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ORIGINAL ARTICLE

Effect of an exercise program emphasizing coordination on preschoolers' motor proficiency

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Abstract
The purpose of the present study was to investigate the effect of an exercise program emphasizing coordination on the motor proficiency of preschool aged children. One hundred and thirteen children, aged 4-6 years (M= 60.17 months, SD=6.43 months) living in Southern Greece, enrolled in the study. The 57 children of the experimental group (EG) attended the intervention program for 28 weeks, while the 56 children of the control group (CG) did not participate in any organized physical activity program. Both groups were tested with the "Democritus" Psychomotor Assessment Tool for Preschool Children (PAT-PRE) (Kambas, Aggeloussis & Gavriilidou, 2003) five times (one before program's start, one after its end and three in the meantime). The ANOVA with repeated measures that was applied showed that, while both groups (EG and CG) displayed an improvement in their performance, the EG surpassed statistically significantly the CG at the fourth measurement and maintained that difference at the fifth one. It seems that an exercise program emphasizing coordination can notably improve children's motor proficiency.

Key words: *preschool age, psychomotor assessment, coordination abilities, PAT- PRE*

Introduction

Preschool age is thought to be very important for human motor development, as in that specific period the fundamental movement skills are developed (Gallahue & Donnely, 2003). The mastery of those skills is a prerequisite for both daily life functioning and participation in later physical or sport-specific activities (Fischer et al., 2005).

During preschool years, changes due to growth and maturation occur quite rapidly and affect children's motor behaviour (Gallahue & Ozmun, 1998). That is why, a large volume of papers refer to the great influence of age, as an index of maturation and growth, on children's motor proficiency (suggestively: Chow, Hsu, Henderson, Barnett & Lo, 2006; Fjørtoft, 2000; Lam, Ip, Lui, & Koong, 2003; Venetsanou, Kambas, Aggeloussis, Fatouros, & Taxildaris, 2009).

However, motor development is not an independent procedure. Although maturity and growth are undoubtedly very important factors for motor development, they are not the only ones. Children do not develop somehow "automatically" their fundamental movement skills with each passing birthday. Factors like the environment, the exposure to and the opportunity to participate in motor or physical activities, as well as instructions used during the activities have an important and positive role to play in this development (Gallahue & Ozmun, 1998). The more opportunities given to children for practice, the more they develop their movement repertoire and refine the fundamental movement skills (Cleland & Gallahue 1993).

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Especially nowadays, when physical activity is not an integral part of daily life, children need both, movement instruction and opportunities for practice just as they do in reading, writing, mathematics, playing an instrument, or in learning a foreign language. However, it is rare to find movement instruction as a fundamental component of a preschool instructional curriculum. Unfortunately, this is the case in Greece, where movement education has not become an integral part of kindergarten curriculum yet.

Nevertheless, a large amount of research gives sound evidence for the positive results of various developmentally adequate movement programs on preschool aged children's motor proficiency (Suggestively: Deli, Bakle & Zachopoulou, 2006; Derri, Tsapakidou & Kioumourtzoglou, 2001; Venetsanou & Kambas, 2004; Wang, 2004; Zachopoulou, Tsapakidou & Derri 2004; Zimmer, Christoforidis, Xanthi, Aggeloussis & Kambas, 2008).

Moreover, research conducted on the brain development has also given encouraging support for early movement experiences. Preschool age is thought to be a sensitive period for the brain growth and it seems that the brain grows in size, complexity, and synaptic connections due to the quantity and quality of sensory experiences (Chisholm, Carter, Ames & Morison, 1995; Chugani, 1996; Ramey & Ramey, 1994; Singer, 1995).

A motor training content considered very important for brain development is activities emphasizing coordination (Cotman & Berchtold, 2002). Besides, coordination is believed to be a prerequisite not only for the learning, refinement, stabilization and implementation of sport skills but also for the sufficient "access" to the physical abilities repertoire (Niklisch & Zimmermann, 1981) and its training in preschool aged children has been proved to be of great significance (Diem, Lehr, Olbrich & Undeutsch, 1980; Kunz, 1993; Zimmer, 1996).

However, the research findings regarding the implementation of exercise programs that focuses on coordination in Greek children are lacking. The only published study is that of Kambas et al. (2005) in which a program aiming at the development of coordination was applied to 330 preschoolers. The results showed that these children outperformed the control group ones after the implementation of the program. However, concerns are raised due to the fact that the experimental group was assessed more times than the control one.

Taking into consideration the importance of coordination development, the aim of the present study was to investigate the effect of an exercise program emphasizing coordination, on the motor proficiency of preschool aged children.

Methods

Participants

One hundred and sixteen children 4 - 6 years old (M= 60.17 months SD= 6.43 mo.) who lived in Southern Greece, volunteered to participate in the current study. Among them, 58 served as experimental group (EG) while the rest constituted the control group (CG) and participated only in the activities that were included in the Curriculum for Kindergarten. Parents gave a written permission for their children's participation in the study. In order comparisons among the age groups formed at preschool age to be possible, the children were divided in the following four age-groups:

- 1st group: 48-53 months (n=27)

- 2nd group: 54-59 months (n=28)
- 3rd group: 60-65 months (n= 32)
- 4th group: 66-71 months (n=26)

Three children among the participants (one of the EG and two of CG) did not participate at the last measurement and their scores were not included in statistical analyses. As a result, the final number of participants was 113 (EG: n=57; CG: n=56).

Measurements

The "Democritus" Psychomotor Assessment Tool for Preschool children (PAT-PRE) (Kambas et al., 2003) was used for the assessment of children's motor proficiency. The PAT-PRE has been developed from the Motor Test for 4 – 6- year old children (Motoriktest für vier-bis sechsjährige Kinder, MOT 4-6) (Zimmer & Volkamer, 1987) to provide preschool educators, clinicians and researchers information about motor proficiency assessment of individual preschoolers aiming at the development and control of psychomotor training programs (Kambas & Zimmer, 2004). The PAT-PRE includes the following 13 tasks: *Tapping, Jumping repeatedly sideways, Catching a dropped stick, Running and carrying and placing a ball in a box, Walking toe-to-heel in a backward direction, Overhead tossing to a specific target, Picking up coins and placing them in an area, Stepping through 3 vertical hoops, Standing jump over a hoop, Catching a bean-bag, Astride jumping with rebound, Standing jump over a stick, Body rolling along the vertical axis.*

Each of the tasks is presented through a fairy tale in order to avoid creating a rigid evaluation climate and to motivate children participate. As norms of the battery have not been created yet, the performance on each item was converted into a z-score and the sum of those z-scores constituted the total PAT-PRE score.

Regarding the psychometric characteristics of the battery, it has a high test-retest reliability (R=.86) (Venetsanou, 2007) and an excellent criterion validity (R= .91) (Kambas & Zimmer, 2004). Moreover, PAT-PRE total score differentiates among the age –groups (Venetsanou, 2007).

Procedure

The children were individually assessed on the PAT-PRE indoors in Kindergartens, where they were studying, according to the test guidelines (Kambas et al., 2003). Each child concluded all testing procedures on the same day and within the time limits of the Kindergarten's timetable.

Both EG- and CG- children were administered the PAT-PRE five times:

- 1st measurement: before program's start (3rd and 4th week of October 2005)
- 2nd measurement: after Christmas holidays (2nd and 3rd week of January 2006),
- 3rd measurement: before Easter holidays (1st and 2nd week of April 2006),
- 4th measurement: after the end of the program (4th week of May and 1st week of June 2006)
- 5th measurement: three months after the end of the program (2nd and 3rd week of September 2006).

Intra-rater reliability had been examined before the study. Videotapes had been made of 36 children, aged 48-71 months, while they had been being tested. With an interval of one month, these videotapes had been scored again by the same examiner. Intraclass correlation coefficient (3.1) used for statistical analysis had been found to be excellent (R=.93).

Exercise program

Due to the importance of coordination in human motor behaviour, it has been approached by the several researchers in variant ways. Hirtz (1985), who has conducted the most systematic and applicative study of coordination abilities until today, defined the following five abilities as important for childhood: *ability of kinesthetic differentiation at time and space, spatial and temporal orientation, response ability, rhythm and balance*. Hirtz's studies on coordination abilities concern the school age; however, they could also be applied to younger ages.

The exercise program applied in the present study was based on Hirtz's (1985) concept. According to Kosel (1992) for the aforementioned coordination abilities development, the exercise program should include activities providing particular stimuli. Specifically:

a) Kinesthetic differentiation: Activities requiring the identification and elaboration of information regarding space and time features of the movement, as well as the degree of muscle activation.

b) Spatial and temporal orientation: Activities aiming at children's conceptualizing their body posture, as well as the position of both their co-trainees and equipment.

c) Response ability: Activities during which the children have to respond in visual, auditory or mixed stimuli.

d) Rhythm: Activities emphasizing temporal - dynamic disjunction of default performance rhythms.

e) Balance: Activities during which the children have to maintain or recover their posture after missing it.

Consequently, the exercise program included activities having the aforementioned features. Moreover, Boes, Lener and Reincke's (1999) methodology for the presentation of activities aiming at the coordination abilities development was adopted. The pedagogic approach of the program was that of Psychomotor Education (PE), as it is considered the most appropriate educational method for preschool children (Volkamer & Zimmer, 1986; Zimmer, 2006; Zimmer & Cicurs, 1993). Basic axes of psychomotor education are the participial and individualization methods (Scientific Psychomotor Association-Hellas, 2005). That means that the planning of the program took into consideration not the performance mean of the group but the individual differences and the children play an important role in the progress of each lesson. In that way the activities gave to every child the opportunity to succeed and to choose the way of his/her own action (Zimmer & Circus, 1993).

The program was applied for a 28 – week period (first week of November until last week of May), twice a week, with an interval of two weeks in both Christmas and Easter holidays. Each training unit lasted 45 minutes.

Statistical analyses

The data were analysed in a 2X4X5 analysis of variance (ANOVA) with treatment group (EG, CG) and age group (48-53, 54-59, 60-65, 66-71 months) as between subjects factors, and the measurements (1^{st}, 2^{nd}, 3^{rd}, 4^{th} ,5^{th}) as a within factor. The data of the present study did not meet ANOVA's assumption for sphericity (Mauchly's W=.122, χ^2= 217.196, p< .001). In order the aforementioned violation to be confronted, the Greenhouse – Geisser ε index was adopted, as its value (ε= .725) allows the implementation of univariate analyses (Dafermos, 2002).

Post hoc comparisons were made using the Bonferroni test, with alpha set at .05. In addition to p values, effect sizes as measured by Eta Squared (η^2) values were also used for data interpretation. Values of $\eta^2 > .14$ were considered as sufficiently large to be of any importance (Cohen, 1988).

Results

The mean values of children's PAT-PRE performance for the five measurements are summarized in table 1.

Table 1. Means and Standard Deviations for PAT-PRE total score for the five measurements by treatment – and age group

		1st test		2nd test		3rd test		4th test		5th test	
		M	SD	M	SD	M	SD	M	SD	M	SD
Experimental group	48-53 mo.	-3.43	2.06	-2.68	2.42	-2.26	2.80	3.63	1.54	4.20	1.45
	54-59 mo.	-2.53	2.05	-1.27	3.76	-.58	3.20	4.86	2.03	5.18	1.95
	60-65mo.	-1.57	1.06	-.19	3.42	-.27	3.25	5.65	1.69	6.16	1.68
	66-71mo.	2.57	2.92	3.66	3.30	3.48	2.04	6.69	2.14	7.42	2.02
	Total	-1.43	3.09	-.34	3.91	-.11	3.50	5.07	2.13	5.61	2.11
Control group	48-53 mo.	-4.58	4.01	-2.48	4.79	-2.83	4.69	-2.20	5.00	-1.78	4.73
	54-59 mo.	-2.65	3.88	-2.93	3.86	-2.77	3.84	-.63	2.30	0.008	2.10
	60-65mo.	.88	3.96	.62	3.88	1.08	4.33	1.15	4.15	2.19	3.72
	66-71mo.	3.68	3.01	4.19	4.19	4.03	3.21	5.37	2.66	5.51	2.59
	Total	-.29	4.69	-003	4.86	.10	4.80	1.11	4.37	1.76	4.07

The between factors ANOVA results revealed a significant age group effect ($F_{3,105}= 23.56$, $p < .001$, $\eta^2= .40$). The factor "treatment group" had also a statistically significant effect ($F_{1,105} = 9.32$, $p < .01$) but with a very low value of effect size index ($\eta^2= .08$), while "age group by treatment group" interaction was found to be insignificant. According the result of the Bonferroni tests that followed, the older children (66-71 months) had significant Mean Differences (MD) with all the younger ones (MD=6.10, $p < .001$ for the 48-53 mo. group, MD= 4.99, $p <.001$ for the 54-59 mo. group and MD= 3.09, $p< .001$ for the 66-71 mo. group). Moreover, the 60-65 mo. age group had a higher PAT – PRE score than the 48-53 mo. group (MD= 3.01, $p< .005$) (Figure 1).

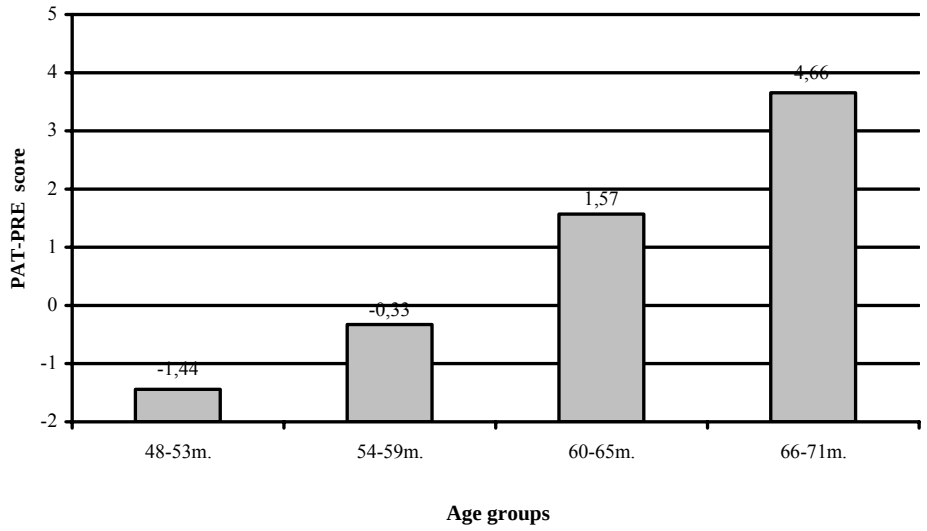

Figure 1: Total PAT-PRE scores by age group.

According to the within factors ANOVA results, there was a significant interaction between "measurement" and "treatment group" ($F_{2.68,\ 281.49}$= 56.02, p< .001, η^2= .35), while the other interactions were of no statistical significance. At the first measurement, the PAT-PRE scores of the two groups were almost the same (MD= 0.57, p= .329, in favour of CG). During the second and third measurements the EG outperformed CG but those differences were not of statistical significance (MD= .03, p= .962 and MD=.21, p= .756 for the two measures respectively). Conversely, at the fourth measurement the differences between the two groups became significant (MD= 4.29, p < .001 in favour of EG). That difference maintained also at the 5th measurement (MD= 4.24, p < .001) (Figure 2).

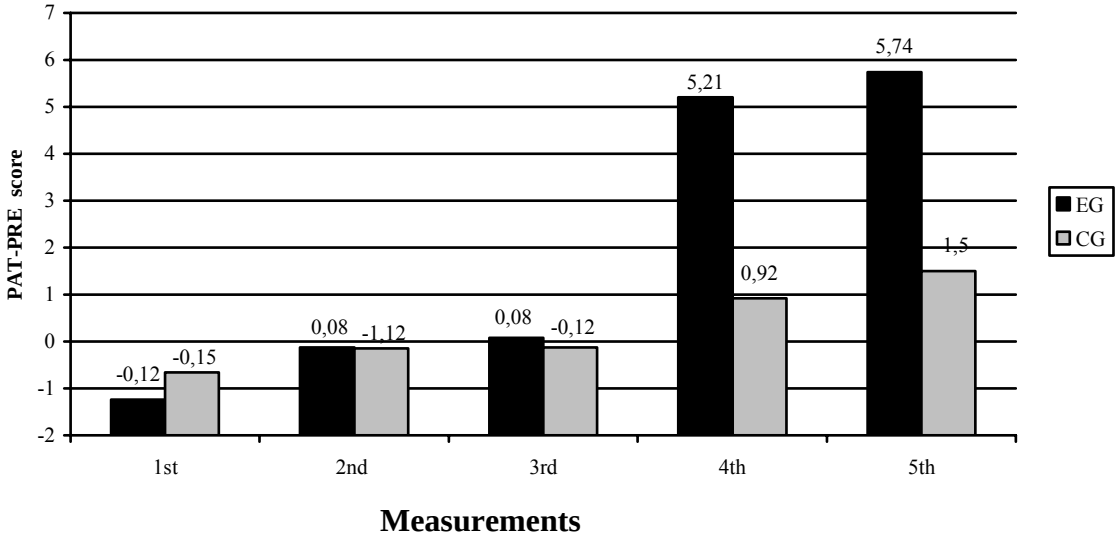

Figure 2: Total PAT-PRE scores of EG and CG across measurements.

Regarding the progress of the two groups' scores across the measurements, the EG had a significant improvement among all the measurements, except the 3rd one, at which although there was an improvement it was not statistically significant. Conversely, the CG showed the first significant improvement at the 4th measurement.

Discussion

In this study the effect of an exercise program emphasizing coordination on preschooler's motor proficiency was examined. For that purpose, 113 children, aged 4-6 years, divided in two groups (EG and CG) that were assessed five times on the PAT-PRE (Kambas et al., 2003). Children's PAT-PRE total scores were analyzed using a three –way ANOVA (age group X treatment group X measurement) with repeated measures on the factor "measurement".

The ANOVA showed that age significantly affected children's motor proficiency, with $\eta^2 = .40$ meeting Cohen's (1988) criteria for acceptability. This finding is in close agreement with previous studies that regard preschool aged children (Chow et al., 2006; Fjørtoft, 2000; Lam et al., 2003; Morris, Williams, Atwater & Wilmore, 1982; Oja & Jurimäe, 1997; Toriola & Igbokwe, 1986; Venetsanou et al., 2009). In the preschool years, changes due to growth and maturation occur quite rapidly and lead to an improvement on children's motor proficiency.

Regarding the treatment groups, both EG and CG improved their performance across the five measurements. However, the CG children that did not participate in any other movement activities beyond those included in the Kindergarten curriculum, showed a significant performance improvement at the 4th measurement (in the end of May). At that measurement, CG's performance was significantly higher than that at 3rd and 1st ones. A further improvement was noticed at the 5th measurement, in which CG's performance was higher than all the previous ones. At this point, it should be noted that although the learning effect could be a factor significantly contributing to the improvement of children's performance, according to a previous study the measurement with PAT-PRE is free from learning effect (Venetsanou, 2003). Consequently, the significant differences between 4th and 1st measurement, as well as between 5th and 3rd, 2nd 1st ones can be attributed to the long time period among them. A child, which at the 1st measurement belonged to 1st age group, passed in the next age group at the 4th measurement. Taking into consideration the significant effect of age on children's motor proficiency, discussed above, the aforesaid finding was expected.

Moreover, as expected can be also characterized the significant differences between both 3rd - 4th measurements and 4th - 5th ones. The favorable weather conditions prevailing in Greece during spring and summer, as well as the contiguity of the most of the areas included in the present study with the sea multiplied children's opportunities for swimming and outdoors playing. That finding is consistent with that of Butcher and Eaton (1989) according to which, children's motor proficiency is straightly associated with their daily motor behavior.

The children of the EG on the other hand, that participated in the exercise program, showed an important improvement of their performance among all the measurements. The only exception was the 3rd measurement, in which although an improvement was noticed it was not statistically significant. Regarding performance differences between EG and CG, it was revealed that even though there were no significant differences between those two groups' scores at the first measurement, they became noticeable at the fourth one, namely after the end of the program. The

above findings are consistent with those of previous studies in which the implementation of exercise programs resulted to the improvement of the participants' motor proficiency (Aggelousis et al., 1999; Brown et al., 1981; Derri et al., 2001; Kambas et al., 2005; Ross & Butterfield, 1989; Venetsanou & Kambas, 2004). An interesting finding of the present study was that the significant differences between the two treatment groups maintained until the 5th measurement, revealing that the effects of the program lasted for at least three months after its end.

The exercise program that implemented in the present study focusing coordination, according to Hirtz's (1985) model, proved to be effective for the improvement of children's motor proficiency. Taking into consideration that coordination abilities training can begin at a very young age (Roth, 1998) due to the early brain development that comes before other developmental processes (Noth, 1998) it can be concluded that developmentally exercise programs focusing coordination can be a valuable means for children's movement education. However, taking intro account that coordination exercise is considered important for brain development (Cratty, 1975), further research is required so that the effect of such a program on children's mental abilities can be investigated.

In conclusion, the assumption according to which, fundamental movement skills develop on their own is not valid. Age significantly affects preschooler's motor proficiency but it is not the only contributor. Moreover, although free play is a significant factor for children's motor development (Butcher & Eaton, 1989; Corrie & Barratt-Pugh, 1997), organized exercise programs appear to have a more determinative role. The findings of the present study are added support for providing developmentally movement experiences during early childhood. Children need appropriate and ample opportunities for practice, a positive environment, knowledgeable instruction and appropriate feedback for optimal motor development. Moreover, the study on the exercise's influence on selected cognitive features of personality has gained ground and it has to be examined with a current method. The support that has been provided by the Neurosciences, in that direction, makes the re-determination of the points of reference in future studies essential.

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