Research in Developmental Disabilities 33 (2012) 996–1005

Contents lists available at SciVerse ScienceDirect

Research in Developmental Disabilities

Motor and cognitive performance differences between children with and without developmental coordination disorder (DCD)

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ARTICLE INFO

Article history:
Received 6 December 2011
Received in revised form 16 January 2012
Accepted 16 January 2012
Available online 21 February 2012

Keywords:
Developmental coordination disorder (DCD)
Cognitive–motor assessment
Information processing
PASS theory
Early identification

ABSTRACT

The current study adopts the PASS theory of information processing to investigate the probable differences in specific motor and cognitive abilities between children with and without developmental coordination disorder (DCD). Participants were 108 5- and 6-year-old preschoolers (54 children with DCD and 54 children without DCD). The Movement Assessment Battery for Children assessed motor function. Running speed and agility were measured using the Bruininks–Oseretsky Test of Motor Proficiency. Finally, the Planning, Attention and Simultaneous Scales from the Das–Naglieri Cognitive Assessment System evaluated cognitive ability. Children with DCD differed significantly from those without DCD performing at a lower level on all motor and cognitive tasks. A correlation analysis revealed significant relationships between cognitive processes and motor skills. Simultaneous cognitive processing and manual dexterity were significantly correlated for both groups. Furthermore, a significant relationship was revealed between planning cognitive processing and balance for the non-DCD group. Thus, early assessment might identify specific cognitive–motor difficulties. Furthermore, early intervention might prevent some of the developmental comorbidities in the academic and everyday lives of children with movement difficulties.

1. Introduction

Developmental coordination disorder (DCD) is characterised by children's difficulties with the acquisition and performance of motor skills (Koutsouki, 2001). These motor difficulties might arise from poor planning, a lack of understanding or a cognitive difficulty with the task and how it connects with other movements (Sugden & Wright, 1998). According to the APA's *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV, 1994) and the WHO's (1992a,b, 1993) *International classification of diseases and related health problems* (ICD-10), DCD is either a marked (DSM-IV) or serious (ICD-10) impairment in the development of motor coordination that significantly interferes with academic achievement, daily living skills or both. According to the DSM-IV (APA, 1994), the incidence of DCD in children aged 5–11 years is 6%. However, researchers report that this prevalence varies across countries (e.g., 4.9% severe and 8.6% moderate DCD in Swedish children, Kadesjo & Gillberg, 1999; 10% of British children, Henderson, Rose, & Henderson, 1992; up to 15.6% in Singaporean children, Wright, Sugden, & Tan, 1994). Furthermore, the ICD-10 (WHO, 1992b) includes the statement that "*it is usual for the motor clumsiness to be associated with some degree of impaired performance on visuo-spatial cognitive tasks*".

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0891-4222/$ – see front matter
doi:10.1016/j.ridd.2012.01.008

A review of the literature reveals that children with DCD form a heterogeneous group with different perceptual-motor profiles (Hoare, 1994; Dewey & Kaplan, 1994; Macnab, Miller, & Polatajko, 2001; Miyahara, 1994; Wright & Sugden, 1996a). Previous studies show that DCD is not an isolated problem that only includes difficulties in motor skills (Miyahara, 1994; Visser, 2003). These movement difficulties may be linked with a number of associated developmental problems, such as learning (e.g., reading disability or dyslexia; Dewey, Kaplan, Crawford, & Wilson, 2002), behavioural and speech disorders (Hill, 2001; Hoare, 1994; Macnab et al., 2001). Dewey et al. (2002) found that "*all children with developmental movement problems, no matter what the degree or severity are at risk for problems in learning, attention and psychological functioning*". Other researchers report attention deficits as well (Gillberg & Kadesjo, 1998; Kadesjo & Gillberg, 1999; Landgren, Kjellman, & Gillberg, 1998).

A meta-analysis of DCD showed that children with DCD performed poorer on all measures of *information processing* compared with typically developing children. In fact, *visual–spatial processing* was the most consistently impaired ability. In addition, DCD seems to manifest itself regardless of whether the cognitive tasks require a motor response (Wilson & McKenzie, 1998). Dwyer and McKenzie (1994) found problems in the *visual memory* of children who were asked to reproduce geometric figures.

Many studies have used the theoretical model of information processing to investigate clumsiness (Hulme & Lord, 1986; Larkin & Hoare, 1991; Van Dellen & Geuze, 1988; Wall, Reid, & Paton, 1990). Concrete processes such as perception, decision making, and so on are inserted and function between the presentation of a stimulus and its associated response. Problems can occur in one or more of these information processes, causing a person to use them to perform skilled movements (Fitts & Posner, 1967; Marteniuk, 1976; Missiuna, 2003; Wall et al., 1990).

The input of information is associated with the cognitive abilities of strategy development and anticipation for *decision making* (Sugden & Wright, 1998). The ability of children with DCD was slower and extremely limited in a cognitive decision-making process (i.e., a response selection task) compared with typically developing children. This result is probably due to "poor" response organisation or "poor" motor ability performance (Van Dellen & Geuze, 1988). In addition, school underachievement is associated with gross or fine motor difficulties (Das, 1986; Wall et al., 1990; Wilson & McKenzie, 1998). Motor coordination can be a "window" for understanding learning disability mechanisms (Getchell, McMenamin, & Whitall, 2005).

The present study adopts an alternative model of cognitive abilities, the PASS theory, to investigate the way that children process information. The works of Das, Kirby, and Jarman (1979) as well as Naglieri and Das (1990) were based on the neuropsychological work of A.R. Luria (1966, 1973, 1980). Naglieri and Das (2004) as well as Naglieri and Das (1999) described the Planning, Attention, Simultaneous and Successive (PASS) theory as an alternative to traditional general intelligence-based assessments of cognitive processing (Naglieri & Das, 1999). Naglieri and Das (1997a) developed the Cognitive Assessment System to operationalise PASS theory. According to this theory, human cognitive functioning is based on four interrelated components: *Planning*, *Attention*, *Simultaneous* and *Successive coding*.

Planning is responsible for making plans, decisions, judgments and evaluations; however, information cannot be processed and plans cannot be made unless people are interested, attend to incoming information and mobilise their *Attention* to make plans and decisions.

Simultaneous and *Successive coding* are responsible for analysing, synthesising and arranging information into a single group or a sequential order. For example, people perform simultaneous coding when they realise that "cats, dogs and goldfish" are all pets; however, people use successive coding when they remember the sequence of numbers that form a telephone number. Simultaneous coding occurs in working memory and its results, simultaneous codes, are stored in long-term memory (Kirby & Das, 1990). This type of coding is involved when people examine logical, grammatical relationships (e.g., "the father's brother and the brother's father; Das, Naglieri, & Kirby, 1994). Finally, the *knowledge base* influences all of the above cognitive processes; more precisely, knowledge moderates processing (Das et al., 1994; Wall, 2004).

The current research protocol investigates the motor and cognitive differences in 5- and 6-year-olds with and without DCD. The characteristics of these children were analysed using a battery of 9 motor and 9 cognitive tasks. Therefore, we collected information on the motor and cognitive domain strengths and weaknesses of each child. In addition, we collected information regarding modes of learning, information processing, action planning and concentration as well as attention when learning a skill.

2. Methods

2.1. Participants

Participants in this study consisted of 108 preschoolers (54 children with DCD and 54 age-matched healthy controls; 73 boys and 35 girls). All children were enrolled at public kindergartens in Attica, Southern Greece. The total sample of 108 was composed of 42 5-year-old (24 children with DCD including 13 boys and 11 girls; 18 children without DCD including 15 boys and 3 girls) and 66 six-year-old preschoolers (30 children with DCD including 23 boys and 7 girls; 36 children without DCD including 22 boys and 14 girls). Participants had never been diagnosed with any physical, emotional, behavioural or intellectual disability (i.e., no children had IQ less than 70); moreover, they had no histories of paediatrician-determined pre- or existing developmental disorder, such as attention-deficit/hyperactivity disorder (ADHD). Note that there is up to 50% overlap between DCD and ADHD (Kadesjo & Gillberg, 2001).

The mean age of the 5-year-old group ($n = 42$) was 61.84 months (SD = 3.12 months, range 55–65 months), and the mean age of the 6-year-old group ($n = 66$) was 69.40 months ($SD = 2.52$ months, range 66–76 months). Stratified sampling (Imbens