Ivana Grubišić, mag. rehab. educ.
Slava Raškaj Educational Centre Split
igrub30@gmail.com

izv. prof. dr. sc. Renata Pinjatela
Department of Motoric Disorders, Chronic Diseases and Art Therapies
Faculty of Education and Rehabilitation Sciences, Zagreb
renata.pinjatela@erf.hr

IMPACT OF A PSYCHOMOTOR DEVELOPMENT PROGRAMME ON VISUAL-MOTOR INTEGRATION, MOTOR ABILITIES AND HUMAN FIGURE DRAWING BY PRESCHOOL CHILDREN

Summary: *The focus of this research was to study a possible association among visual-motor integration, motor coordination and ability to draw human figures in typically developing preschool children. The sample of 28 Croatian children was divided into a control group, who participated in the regular preschool programme, and an experimental group, who participated in a custom-designed psychomotor development programme. The psychomotor programme led to a significant improvement in visual-motor integration and coordination skills. Visual-motor integration and bilateral coordination in the experimental group were significantly associated with their ability to draw human figures. The results emphasise the importance of comprehensive support programmes to promote preschool child development.*

Keywords: *visual perception, motor skills*

FOREWORD

Preschool involves significant changes in all aspects of psychomotor development, including visual and perception development as well as visual-motor integration, which interrelates visual information from the surroundings with hand movement. This integration allows coordinated motor actions, such as writing, drawing and manipulations, on the basis of visual information processed by the brain.

Normal development of these abilities in the preschool period is important for later academic performance. This development can be influenced by programmes that take advantage of brain plasticity to improve perception and motor processes.

IMPORTANCE OF VISUAL-MOTOR INTEGRATION IN PSYCHOMOTOR DEVELOPMENT

Visual-motor integration allows visual information to support purposeful motor activity. Sanghavi and Kelkar (2005) point out that visual-motor skills involve motor control, coordination and psychomotor speed. Visual-motor integration is required for many activities, from eating, walking, and running; to academic skills such as writing and reading; to more advanced intellectual skills such as using a computer (Gül Ercan, Ahmetoğlu, Aral, 2011). Indicators of visual-motor integration can include writing legibly and correctly, or performing other visual-motor activities at an adequate speed (Schneck, 2010; Chinner, Brown, Stagnitti, 2011). Visual-motor integration depends on receptive functions, fine motor ability and the combination of cognitive, visual and motor processes (Dankert et al, 2003; Schneck, 2010a; Coallier et al, 2014).

Neurophysiological and neuroanatomical studies support the importance of visual-motor integration. Visual and motor areas in the cortex are interconnected (Brown et al, 2007) and vision is crucial for motor skills (Atasavun Uysal, Düger, 2011). Visual-motor integration coordinates visual perception with hand movements (Beery, Beery, 2006; Gabbard, Goncalves, Santos, 2001; Chinner, Brown, Stagnitti, 2011) during which the brain translates perceptual information into a specific motor action (Cui, Andersen, 2011). That relation between perceptual-motor and cognitive systems defines the development of drawing and handwriting (Tükel, 2013). In fact, visual-motor coordination and visual perception are important in the development of academic skills and school readiness (Tükel, 2013).

ASSOCIATION BETWEEN COORDINATION AND VISUAL-MOTOR INTEGRATION IN PRESCHOOL CHILDREN

Coordination allows movements to be executed completely (Iveković, 2013), and bilateral coordination allows movements involving both sides of the body (Williams, 1983; Magalhaes, Koomar, Cermak, 1989). By developing body awareness, children learn to move the two sides of the body symmetrically (Fazlioglu, Gunsen, 2011; Iveković, 2013). Developing coordination usually begins with control over symmetrical movements, then to homolateral movements and lastly to reciprocal movements and adept bilateral function (Williams, 1983; Magalhaes, Koomar, Cermak, 1989). Mechanical differences between hands and feet mean that hand-foot coordination is more demanding than hand-hand coordination (Bobbio, Gabbard, Caçola, 2009).

Motor control depends on the interaction among the individual, the environment and the task involved (Shumway-Cook, Woollacott 2001; Tükel, 2013). For example, the individual needs to combine visual and proprioceptive signals from the sensory periphery to estimate arm position when reaching (Sober, Sabes, 2003). The individual must then coordinate the hand muscles to grasp the pencil (Tükel, 2013), and then fixate the elbow and wrist (Cornhill, Case- Smith, 1996) while separately moving the thumb and individual fingers to move the pencil along the paper (Cornhill, Case-Smith, 1996). Problems with coordination can lead to difficulties in transcription and writing (Golubović, Rapaić, 2008), ultimately affecting overall academic performance (Henderson, Hall, 1982; Davidson, Williams, 2000).

ASSOCIATION BETWEEN VISUAL-MOTOR INTEGRATION AND HANDWRITING DEVELOPMENT IN PRESCHOOL CHILDREN

Visual-motor integration subserves many skills (Marr, Cermak, 2002; Coallier et al, 2014), including the development of handwriting (Volman et al., 2006; Coallier et al., 2014). In fact, the level of this integration can predict handwriting performance (Cornhill, Case-Smith, 1996; Dankert et al, 2003; Feder, Majnemer, 2007; Coallier et al, 2014) as well as academic performance (Schoemaker, Kalverboer, 1994; Taylor, 1999; Ratzon, Efraim, Bart, 2007).

If handwriting performance can reflect the level of visual-motor integration, so too can drawing ability (Dankert, Davies, Gavin, 2003; Shooman, Rosenblum, 2014). Children develop the ability to draw at a time when their visual-motor integration increases (Bonoti, Vlachos, Metallidou, 2005; Kaiser, Albaret, Doudin, 2009; Shooman, Rosenblum, 2014). Drawing ability is associated with a child's subsequent development of writing skill, which demands greater coordination (Smits-Engelsman et al, 2001; Matijević-Mikelić et al, 2011).

Analysis of children's first drawings of human figures can provide information on visual-motor skills, cognition, observation skills and self-image (Prstačić et al, 1990), as well as motor and cognitive maturation (Matijević-Mikelić et al, 2011). Drawings can be analysed, for example, for proportion and symmetry of body parts (Harris, 1963; Tükel, 2013). When constructing a human figure, a child must depict the length and shape of certain features in realistic proportions, which relates to handwriting ability (Prstačić et al, 1990).

PROBLEM STATEMENT AND RESEARCH AIM

The aim of this study was to assess the association among visual-motor integration, upper limb coordination and bilateral coordination in preschool children, as well as evaluate the ability of a custom-designed psychomotor development programme to improve visual-motor integration and thereby figure drawing ability. While the association between visual-motor integration and motor abilities when drawing human figures has been explored in children in various countries, it has not been explored in typically developing preschool children in Croatia.

Based on the objectives of the study, the following hypotheses were established:

Hypothesis 1. Our custom-designed psychomotor development programme can improve visual-motor integration.

Hypothesis 2. There is positive correlation among visual-motor integration, bilateral coordination and upper limb coordination.

METHOD

PARTICIPANTS

The sample consisted of 28 typically developing children (14 boys, 14 girls) aged 63-79 months (5-6 years) in one preschool group in Zagreb, Croatia. All children underwent initial assessment using two of the instruments described below, Beery-Buktenica Developmental Test of Visual-Motor Integration and Bruininks-Oseretsky Test of Motor Proficiency 2. Then 14 children (7 boys, 7 girls) were assigned to an experimental group that participated in our 4-month psychomotor development programme, while the other 14 children participated in the normal activities of their preschool group. At the end of the study, all children underwent a final assessment with the same instruments, as well as with the Goodenough-Harris Draw-a-Person Test.

Parents provided written informed consent for their children to participate in this study and in the psychomotor development programme. The study was conducted according to the Ethical Code for Research on Children (2003).

INSTRUMENTATION

Beery-Buktenica Developmental Test of Visual-Motor Integration

The Beery-Buktenica Developmental Test of Visual-Motor Integration (VMI) (Beery, Beery, 2010) assesses visual-motor integration (Goyen, Duff, 2005; Parush, Lifshitz, Yochman, Weintraub, 2010; Coallier et al, 2014). The test is administered by showing the subject geometric figures, which they proceed to draw in a designated place (Chinner, Brown, Stagnitti, 2011). A short form of the test for ages 2-7 was used for this study.

Bruininks-Oseretsky Test of Motor Proficiency 2

The Bruininks-Oseretsky Test of Motor Proficiency 2 assesses motor abilities and skills (Bruininks, Bruininks, 2005; Miletić et al, 2012) in subjects 4-21 years old (Miletić et al, 2012). The subtests estimate motor abilities of large groups of muscles as well as analyse movement and abilities of small groups of muscles (Miletić et al, 2012). Only the subtests Bilateral Coordination (BOTBC) and Upper-Limb Coordination (BOTULC) were administered in this study.

Goodenough-Harris Draw-a-Person Test

The Goodenough-Harris Draw-a-Person Test is the test most frequently used to assess a child's ability to draw a human figure (Short-DeGraff, Holan, 1992). The test is administered by asking the child to draw a fully clothed person.

PSYCHOMOTOR DEVELOPMENT PROGRAMME

A programme to support psychomotor development was constructed by combining theory and practical knowledge in educational rehabilitation, pedagogy and kinesiology. During the 4-month programme (November 2014 until February 2015), children attended a single, 45-min class twice a week in a sport hall of a kindergarten in Zagreb.

Dynamic perception and motor activities were alternated with games and activities to support interaction, teamwork and group cohesion during the programme (Table 1.).

Table 1. Components of the psychomotor development programme

Sequence	Component	Purpose
1	Activities for social skills development	introduce children to activities and motivate them to participate
2	Exercises for motor development and coordination of movement	activate parts of the body that would be most utilised in the main part of the class
3	Activities for cognitive development and support of communication	support cooperation between children in order to finish a task through teamwork
4	Sensory/motor activities	support the integration of different types of sensory information
5	Psychomotor relaxation	supports relaxation through calm music or calm activities

DATA PROCESSING

Statistical analyses were conducted using SPSS 20.0 (IBM, Chicago, IL, USA). Differences between groups were assessed for significance using the Wilcoxon rank-sum test, while potential correlations between variables were assessed using Spearman's rank correlation coefficient rho. These nonparametric methods were used because the data showed a skewed distribution.

RESULTS

Descriptive analysis of the results is shown in Table 2.

Table 2. Descriptive analysis of results

Group	Instrument	N	Mean	Standard deviation	Minimum	Maximum
Experimental	BOTULC-I	15	12.33	4.117	6	19
	BOTULC-F	15	17.53	2.800	13	21
	VMI-I	15	8.27	1.981	4	11
	VMI-F	15	10.47	1.246	9	12
	BOTBC-I	15	6.73	2.120	3	10
	BOTBC-F	15	9.80	1.740	7	12
Control	BOTULC-I	13	12.31	2.016	9	16
	BOTULC-F	13	12.62	2.468	8	18
	VMI-I	13	7.54	1.941	4	10
	VMI-F	13	7.85	1.676	5	11
	BOTBC-I	13	7.15	1.519	5	10
	BOTBC-F	13	7.62	1.193	6	10

BOTBC, Bruininks-Oseretsky Test of Motor Proficiency, Subscale Bilateral Coordination; BOTULC, Bruininks-Oseretsky Test of Motor Proficiency, Subscale Upper-Limb Coordination; VMI, Beery-Buktenica Developmental Test of Visual-Motor Integration. The endings "-I" and "-F" indicate initial and final scores, respectively.

Table 3 analyses differences between initial and final results in visual-motor integration, bilateral coordination and upper limb coordination. The experimental group showed significant improvement in all variables.

Table 3. Differences in visual-motor integration and motor coordination before and after the psychomotor development programme

Group	Instrument	Sign of difference (final – initial)	N	Median difference	Sum of difference	Z	p
Experimental	VMI	negative	0	0.00	0.00	-3.210	**0.001**
		positive	13	7.00	91.00		
	BOTBC	negative	0	0.00	0.00	-3.322	**0.001**
		positive	14	7.50	105.00		
	BOTULC	negative	0	0.00	0.00	-3.420	**0.001**
		positive	15	8.00	120.00		
Control	VMI	negative	2	7.50	15.00	-1.387	0.166
		positive	8	5.00	40.00		
	BOTBC	negative	2	4.50	9.00	-1.732	0.083
		positive	7	5.14	36.00		
	BOTULC	negative	3	3.83	11.50	-0.933	0.351
		positive	5	4.90	24.50		

BOTBC, Bruininks-Oseretsky Test of Motor Proficiency, Subscale Bilateral Coordination; BOTULC, Bruininks-Oseretsky Test of Motor Proficiency, Subscale Upper-Limb Coordination; VMI, Beery-Buktenica Developmental Test of Visual-Motor Integration

Table 4 analyses potential correlations among visual-motor integration, bilateral coordination, upper limb coordination and ability to draw a human figure in the two groups. Following the psychomotor support programme, the experimental group showed significant correlations among visual-motor integration, bilateral coordination and the ability to draw a human figure.

Table 4. Correlations among visual-motor integration, motor abilities and the ability to draw human figures at the end of the study

Group		Instrument and measure		VMI	BOTBC	BOTULC
Experimental	Goodenough	rho	**0.623***	**0.585***	0.195	
		p	**0.013**	**0.022**	0.487	
Control	Goodenough	rho	0.298	0.077	0.469	
		p	0.322	0.802	0.106	

BOTBC, Bruininks-Oseretsky Test of Motor Proficiency, Subscale Bilateral Coordination; BOTULC, Bruininks-Oseretsky Test of Motor Proficiency, Subscale Upper-Limb Coordination; VMI, Beery-Buktenica Developmental Test of Visual-Motor Integration

DISCUSSION

During preschool, children's motor skills deepen and mature (Gallahue, Ozmun, 1998; Spanaki et al, 2014), and their integration of perception with certain actions develops to give rise to coordinated behaviour (Smith, Thelen, 2003; von Hofsten, 2004; Getchell, 2007). Improving these skills can prepare children for school, since better gross motor skills may correlate with faster information processing, which may translate to better cognitive performance (Piek et al, 2008; Bobbio, Gabbard, Caçola, 2009). Nevertheless, motor abilities and visual-motor integration are often overlooked during assessment of school readiness (Sandler et al, 1992; Sortor, Kulp, 2003; Pagani, Messier, 2012). The significant improvement in performance in our experimental group indicates the importance of psychomotor support during preschool development.

Our results suggest a significant correlation between visual-motor integration and drawing of human figures, which is consistent with previous studies. For example, Short-Degraff and Holan (1992) found that evaluating the ability of preschool children to draw themselves can be used to assess their perceptual-motor skills, and they further showed that the ability to draw oneself correlated more strongly with visual-motor abilities than with verbal intelligence. Despite being a relatively simple task, drawing a human figure can reveal a substantial amount of information about motor development (Schepers, Dekovic et al, 2012; Tükel, 2013) and cognitive development (Harris 1963; Abell, Wood et al, 2001; Schepers, Dekovic et al, 2012; Tükel, 2013). Also, several sex-dependent differences have been described in how children develop drawing ability. Girls are better than boys at drawing details of the face, especially a female face; boys tend to draw female legs separated, while girls tend to draw them together as parallel lines (Routledge, 1976). Our results, together with the literature, highlight the usefulness of including this test among standard assessments of preschool children.

Our finding that visual-motor integration correlates with human figure drawing suggests an influence on motor coordination, yet this influence is likely to be complex, since the ability to draw a human figure did not correlate significantly with upper limb coordination in our experimental or control group, but it did correlate significantly with bilateral coordination in the experimental group. Similar evidence for complexity comes from the study by Scordella et al (2015) showing that motor coordination and handwriting skills are associated with visual-spatial skills but not with each other. Further work should explore the interrelationship among visual-motor integration, motor coordination and handwriting or drawing.

Our results should be interpreted with caution given the small sample; on the other hand, the small size means that we can be reasonably confident that the 4-month psychomotor development programme was implemented uniformly for the entire experimental group. The mere fact that we conducted these assessments enabled us to detect children who, despite having no history of developmental delays, performed poorly on certain subtests, and this information can be communicated to the teacher and shared with the parents to recommend further assessments before the child enters primary school.

The present study extends a sparse literature on the connection between perception and motor development in typically developing preschool children. It suggests that well-designed psychomotor development programmes can improve motor skills and potentially even cognitive abilities. Implementing such programmes for preschool children may be beneficial in Croatia and other countries.

CONCLUSION

Visual-motor integration and coordination are important during the preschool and early school years, and they help determine future academic skills and involvement in school activities. An interdisciplinary approach was used here to design a psychomotor development programme, which we showed could significantly improve preschoolers' ability to draw human figures, an index for motor abilities. Our results here with typically developing children suggest the efficacy of such programmes for them as well as potentially for children with disabilities. We also found significant associations between the ability to draw human figures and at least certain types of motor coordination, suggesting that this drawing test could become part of assessments of perceptual-motor abilities for school readiness. Understanding the connection between visual-motor integration and coordination is important for guiding interventions to strengthen overall development of typically developing children and those with disabilities.

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