Human Movement Science 32 (2013) 9–20

Contents lists available at SciVerse ScienceDirect

Human Movement Science

journal homepage: www.elsevier.com/locate/humov

Associations between gross Motor Coordination and Academic Achievement in elementary school children

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ARTICLE INFO

Article history:
Available online 20 December 2012

PsychINFO classification:
2820
3550
3720

Keywords:
Motor coordination
Academic achievement
Cardiorespiratory fitness
Socio-economic status
Body mass index

ABSTRACT

We aimed to evaluate the relationship between gross motor coordination (MC) and academic achievement (AA) in a sample of Portuguese children aged 9–12 years. The study took place during the 2009/2010 school year and involved 596 urban children (281 girls) from the north of Portugal. AA was assessed using the Portuguese Language and Mathematics National Exams. Gross MC was evaluated with the Körperkoordination Test für Kinder. Cardiorespiratory fitness was predicted by a maximal multistage 20-m shuttle-run test of the Fitnessgram Test Battery. Body weight and height were measured following standard procedures. Socio-economic status was based on annual family income. Logistic Regression was used to analyze the association of gross MC with AA. 51.6% of the sample exhibited MC disorders or MC insufficiency and none of the participants showed very good MC. In both genders, children with insufficient MC or MC disorders exhibited a higher probability of having low AA, compared with those with normal or good MC ($p < .05$ for trend for both) after adjusting for cardiorespiratory fitness, body mass index and socio-economic status.

1. Introduction

Mastery of a variety of motor skills is a requisite for children to engage in everyday activities and has important implications for different aspects of development in children and adolescents

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http://dx.doi.org/10.1016/j.humov.2012.05.005

(Piek, Baynam, & Barrett, 2006). Children's motor skill development incorporates many body systems, including sensory, musculoskeletal, cardiorespiratory, and neurological systems (Dwyer, Baur, & Hardy, 2009), as well as the child's ability to interact with the environment (Riethmuller, Jones, & Okely, 2009). Consequently, the study of a child's motor development is a prerequisite for the full understanding of the child's whole development (Payne & Isaacs, 1998).

The importance of promoting the development of MC at younger ages relies on the current and future benefits associated with the acquisition and the maintenance of motor proficiency (Lubans, Morgan, Cliff, Barnett, & Okely, 2010). For instance, it has been suggested that an appropriate acquisition of MC contributes to children's physical, cognitive, and social development (Payne & Isaacs, 1998). Furthermore, a proper MC level is essential for a strong general development, as well as for health, psychosocial development, and well-being (Haga, 2008; Piek et al., 2006). Childhood is a critical period for the development of these skills, which are considered building blocks of more complex movements (Clark & Metcalfe, 2002) and represent a key factor in the promotion of lifelong active lifestyles (Clark, 2005; Stodden et al., 2008). It is also known that motor skills have been observed to track during childhood (Malina, 1996).

Recently, there is a re-emerged debate around the possible relations between physical activity (PA), physical fitness, motor coordination (MC) and cognitive development (Niederer et al., 2011), based on the decrease in children's PA (Knuth & Hallal, 2009), physical fitness (Tomkinson & Olds, 2007), MC (Prätorius & Milani, 2004), and the pressure of schools and parents to improve cognitive performance (Chomitz et al., 2009; Ertl, 2006).

While the relationship between PA and physical fitness with academic achievement (AA) has been thoroughly explored (Ahamed et al., 2007; Carlson et al., 2008; Castelli, Hillman, Buck, & Erwin, 2007; Chomitz et al., 2009; Coe, Pivarnik, Womack, Reeves, & Malina, 2006; Etnier, Nowell, Landers, & Sibley, 2006; Eveland-Sayers, Farley, Fuller, Morgan, & Caputo, 2009; Fox, Barr-Anderson, Neumark-Sztainer, & Wall, 2010; Grissom, 2005; Hillman, Erickson, & Kramer, 2008; Kwak et al., 2009; Niederer et al., 2011; Rasberry et al., 2011; Ruiz et al., 2010; Sigfusdottir, Kristjansson, & Allegrante, 2007; Strong et al., 2005; Taras, 2005; Trudeau & Shephard, 2008), is known about the relation between gross MC and AA in elementary school children.

Studies suggest that neuronal structures (in the cerebellum and the frontal lobe) are responsible for coordination as well for cognition (Serrien, Ivry, & Swinnen, 2006). There is also evidence that working memory capacity and visual perceptual ability limit children's AA (Alloway, 2007; Alloway & Alloway, 2010; Sortor & Kulp, 2003). Besides, one cross-sectional and longitudinal study found that higher baseline motor skills (agility and dynamic balance) were related to better spatial working memory and/or baseline attention as well as their future improvements over the following nine months (only no association was found between dynamic balance and attention) (Niederer et al., 2011). Indeed, children with developmental coordination disorders tend to perform poorly in literacy and numeracy assessments (Alloway, 2007), while fine MC was found to positively correlate with AA (Sortor & Kulp, 2003), and children with learning disabilities scored poorer in gross MC test (both locomotor and object-control) (Westendorp, Hartman, Houwen, Smith, & Visscher, 2011). Additionally, other cross-sectional (Knight & Rizzuto, 1993; Nourbakhsh, 2006; Planinsec, 2002) and interventional studies (Budde, Voelcker-Rehage, Pietrabyk-Kendziorra, Ribeiro, & Tidow, 2008; Erickson, 2008; Uhrich & Swalm, 2007) have shown that improved motor skill levels may be positively related to improvements in AA or other cognitive variables. Moreover, longitudinal studies in preschool children found a relationship between early motor development and later cognitive function (Piek, Dawson, Smith, & Gasson, 2008; Son & Meisels, 2006), suggesting that early school motor skills assessment may increase the predictability of later achievement and the probability of identifying children at risk for school failure (Son & Meisels, 2006).

It is important to note that the term "motor coordination" used in this study is a general term that encompasses various aspects of movement competency. There are many different test batteries that assess movement in a variety of ways using various movement tests. Specifically, process and product oriented movement assessments are used to examine differences in levels of MC. While it is outside the scope of this study to explain the differences and limitations in how movement and/or movement outcomes are assessed, we used the term "motor coordination" in this study as it specifically aligns with the language used in the assessment implemented for this study (Kiphard-Schilling body coordination test) and with previous literature that has used the same assessment.