed low competence in high school [28].

In school-age children, the role of motor competence in several important health outcomes has been recognized, such as physical activity, cardiorespiratory fitness [28], and adiposity [5, 6]. Most studies have examined the effects of motor competence on physical activity, even though the relationship is considered cyclical or reciprocal [1, 16]. A popular model described by Stodden and colleagues [16] suggests that physical activity (as in participation in activities, including sports) in early childhood will initially promote the development of motor competence, as basic motor patterns are developed through a variety of exploratory movement experiences. Participation in sports is a special context for the acquisition of motor skills in young children and may help promote long-term adherence to physical activity [29]. This relationship becomes more cyclical in middle and late childhood, when a high level of motor competence is expected for children to engage in physical activities. This progression fosters continued participation as children enjoy success and are motivated to continue to improve motor competence [16].

Developmental Coordination Disorder

Developmental coordination disorder (DCD) is a neurodevelopmental disorder characterized by poor motor coordination and difficulty learning motor skills. Motor performance in children with DCD is slower, less accurate, and more varied than their peers, and upon assessment, children with DCD score below that expected for their age and intelligence [30]. The movements of children with DCD frequently lead to performance difficulties in activities of daily living and physical games that typically developing (TD) children perform easily. With a prevalence of 5–6% [7], DCD is one of the most common disorders affecting school-aged children. Interestingly, DCD has been described as a "hidden problem" [31].

DCD also tends to be heterogeneous, with distinctions in the type and level of motor skill impairment [32]. In general, these impairments can be described in three broad areas: limited postural control, difficulty in learning new motor skills, and sensorimotor coordination deficits [33]. The word "developmental" in the term "developmental coordination disorder" refers to the onset in the developmental period (i.e., early childhood). A DCD diagnosis is made according to the Diagnostic and Statistical Manual of Mental Disorders, 5th ed. [7] four criteria: (A) Learning and execution of coordinated motor skills are below the expected level for age, given opportunity for skill learning; (B) Motor skill difficulties significantly interfere with activities of daily living and impact academic/school productivity, prevocational and vocational activities, leisure, and play; (C) Onset is in the early developmental period; (D) Motor skill difficulties are not better explained by intellectual delay, visual impairment, or other neurological conditions that affect movement.

International clinical practice recommendations for DCD state that it should be diagnosed by a multidisciplinary team of professionals qualified to examine the specific criteria for the disorder [34]. Ideally, the team should include a physician (e.g., child psychiatrist, developmental pediatrician, child neurologist) and a professional trained in the standardized motor tools used to assess children suspected of having the disorder [34]. Criterion A is assessed through the administration of a standardized motor assessment, such as the Movement Assessment Battery for Children, 2nd edition (MABC-2) [35]. For Criterion B, child history and standardized questionnaires such as the Developmental Coordination Disorder Questionnaire (DCDQ) [36] or Little Developmental Coordination Disorder Questionnaire (Little DCDQ) [37] are recommended. For Criterion C, developmental history should be taken, and for Criterion D, a physical and neurological exam should be conducted, and assessments of vision and IQ may be needed in some cases [38].

DCD has received considerable attention from researchers across disciplines in the last few decades. Researchers have suggested several areas of pronounced difficulty in this population, including internal (forward) modeling, rhythmic coordination, executive function, gait and postural control, catching and interceptive action, and aspects of sensoriperceptual function [39]. There has also been a recent interest in detecting neural mechanisms associated with the condition, and a combination of these findings supports the hypothesis that DCD is the result of atypical brain development and establishes the notion that children with DCD are neurobiologically different than TD peers [30]. But most importantly, DCD has been considered one of the major health problems among school-age children [40], with the outcomes often extending beyond the motor domain to include secondary mental and physical health issues.

In addition, DCD typically co-occurs with several other conditions. Comorbidity tends to be the rule rather than the exception in DCD [41]. DCD frequently co-occurs with other disorders including autism spectrum disorder (ASD) [42, 43], attention deficit hyperactivity disorder (ADHD) [44, 45], childhood apraxia of speech (CAS) [46], and developmental language disorder (DLD) [47, 48], but it is not commonly co-diagnosed.

Similarities and Differences Between DCD and Low Motor Competence

DCD and LMC have been used interchangeably in the literature. However, DCD is more than just the lower end of normal variance in motor abilities [49] such as LMC. The terms probable DCD (pDCD) or at risk for DCD (rDCD), as well as "low" or "poor motor ability" and "motor skills difficulties" have also been used to describe what seems to be characteristics of overall low motor competence. Studies usually adopt such terms due to their participants not being able to meet all the diagnostic criteria of the DSM or the lack of measurement of all the criteria. In 2017, a consensus during the DCD-12 Conference in Freemantle, Australia established that researchers in the field should start using the DCD terminology throughout their publications even if they do not meet all the DSM-5 criteria for diagnosis of if not all criteria were assessed. This measure was put in place to unify research studies and strengthen the field and has already been adopted in recent studies (for an example, see Pimenta et al. [50]). Obviously, all diagnostic criteria (met and unmet) should be clearly disclosed in the Methods section of articles. The most common issue, however, is the lack of a proper screening, investigation, and diagnosis of DCD. For example, a study in Australia showed that the time between seeking help and diagnosis was on average

2.8 ± 2.3 years, with almost half of the participants who received a diagnosis waiting over 2 years for a diagnosis after first seeking help [51]. A study in the USA has shown that 3 out 5 children (61%) in the study had received a diagnosis of the globally accepted diagnostic label DCD, but there were at least 10 other diagnostic labels for movement difficulties provided to families [52•]. In the USA as well as other countries, there is no clear pathway for diagnosis, which may discourage families from pursuing one.

On the other hand, LMC is typically established after a one-time measurement of motor skills using a standardized assessment, and it can be counteracted with practice, training, and instruction of motor skills. Children do not develop FMS naturally through maturational processes [44]. In fact, several studies have established that interventions can and will increase motor competence if proper intervention is administered. Typically, these interventions employ different approaches including modified physical education, free play, and sports-based interventions [53] and may be delivered by physical education teachers, coaches, kinesiologists, exercise science professionals, and physical/occupational therapists. Generally, interventions grounded in achievement goal theory are an effective instructional approach for teaching motor skills in young children. This approach focuses on mastery orientation for learning, where task engagement relates to the intrinsic value of learning itself and measures improvement using self-referenced standards [54]. A meta-analysis of the effectiveness of motor skill interventions in children has showed that both object control and locomotor skills improve from a pre- to a post-test and suggests that early childhood education centers should implement planned movement programs as a strategy to promote motor skill development in children [55].

Certainly, if more attention is paid to motor skills early on, both through parent/family practice, encouragement, and experience in early education centers/schools, a large percentage of low motor competence could be overridden. As previously mentioned, practice is essential to the development and learning of motor skills. However, *lack* of instruction and practice is not the cause of DCD. While interventions can improve a child's motor skills, a diagnosis of DCD "implies" continued difficulty in the learning and performance of motor skills. Research shows that certain types of interventions can be effective for motor skill improvement in this population: activity-oriented approaches, body function-oriented when combined with activities, active video games, and small group programs [56]. One example of a specific approach that shows overall effectiveness for children with DCD is the Cognitive Orientation to daily Occupational Performance (CO-OP). CO-OP is an individualized, task-specific (activity-oriented), cognitive-based, problem-solving approach for individuals experiencing difficulties performing the skills they want or need to do [57]. This is important to highlight as it is possible to find children with DCD who are very successful at certain tasks they are devoted to learn, but that does not mean that they do not struggle with other motor skills. There is limited evidence that the skills learned by children with DCD transfer to others, for example, riding a bike does not lead to riding a sideboard. This seems to be a hallmark feature of DCD—they can learn skills, but it is an intensive and specific process, and it does not easily generalize to other skills.

Another interesting difference between DCD and LMC is sex differences—prior research has documented that girls may lag behind boys in the early development of some object-control motor skills [19, 58]. A more recent study showed that boys were more likely than girls to demonstrate low motor competence for hand-foot coordination while girls showed lower levels of proficiency for agility and skills involving object-control [59]. While these differences may be partially rooted in social experiences and opportunities for motor skill development in boys and girls, it is known that girls have shown lower motor competence overall. In DCD, studies have reported a higher prevalence in boys overall [60]. However, it is not clear yet if there is a true sex ratio or if other factors contribute to a higher prevalence of boys in DCD (such as a lower detection and investigation rate in girls, for example).

Theoretical/Practical Framework for a Comparison

A practical framework can help practitioners and researchers understand and make decisions about low motor competence and DCD. This is not intended to be a final or definitive framework for a clear identification, but it is aimed at providing clarity in the field of what CAN constitute LMC or DCD in childhood. While this framework is not strict and should be viewed as fluid, it can provide important clues to assessment, intervention, and/or referral for services. It can also be particularly useful when helping different professionals understand the differences between DCD and LMC. The framework reinforces the idea that LMC is a product of an environment that is not conducive to motor skill development, while DCD is a chronic, lifelong condition (Table 1).

Final Considerations

The goal of this review was to provide an overview of DCD and low motor competence in children, review studies associated with each of these groups, and determine the similarities and differences between DCD and LMC. More

Table 1 Characteristics associated with developmental coordination disorder and low motor competence

Characteristic	Developmental coordination disorder	Low motor competence
Below average performance on any motor assessment	Yes	Yes
Adequate practice and experiences for motor development	Yes	No
Low motor performance interferes with school activities	Yes	Potentially
Low motor performance interferes with daily living activities	Yes	Potentially
Associated with low SES and disadvantaged circumstances	No	Yes
Boys tend to have more problems than girls	Yes	No
Motor performance improves with intervention	Sometimes, depending on the intervention; improvement tends to be in specific motor skills, not overall motor performance	Yes
Delays in early motor milestones	Sometimes; usually within or at the later end of the expected range	Unknown
Can be "reverted" with intensive motor intervention	No	Potentially

specifically, we wanted to offer a discussion on DCD and LMC and provide a concise outline to help health professionals, educators, and researchers understand the characteristics associated with DCD and low motor competence and support their decision-making. First, we established the high prevalence of both DCD and LMC in children—and given their important connections to physical and mental health, it is essential to continue to study the mechanisms, interventions, and consequences associated with both.

Overall, the present review describes how LMC is a broad term that describes children who have not reached age-appropriate levels for motor skill development, usually because of low stimulation and experience, practice, and instruction. However, most, if not all children with LMC can and will benefit from motor skill intervention, as shown by several studies [5]. In general, we believe that there should be further assessment and motor intervention provided to every child scoring below average on motor skills. The high prevalence of LMC in children represents an emerging epidemic that needs to be systematically acknowledged and addressed [27••]. DCD can also be described as a lack of age-appropriate motor skills that affect daily living and academic achievement. It is diagnosed after multiple evaluations made by a multidisciplinary team, whereas LMC is determined from a one-time assessment of motor competence. DCD is a chronic condition that significantly affects physical and mental health if no proper diagnosis and intervention/treatment is provided.

It is important to point out the possibility that a small subset of children with LMC might have DCD, and that some children identified as DCD in some studies that rely on single assessments and do not assess the full criteria for DCD, could be LMC instead of DCD. It is only through careful and proper assessment, as well as rigorous measurement and longitudinal designs and a thorough clinical investigation that it is possible to tease out LMC from a diagnosis of DCD. It is particularly difficult to dissociate LMC from DCD at a young age, but it is essential to identify and intervene early. With young children, it has been recommended that health care providers explicitly use the term "at risk for DCD" during parent education, advocacy, and communication with the health care team to increase awareness of this common but under-recognized disorder [58, 61]. Most importantly, accumulating evidence suggests that intervention is beneficial for preschool-age children with (or at risk) of the disorder [62].

Labeling LMC and DCD correctly can provide important cues for proper intervention and supports to be put in place. Identifying LMC is the first step to a potential diagnosis of DCD, and since there is no clear pathway for a diagnosis in many countries (for example, in the USA), perhaps intervention should be administered even before the potential of a diagnosis is investigated, due to the usual long wait between time of seeking help and a diagnosis. In schools, physical education teachers should be able to provide general assessments of motor skills for children, and a low score can be the initial step for further evaluation, referral, and intervention.

The discussion provided in this review should provide a clearer picture of the similarities and differences between LMC and DCD. We believe that a clear distinction between the two can help better understand the results of research studies and provide better assessments and therapies for children. We expect that the present discussion and table can support efforts for increased awareness, improved diagnosis, and increased availability of services for both children with LMC and DCD.

Author Contribution P.T. and J.C. conceived the idea and wrote the main manuscript text. All authors reviewed the manuscript.

Data Availability Not applicable.

Declarations

Ethical Approval This article does not contain any studies with human or animal subjects performed by any of the authors.

Competing Interests The authors declare no competing interests.

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- • Of importance
- •• Of major importance

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