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An investigation of age and gender differences in preschool children's specific motor skills

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Abstract

The present study aimed to assess the effect of age and gender on preschool children's specific motor skills. Three hundred children (154 boys and 146 girls) aged 60 to 71 months, were divided into two age subgroups (60-65 and 66-71 months) and were examined in three motor tasks: bead threading, shape copying and postural stability, assessing visual motor, graphomotor and balance skills respectively. Results showed a significant effect of age in the graphomotor task, with older children performing better than younger ones. As regard gender, girls scored significantly better than boys on both visual motor and graphomotor tasks, while boys outperformed girls on the balance task. The findings are discussed on the basis of biological (different rates of brain maturation and gender differences in brain structure and function) and environmental (opportunities and encouragement) factors that influence motor behavior.

Keywords: Motor skills, preschool children, biological and environmental factors.

Introduction

Motor achievements constitute a significant developmental task during childhood. Notably, preschool years are considered a critical period for the acquisition of motor skills, since during this phase motor skills and fundamental neuroanatomic structures present considerable development, elaboration and myelination (Denckla, 1974). Unless having a severe disability, almost every child is expected to develop a wide range of basic movement actions and specialized motor skills (Malina, 2004).

Available developmental data reveal an age improvement in overall motor performance (Denckla, 1974; Largo, Fischer & Rousson, 2003; Wolff, Gunnoe & Cohen, 1985), and more specifically in fine and gross motor skills (Gidley-Larson et al., 2007; Wilson, Iacoviello, Wilson & Risucci, 1982). Children with typical development are normally expected to attain basic gross motor skills required for postural control and vertical mobility by the age of 5 years (Rosenbaum, Missiuna & Johnson, 2004). However, a recent study showed that age significantly affects balance skills during preschool years (Venetsanou & Kambas, 2011). Moreover, Gabbard and Hart (1993) using a foot-tapping speed task in children aged 4- to 6-years postulated that their performance improves with age. Recently, a study of motor coordination in Greek preschool aged children (Giagazoglou et al., 2011), indicated that older children outperformed younger ones in ball and manual dexterity tasks, showing the impact of age in specific motor skills.

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The above findings suggest that "variation in motor development within individual children, between children, and from age to age" is significant during preschool years (Malina, 2004. p. 57).

Besides age, gender has also been found to affect children's developing motor skills, although relevant empirical data are often contradictory. Researchers either report gender differences in various motor tasks (Brito & Santos-Morales, 2002; Largo et al., 2001; Largo, Fischer & Rousson, 2003; Mathiowetz, Wiemer & Federman, 1986; Thomas & French, 1985) or they focus on the age in which boys and girls attain specific motor skills (Gidley-Larson et al., 2007). For instance, according to Denckla (1973) school-aged girls seem faster and better synchronized than boys; however these differences are not obvious during adolescence. Additionally, it has been reported that boys' ball skills develop earlier than girls', while girls present manual dexterity skills earlier than boys (Giagazoglou et al., 2011; Junaid & Fellowes, 2006). Regarding balancing tasks, previous findings showed that girls outperform boys (Engel-Yeger, Rosenblum & Josman, 2010; Gabbard, 2004), while other suggest small gender differences (Venetsanou & Kambas, 2011). However, it should be noticed that a considerable amount of studies failed to found gender differences in motor performance (Gaub & Carlson, 1997; Kambas, Fatouros, Aggeloussis, Gougoulis & Taxidaris, 2003; Wilson et al., 1982). The aforementioned contradictory findings suggest that gender differences in motor performance are either too small to be easily detected or that they are restricted to specific motor skills, some of which favor girls and some others boys. The assessment of children's motor performance in an early age, is of particular significance given that several studies have documented that motor impairment is associated with cognitive, language and social problems (Piek, Hands & Licari, 2012) and it goes along with various developmental disorders (e.g. autism, attention deficit hyperactivity disorder, dyslexia). Within this research tradition and taking into account that preschoolers' motor skills develop rapidly, the present study aimed to assess the effect of age and gender on specific motor skills in a sample of 5- to 6-years old children attending kindergarten.

Recently, there seems to be a lack of consensus regarding assessing general motor performance vs specific motor skills in preschool years (Piek et al., 2012). The present study was designed to examine specific motor skills, which require the involvement of "specialized motor systems" (Carlson, 2010, p. 273), since it has been suggested that such an assessment could "provide some indication of where possible deficits originate" (Piek et al. 2012, p.408). More specifically, we used three motor tasks, namely bead threading, shape copying and postural stability task, designed to assess respectively visual motor coordination, graphomotor coordination and balance.

Based on previous studies it was predicted that performance in motor skills would improve with age (*Hypothesis 1*). We also hypothesized that boys' and girls' performance would be differentiated in specific motor tasks (*Hypothesis 2*).

Method s

Participants

The sample consisted of 300 students [(154 boys and 146 girls) (chronological age Mean=64.9 months, SD=2.94 for boys and Mean=64.8 months, SD=3.09 for girls)] selected from 15 Greek kindergartens. Participants were randomly selected from the school population of a medium-sized city in central Greece, after permission of the Greek Ministry of Education and parents' consent had been given. Kindergartens' selection followed a stratified randomized approach and included four urban (cities with more than 10000 people), three semi-urban (places of 2500 to 10000 inhabitants) and seven rural (areas with less than 2500 inhabitants) schools. Pupils were grouped into two age cohorts: the first (younger) cohort was aged 60 to 65 months (n=78, M=63.5 months, SD=1.52 for boys and M=63.5 months, SD=1.42 for girls) and the second (older) was aged 66 to 71 months (n=222, M=69.1 months, SD=1.84 for boys and M=69.3 months, SD=1.67 for girls). All children were speaking fluently the Greek language, were in mainstream school placement and did not have any history of psychiatric illness, development disorder, visual or auditory impairments according to their school records.

Tasks and Procedure

For the assessment of preschoolers' motor performance three motor tasks from the Dyslexia Early Screening Test (DEST) (Nicolson & Fawcett, 1996) were used. DEST is a well-established screening instrument designed to identify preschool children at risk for reading failure. The battery comprises screening tests of attainment and ability and evaluates a range of skills, such as motor and phonological skills, as well as-memory. More specifically, the following motor sub-tests were used: (a) *bead threading* (b) *shape copying* and (c) *postural stability* task:

(a) The bead threading task (Nicolson & Fawcett, 1996), measured how many beads a child could thread in 30 seconds. Each participant was asked to grasp in his/her dominant hand a cord (40-cm in length and 3 mm in diameter) and to thread on it 13 wooden holed beads (6 cm in diameter) as quickly as possible with his/her other hand. Reported 1-week test–retest reliability was satisfactory (r=.72, p<.01; Nicolson & Fawcett, 1996).

(b) In *the shape copying* task (Nicolson & Fawcett, 1996), the child was given a pencil and paper and was asked to copy (one at a time) seven simple geometrical shapes. After practising the drawing of an X, he/she was presented seven shapes of escalating difficulty. All participants began the task by drawing two vertical lines and end it by copying a diamond. Scores were based on each drawing's accuracy derived from the test manual's instructions and were ranged from 0 to 3. Finally, the total score for the 7 shapes was calculated. Test-retest reliability was good (r=.80, p<.01) (Nicolson & Fawcett, 1996).

(c) In *the postural stability* task (Nicolson & Fawcett, 1996), participants were asked to stand up blind-folded and to try to stay still. Their degree of sway was measured, two seconds later, by pushing a balance tester (included in the DEST kit) on the child's back with a force of 1.5 Kg. Scores ranged from 0 to 6, where 0 represented no sway at all and 6 meant significant loss of balance. The task was

repeated four times. In two of them participants had their hands by their side and in another two they had them stretched. Scores in each trial were added, yielding a total score. Test-retest reliability was very good ($r=.88$, $p<.01$; Nicolson & Fawcett, 1996).

All children were examined individually in a session during the second term of kindergarten. Most children completed all assessment measures on one session which lasted approximately 10 min. The tester was a doctoral student experienced in motor assessment. Bead-threading and shape copying tasks are considered completely objective (Nicolson & Fawcett, 1996), and therefore inter-rater reliability was calculated only for the postural stability task. Specifically, videotapes of 20 children while being tested for postural stability were given to two independent researchers and their inter-rater reliability was .93.

Statistical analysis

Non-parametric statistical analyses were performed because the requirements for the normality of the distribution were not satisfied. Data were analyzed using Mann-Whitney U test to examine whether the two age and the two gender groups of preschoolers' exhibit significant differences in their motor performance.

Results

Table 1 presents the mean scores and standard deviations of preschoolers' performance on motor tasks by age group. Mann-Whitney U test detected a statistically significant effect of age in the shape coping task ($z=-2.95$, $p<.05$), with older children presenting better scores than younger ones. Such differences were not observed for the two other tasks.

Table 1. Mean scores and standard deviations in motor skills by age group

	Age			
	60-65 months		**66-71 months**	
Motor skills	*M*	*SD*	*M*	*SD*
Balance	3.69	2.54	3.97	2.98
Visual-motor	5.04	1.30	5.24	1.50
Graphomotor	12.12*	3.03	13.43*	2.89

*p<.05

The means and standard deviations of preschoolers' performance on motor tasks by gender are given in Table 2. Mann-Whitney U test revealed statistically significant differences between genders on the three motor tasks. Girls scored significantly better than boys on both the bead threading ($z=-2.56$, $p<.05$) and the shape copying ($z=-2.72$, $p<.01$) tasks, while boys performed better than girls on the postural stability task ($z= -2.62$, $p<.01$).

Table 2. Mean scores and standard deviations in motor skills by gender

	Gender			
	Boys (*n=154*)		**Girls (*n=146*)**	
Motor skills	*M*	*SD*	*M*	*SD*
Balance	4.32**	2.95	3.46**	2.73
Visual-motor	4.99*	1.30	5.40*	1.58
Graphomotor	12.69**	2.78	13.53**	3.12

*p<.05, **p< .01

Discussion

Given that motor competence constitutes a significant developmental challenge during preschool years, the present study was designed to investigate the effect of age and gender on preschool children's specific motor skills. The results showed an improvement with age in graphomotor task, since older children presented better scores than younger ones, confirming partially our first hypothesis. Nevertheless, age-related changes were not observed to all tasks. Contrary to previous findings indicating age-related improvement in visual motor (Gabbard & Hart, 1993) and balance skills (Venetsanou & Kambas, 2011) during preschool years, our results did not reveal any significant differences between the age cohorts we examined. Given that in typically developing children, gross motor skills needed for postural control are attained by the age of 5 years old (Rosenbaum et al., 2004), the absence of age-related differences in the balance task probably indicates that preschoolers have already reached a sufficient level in this dexterity, although its complete development is expected in late childhood (Scheid, 1994).

Regarding gender, our results showed that girls scored significantly better than boys on both visual motor and graphomotor tasks, while boys outperformed girls on the balance task, confirming our second hypothesis. The gender differences observed on the two first tasks are in agreement with previous studies suggesting that girls attain manual dexterity earlier than boys (Junaid & Fellowes, 2006), and are more skillful than boys in peg placing (Largo et al., 2001). However, boys' better performance on the balance task, contradicts previous findings according to which either girls overmatch boys (Engel-Yeger et al., 2010; Gabbard, 2004) or that gender differences are not of great significance (Venetsanou & Kambas, 2011).

The variability in results is not uncommon between studies assessing motor performance of preschool children (Piek et al, 2012). It has been mainly attributed to the multiplicity of assessment tools used (Piek et al. 2012), individual differences which generate a great variance within children of similar age (Cools, De Martelaer, Samaey & Andries, 2009; Tomassini et al., 2011), preschoolers' lack of motivation and unwillingness to cooperate during assessment (Blank, Smits-Engelsman, Polatajko & Wilson, 2012), possible gender (Touwen, 1976) and cultural differences (Cools et al., 2009; Super, 1976), thus leading Piek et al. (2012, p. 402) to argue that "there is no one gold standard assessment tool to investigate motor ability in preschool children". In the present study we have not used a typical motor assessment battery, but we adopted motor tasks from the DEST. In that sense, the differentiation of the assessment tool used could partially explain the contradictory results of the present study. However, it should be mentioned that although DEST is a test for early screening of dyslexia, the three subtests used have been designed to identify children who present signs of motor deficits, which are often accompanying dyslexia (Fawcett, Nicolson & Dean, 1996). Given that the detection of specific motor deficits in preschool children might be of extremely importance for their overall development, the information provided by such tools might be useful for the prevention of possible motor or other developmental impairments.

Moreover, attempting to interpret the results of the present study, we should shed light in both biological and environmental factors that probably intervene and affect preschool children's motor performance. As Malina (2004) has pointed out motor development is shaped through the interaction of child's maturation and environmental experiences and thus a better understanding of this developmental process should take into account both factors.

The neural background of motor skills has been well documented recently, since new neuroimaging techniques permitted to enlighten the brain functions related to motor performance (Dayan & Cohen, 2011). Brain development studies have shown that sensory and motor areas are developing firstly (Gogtay et al., 2004; Johnson, 2001), while a preschooler's density of synapses in the sensorimotor cortex approaches adult levels (Piek et al., 2012). In this sense, the absence of significant age differences in visual motor and balance skills among preschoolers could be attributed to the fact that main motor circuits attached to the cerebellum, which regulates posture and coordination, have been already shaped during their first two years.

However, the differences observed in graphomotor task between younger and older children might mirror differences in maturation and enhanced organization of the brain hemispheres. Studies have shown that the execution of fine motor actions depends on integral interhemispheric and corticospinal connections (Knyazeva et al., 1997; Meyer, Röricht & Woiciechowsky, 1998). Evidence from transmagnetic stimulation suggests that children do not present transcallosal inhibition until the age of 6 years and they gradually reach adult levels in early adolescence (Garvey et al., 2003; Heinen et al., 1998). An additional explanation for the observed age differences derives from a very recent neuroimaging study (Tomassini et al., 2011) which tested for associations between magnetic resonance imaging measures and performance in simple motor tasks and demonstrated that between-subjects variation in motor performance can be partially attributed to individual differences in brain function and structure.

In sum, the different rates of brain maturation and the age-increased myelinization of the central nervous system which promotes development of children's fine motor skills, could explain the graphomotor improvement observed in this study. This interpretation is also supported by the coordinated emergence of neurological functions (Anderson, Northam, Hendy, & Wrennall, 2001; Klinberg, Viadya, Gabrieli, Moseley & Hedehus, 1999), motor and cognitive advances (Case, 1992) during human development.

Gender differences in motor development have been also attributed to biological factors and more precisely to the differentiated neurological maturation of girls and boys (Piek et al., 2012). Within this context, girls' predominance on both visual motor and graphomotor tasks could be partially explained by young girls' left hemisphere more rapid development (Hanlon, Thatcher & Cline, 1999). More specifically, during the first 6 years of life, girls have been found to exhibit synchronized EEG coherence peaks in brain regions which are mainly related to language acquisition, fine motor performance and social cognition (Hanlon et al., 1999). These different gender-specific rhythms in brain maturation, could suggest that a 5 to 6-year-old boy need a longer period of time to build up fine motor (small muscle and nerve) skills, which are required for detailed hand work while executing graphomotor and visual motor tasks.

Besides the aforementioned biological factors, environmental factors as well could explain the gender differences observed in the present study. Previous findings suggest that gender differences in motor skills during early years could be attributed to social-environmental factors (Thomas & French, 1985; Thomas, Yan & Stelmach, 2000) and more specifically to significant others' attitude towards young children's activities. For example, parent and teachers often encourage girls to engage in quiet activities requiring fine motor skills (e.g. drawing), while they promote boys' participation in dynamic movement actions (e.g. running). In a recent review Venetsanou and Kambas (2010) summarized that various environmental factors, such as family characteristics and child's socio-cultural context may pose "certain demands for his/her motor behavior, favoring specific aspects of motor development and impairing others" (Venetsanou & Kambas, 2010, p. 319). In sum, the differentiated environment-initiated opportunities provided to boys and girls could explain the observed predominance of boys on balance skills (usually termed gross motor), and the superiority of female preschoolers in manual skills (usually termed fine motor).

In conclusion, this study revealed that girls and boys present different developmental patterns in specific motor skills during preschool years. This finding supports the recent suggestion that in an attempt to assess motor performance in children we should employ distinct gender and age norms (Gidley-Larson et al., 2007; Van Waelvelde, De Weerdt, De Cock & Smits Engelsman, 2003). However, due to the large number of biological and environmental factors which intervene and possibly affect motor skills development during early childhood the critical issue is to provide opportunities for practice to all children (Zimmer, 2009) not only to improve their motor skills, but also to prevent or eliminate difficulties stemming from poor motor competence. Such opportunities seem increasingly important during preschool years, since young children's encouragement to participate in motor activities, could not only promote the development of their motor skills, but also facilitate the identification of children at risk to present motor impairment (Giagazoglou et al., 2011; Piek et al., 2012).

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