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Review Article

The Assessment of Developmental Disorder of Motor Coordination in Children

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Abstract:

Developmental coordination disorder is a lack of coordination between mental intentions and the body's ability to carry out those intentions. For example, you may think, "I need to run." However, the brain does not normally send the appropriate instructions to the arms and legs. The arms and legs do not follow the brain's instructions. The same thing happens when you try to jump, write, push a button, or perform many other tasks that most people take for granted. People with developmental coordination disorder generally have normal intelligence. However, developmental coordination disorder is sometimes called "clumsy child syndrome," and it can give the false impression that people with the condition are of reduced intelligence because they cannot perform basic tasks. The condition may be considered a childhood disorder, but its effects continue into adulthood. The main purpose of this paper was to present the basic assessment procedure for developmental motor coordination disorders in children. The process of assessment motor difficulties is presented after mentioning the etiology, the complexity of the disorder and the tests for its detection. Finally, the movement test Movement Assessment Battery for Children is presented.

Key Words: developmental disorder; assessment; motor coordination

Introduction

The etiology and comorbidity of developmental motor coordination disorder

The etiology of developmental coordination disorder is not entirely clear, because as a disorder, it is characterized by many symptoms and usually there is comorbidity with other disorders (Visser, 2003). Some cite neurological, physiological, cultural, environmental, and genetic factors (VanWaelvelde & Miyahara, 2016), such as incomplete motor patterns and stimuli (Missiuna, Gaines, Soucie, & McLean, 2006) as possible causes. The disorder occurs across many cultures, races, and socioeconomic conditions. By definition, "activities of daily living" involve cultural and intercultural differences. Examining the context in which each child lives and whether they have appropriate opportunities to learn and practice such activities is important to take into serious consideration (APA, 2013). Environmental factors, according to Barnett and Hill (2019), can include perinatal causes, such as short gestation (<37 weeks) and low birth weight (<2500g), (APA, 2013). Smoking in the early months of pregnancy and stress in the latter months, preeclampsia, and cesarean section are associated with poor motor development (Grace, Bulsara, Robinson, & Hands, 2016). Among monozygotic twins, according to Pearsall-Jones, Piek, Rigoli, Martin, and Levy (2009), it has been shown that second-born twins aged 8-17 years are twice as likely to meet DSM-5 criteria for developmental motor coordination disorder compared to the first-born twin. A significant number of children diagnosed with developmental motor coordination disorder have also been diagnosed with other developmental disorders, such as learning disabilities (Gomez, et all., 2015), dyslexia (Biotteau, et all., 2017), attention deficit hyperactivity disorder (ADHD) (Goulardins et all., 2015), and autism spectrum disorder (Caçola et. all., 2017).

In fact, comorbidity in developmental coordination disorder is considered the "rule" rather than the "exception" (Lingam et all., 2012) and it is essential for researchers and practitioners to recognize this fact (Barnett & Hill, 2019). Regarding genetic factors, impairments in the underlying neurodevelopmental processes, and in particular in visual-motor skills (visual-motor perception and spatial intelligence), have been found to affect the ability to make rapid motor adaptations as the complexity of movements increases. Dysfunction in the cerebellum has been proposed, but the neurological basis of developmental coordination disorder remains unclear, due to its coexistence with other disorders, while shared genetic influences have also been proposed (APA, 2013). Few studies have focused on the genetic etiology of the disorder, with Fliers, Vermeulen, Rijsdijk, Altink, Buschgens, Rommelse, and Franke (2009) and Martin, Piek, and Hay (2006) examining the possible common etiology of developmental motor coordination disorder and its comorbidity with attention deficit hyperactivity disorder. Both questioned the potential common genetic etiology of these two disorders.

Genes shared by parents and children influence motor or cognitive skills. A more complex relationship is likely to exist regarding genes and environmental influences (Friend, Defries, & Olson, 2008). It has been argued that developmental motor coordination disorder may be due to information processing difficulties, such as slow kinesthetic (Li et all., 2015) and visual-motor processing (Caçola et all., 2017). Kandel, Schwartz, and Jessel (2020) report that movement first begins with the formation of a mental image, which is produced in the area of the brain responsible for movement. A large body of literature has linked the possible cause of the disorder to a deficit in the planning of motor actions and, confirming this hypothesis, several studies have documented that there are deficits in motor imagery (Adams et all., 2017). Motor imagery involves simulating a skill in the imagination (mental level), without actually performing the movement (Decety & Grèzes, 2006) and is believed to represent the individual's ability to accurately perform the skills, using internal models of motor control. These internal models provide stability to the motor system, by predicting the outcome of movements before the feedback from the sensory-motor system, or in other words, predicting the time it takes to react to the movement and complete it (Gomez & Sirigu 2015). Without the proper development of this ability, movements are clumsy and disorganized, which explains most of the problems that appear in developmental motor coordination disorder (Caçola & Lage, 2019). Therefore, the cause of the motor coordination deficit may lie at the cognitive level, in the processing of information and in the inability of cognitive processing to solve the motor problem (VanWaelvelde et al., 2016), but here too the situation is not completely clear (Henderson, 1994).

Some researchers have hypothesized that the cerebellum is a possible source of motor dysfunction, as abnormal cerebellar activity has been found in some activities in children with developmental motor coordination disorder (Zwicker, Missiuna, Harris & Boyd, 2011). After all, the role of the cerebellum in motor control, motor learning and movement coordination is known (Koziol et all., 2014). Findings from various studies on the cerebellum and developmental motor coordination disorder show that these children are less precise in their movements and more variable in their motor performance, compared to children in the control groups of these studies (Debrabant et all., 2013). Similar to patients with cerebellar degeneration children with developmental motor coordination disorder tend to repeat the same movements over and over again, but this does not improve their performance (Marchiori, Wall, & Bedingfield, 1987). In this case, however, it is not clear whether children fail to correct their movement either because they are unaware of their poor performance or because they simply do not have the ability to correct their mistakes. There is research that implicates the parietal lobe in the etiology of the disorder. Neuroimaging studies seem to have shown that parietal lobe dysfunction may be the source of motor deficits in children with developmental motor coordination disorder (Debrabant et al., 2013). Research has shown that these children showed hypoactivation of the posterior parietal cortex compared to children in the control group during the performance of a continuous monitoring of a skill.

In the review study by Brown-Lum and Zwicker (2015), it was shown that children with developmental motor coordination disorder show increased activation in some brain areas (e.g., fronto-central areas), or under-activation in some other areas (e.g., dorsolateral prefrontal cortex) when performing certain skills. Zwicker and her colleagues (2011), using functional magnetic resonance imaging (fMRI), argued that children with developmental motor coordination disorder use different areas of their brain and activate them differently than typically developing children to support their motor performance when performing a skill. Clinical and experimental studies have shown that difficulties in learning motor skills in children with developmental motor coordination disorder may be related to dysfunction of the basal ganglia, which are involved in the initiation and learning of movement (Calabresi, et all., 2014), the hippocampus (Gheysen et al., 2011), and the midbrain (Sigmundsson, 2003). Brain regions involved in a variety of neurological processes (temporal pole, middle and superior frontal gyrus), including movement planning and execution, attention, memory, and other elements of the movement execution function, appear to be located differently in individuals with motor difficulties (Rey nolds, et all., 2017). However, because the motor system is extremely complex, the above is not yet a foregone conclusion. However, the field of etiology of developmental coordination disorder presents many gaps, without clarifying the exact etiology of the disorder. Perhaps, the causes of developmental coordination disorder are a combination of psychological, physiological, environmental, cultural, genetic and hereditary factors (Geuze, et all., 2001). The development of genetics and neuroimaging research in recent years seems to take us one step closer to understanding the complex mechanisms involved in developmental coordination disorder and neurodevelopmental disorders in general. The next step, after understanding, is to find and implement interventions that may improve the way the brain functions when a neurodevelopmental disorder is present (Barnett & Hill, 2019).

The detection of developmental motor coordination disorder

The fact that developmental motor coordination disorder has no clear etiology, as well as the multitude of symptoms that govern it, make it difficult to detect. The factors that make it difficult for specialists to easily detect the disorder are the heterogeneity it presents, in terms of the severity of the difficulties (Visser, 2003). Also, its diagnosis is achieved only if there are no other neurological disorders, such as cerebral palsy (Pearsall-Jones, 2010), multiple sclerosis, or Parkinson's disease, etc. (APA, 2013). According to DSM-5 criteria, the diagnosis of developmental motor coordination disorder is made by a clinical synthesis of history (developmental and medical examination), physical examination, school or workplace reports, and individual assessment using psychometric and motor tests. The manifestation of motor difficulties in performing skills that require motor coordination varies with age. Young children may be delayed in achieving motor milestones (sitting, crawling, walking), although many of them achieve typical motor milestones. They may also be delayed in developing skills such as climbing stairs, riding a bicycle, buttoning buttons, completing a puzzle, or using zippers. Even when the skill is achieved, the execution of the movement may seem strange, slow, or less precise than that of peers.

Older children and adults may exhibit slowness or inaccuracy in skills such as assembling puzzles, playing ball games - especially team games - , writing, typing, or driving (APA, 2013). A diagnosis of developmental motor coordination disorder is made only if the motor deficit significantly interferes with performance or participation in daily activities (family, social, school, or community life). Examples of such activities include dressing, eating with age-appropriate utensils without making a mess or mess, participating in motor games with others, using special tools such as a ruler and scissors, and participating in group exercise activities at school. All of these skills are not only deficient, but also slow in execution. Writing ability is affected by the disorder, which in turn affects academic performance. In adults, everyday skills in education and work, especially those that require speed and accuracy, are affected by problems with motor coordination (APA, 2013). The onset of symptoms of developmental motor coordination disorder is in the early developmental period. However, the diagnosis of this disorder is usually not made before the age of 5 years because there is significant variation in age and development in the acquisition of many motor skills, or lack of measurement stability in early childhood, or because other causes of delayed motor development may not have fully manifested themselves (APA, 2013).

The diagnosis of developmental motor coordination disorder is not due to another neurological condition. Thus, examination of visual and neurological function should be included in the diagnostic evaluation. If intellectual disability is present, motor difficulties exceed those expected for mental age. However, no cut-off criterion, or IQ deviation, has been established (APA, 2013). Two other important factors that make it difficult to detect developmental coordination disorder are differences in the age and gender of children (Chow & Henderson, 2003). As the child grows older, the motor demands change, as well as the nature of the existing disorder, making it difficult to identify children with motor difficulties (Henderson, 1994). The nature of the motor skills can give false impressions regarding developmental coordination disorder. Skills such as throwing or catching a ball, jumping, or running are "learned skills," according to Smyth (1997), so if a child performs poorly in one of these skills, it is due to a lack of experience and not to a motor problem. In their research, Geuze and colleagues (2001) discuss the positive or negative impact of the choice of exercises on detection. Specifically, they report that the difficulty or ease of the exercises, their complexity, the quality of the demonstration, and the emotions they create (fear or anxiety) can negatively affect the detection of developmental motor coordination disorder. Another important parameter, with regard to detection, is the appropriate measurement and evaluation tool/instrument, which, as provided by valid measurement instruments, generally in research, in order to be effective, must measure what it has been designed to measure, be easy to use, have norms for comparing results and of course be appropriate for the population to which it is applied (Cancer, Minoliti, Crepaldi, Antonietti, 2020). All of the above demonstrates the importance of early detection and assessment, in order to promptly address the developmental motor coordination disorder, thus reducing the motor, social, psychological and academic impacts on the child's life, while according to DSM-5 (APA, 2013) it now appears that the difficulties of the disorder continue to exist, both in adolescence and in adulthood.

Motor tests for detecting developmental motor coordination disorder

As mentioned previously, the detection and assessment of individuals with developmental motor coordination disorder is not an easy task. However, its importance is enormous as it allows for early intervention and treatment. The main method of detecting and assessing children with motor difficulties is motor tests. Previously, the recording of any difficulties was done by observing the characteristics of movement, without the existence of specific detection and assessment criteria (Baker, 1981). Over the years, various tests began to be used to detect developmental motor coordination disorder. The first motor detection tests used were the Test of Motor Proficiency (TMP), the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP), the Test of Gross Motor Development (TGMD), the McCarron Assessment of Neuromuscular Development, and the Test of Motor Impairment (TOMI), (Stott, Moyes, & Henderson, 1985).

The Test of Motor Impairment (Stott et al., 1985) was the basis for the creation of the most modern assessment tool, the Movement Assessment Battery for Children, which was developed a few years later into its new version, the Movement Assessment Battery for Children – 2 (MABC-2), (Henderson, Sugden, & Barnett, 2007). The abundance of motor tests that exist also requires their correct use, so that the information collected from them can be utilized in the design and implementation of appropriate therapeutic and educational programs. Their suitability should also be checked from country to country since they can give different results (Chow et al., 2003). Motor tests have at times received severe criticism regarding their usefulness and effectiveness, but despite their possible disadvantages, the fact is that they are valuable tools in the hands of specialists who know how to use the information they obtain from them. Many of them are used in combination with other alternative assessment methods, or in combination with medical examinations, etc., in order to identify difficulties.

The Movement Assessment Battery for Children-2 (MABC-2) motor test

The Movement Assessment Battery for Children-2 (MABC-2) is a test whose aim is to identify, describe and guide the goals of the intervention to treat motor deficiency in children aged between 3-16 years, while it is based on norms that cover these ages (Caçola & Lage, 2019). It is one of the most reliable and valid motor tests that have been constructed (Chow & Henderson, 2003), as well as one of the most widely used, to date, instruments for detecting motor difficulties that is widely used in modern literature (Cavalcante, et all., 2019). The MABC-2 (Henderson, et all., 2007) is a diagnostic assessment tool, specifically designed for the detection and assessment of children with developmental motor coordination disorder. It consists of a motor test, with the execution of exercises related to fine motor skills, ball handling skills and balance ability. It is applied individually, while there is a questionnaire, the Movement ABC Checklist (Henderson & Sugden 1992) that is completed by teachers, parents, or specialist therapists. According to Henderson and Sugden (1992), the main characteristics of the motor test are that: a) it identifies and describes problems in children's motor function, b) it is easy to move and simple to use, c) it provides an objective quantitative assessment, d) the time required ranges from 20΄- 30΄ individually and e) it can be used by professionals in the educational and medical fields. As it is one of the most frequently and widely used measurement instruments in the field of research on motor difficulties and developmental motor coordination disorder, its validity and reliability have been examined for its suitability in terms of detecting and assessing this disorder.

Research on the reliability and validity of the MABC-2 has shown that this measurement instrument has a high degree of reliability, both in terms of stability in repeated measurements (Van Wael Velde et al., 2016), and reliability between different raters (Smits, et all., 2008). Therefore, it is a useful tool for identifying children and adolescents with motor difficulties, so that by collecting information, appropriate interventions can be designed to address these difficulties.

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