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ORIGINAL ARTICLE

Motor and Graphomotor performance of students aging from 5 to 10 years old

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Abstract
The purpose of the study was to examine: a) the graphomotor skills of students with high, average and low motor performance and b) the relationship between motor and graphomotor skills. The total sample consisted of 275 kindergarten and elementary school students in Athens, Greece (138 boys and 137 girls), who were examined in the BOTMP-SF and the five graphomotor items of BOTMP-LF. The ANOVA revealed significant differences among the three groups ($F = 19.726$, $p < .001$, $\eta^2 = .150$) and the Least Significant Difference-LSD post hoc method revealed that the 'high' group ($M_z = 1.02$, $SDz = .82$) scored significantly higher than the 'average' group ($Mz = .60$, $SDz = .87$) which, in turn, scored significantly higher than the low motor performance group ($Mz = -.70$, $SDz = 1.51$). Finally, the graphomotor performance was significantly predicted, through stepwise multiple regression, from five gross motor skills (running speed and agility, standing on preferred leg-static balance, walking on balance beam-dynamic balance, tapping feet alternative while making circles with fingers and standing broad jump). Overall, physical educators and teachers may consider that the motor and graphomotor skills of their students constitute interrelated academic elements.

Keywords: *Motor and graphomotor performance, gross motor skills*

Introduction

The motor and graphomotor skills have been reported in the literature, as inter related aspects of motor development for kindergarten and elementary school students, (Anagnostatou, Gioftsidou, Basiketopoulou, Papadopoulou & Kambas, 1998; Düger, Bumin, Uyanik, Aki & Kayihan, 1999; Kambas, 1996; Kambas, Aggelousis, Proviadaki, Mavromatis & Taxildaris, 2004; Kambas, Amoutzas, Makri, Gourgoulis & Antoniou, 2002; Marr, Windsor & Cermak, 2001). To that extend, Kambas (1996) examined the intervention of a physical education programme on 46 children, 4 to 6 years old, and found an improvement of their gross and fine motor skills. The researcher concluded that visual-motor coordination and eye-hand coordination are essential elements for the development of graphomotor performance.

Anagnostatou, Gioftsidou, Basiketopoulou, Papadopoulou and Kambas (1998) examined the effect of an intervention psychomotor programme, in pre-schoolers, on a variety of skills, such as static and dynamic balance, aiming skills, fine motor skills, motor stability and dominant hand use. Four repeated evaluations were administered and significant improvement was found in balance and fine motor skills which, in turn, may exhibit a direct influence for the development of writing skills in the future.

Düger, Bumin, Uyanik, Aki and Kayihan (1999) examined the relationship between motor skills and demographic characteristics in children from the general population, aging from 4 to 11 years old. The researchers used the Bruininks Oseretsky test of Motor Proficiency-Long Form (BOTMP-LF) (Bruininks, 1978) and found significant differences between boys and girls in balancing tests and reaction time to a visual stimulus. In both measures boys scored higher than girls.

Marr, Windsor and Cermak (2001) examined the relationship of perceptual-motor and graphomotor skills, in a sample of 138 children aging from 4 to 7 years old, with and without

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writing problems. The purpose was to examine the relationship between cognitive, visual-motor and graphomotor skills. The researchers found a significant relationship between visual-motor and graphomotor skills and concluded that a replication study, with students exhibiting writing and speech problems simultaneously, may be necessary in the future.

Kambas, Amoutzas, Makri, Gourgoulis and Antoniou (2002) examined the effect of a psychomotor programme, emphasizing time and space, in 35 children attending public kindergarten schools (4 to 5 years old). The participant's graphomotor skills were assessed through the respective BOTMP-LF items (copying circle, triangle, rhombus and pencils). The researcher found significant differences between the experimental and control group at the end of the intervention programme. The differences were attributed to the improvement of the experimental group. On the contrary, the control group did not improve in the four examined skills. Kambas et al. (2002) suggested that the development of graphomotor skills for students with poor motor performance may be examined in the future.

Further, students with poor motor performance may exhibit certain developmental disabilities, such as developmental coordination disorder (DCD), attention deficit hyperactivity disorder (ADHD), learning disabilities (LD), etc. (Gallahue & Ozmun, 1997). Further, these students differ from each other in turns of the severity of their perceptual-motor dysfunction and may exhibit a combination of the above developmental disabilities (Beyer, 1999; Jongmans, Smits-Engelsman & Schoemaker, 2003). Overall, being in the poor motor skilled group is often associated with academic difficulties which, in turn, may lead to school failure, depression delinquency, etc. (Gallahue et al., 1997; Koutsouki, 2001).

Based on our review of literature, a relationship between motor and graphomotor skills is evident for kindergarten and elementary school children. Furthermore, the above relationship has not been examined in a Greek population of children with and without motor difficulties. The aim of the present study, therefore, was to: a) examine the graphomotor skills of Greek kindergarten and elementary school children who differ according to their motor skills (low, average, high) and b) to predict the graphomotor performance from the student's gross motor skills.

Methods

Participants

The participants were 275 kindergarten and elementary school students from the first, second and third grades (138 boys and 137 girls). All students, attending public schools within Athens, Greece, were examined in the BOTMP-SF and the five graphomotor items of the BOTMP-LF. Their demographic characteristics and their scores in the above measures are presented in Tables 1 and 2.

Table 1. Demographic Characteristics of the Students

Variable		Mean	SD	Min	Max	N
Sex						275
	Boys					138
	Girls					137
Age (months)		88.39	11.86	54	110	275
Grades						
	Kindergarten					25
	1st grade					100
	2nd grade					89
	3rd grade					61

Table 2. The Scores in BOTM P-SF and the Five Graphomotor Skills of BOTMP-LF

Variable	Mean	SD	Min.	Max.	N
BOTMP-SF					
Rsa1	8.26	3.30	.00	15.00	289
Stb2	5.57	1.15	1.00	6.00	289
Db3	3.31	1.01	.00	4.00	289
Tfa4	.53	.49	.00	1.00	289
Juch5	1.95	1.39	.00	22.00	289
Sbj6	5.73	2.19	.00	11.00	289
Ctb7	2.25	.86	.00	3.00	289
Tb8	1.79	.79	.00	3.00	289
Rs9	4.12	2.34	.00	11.00	276
Dl10	3.49	.82	.00	4.00	288
Cc11	1.57	.60	.00	2.00	288
Cop12	1.00	.75	.00	2.00	288
Ssc13	4.45	1.47	1.00	8.00	276
Md14	5.63	2.32	1.00	10.00	288
Sum15	49.62	10.41	12.00	73.00	285
BOTMP-LF					
CutC16	3.33	.97	.00	4.00	224
Cl17	3.47	.87	.00	4.00	224
Trig	1.45	.57	.00	2.00	224
Romb19	.92	.59	.00	2.00	224
Kamb20	2.75	1.15	.00	4.00	224
Vmct21	11.95	2.85	.00	16.00	224

1: Running speed & agility, 2: Static balance beam, 3. Walking balance beam, 4. Tapping feet, making circles, 5. Jumping up, clapping hands, 6. Standing broad jump, 7. Catching tossed ball, 8. Throwing ball, 9. Response speed, 10. Drawing line, straight path, 11. Copying circle, 12 Copying overlapping pencils, 13. Sorting shape cards, 14. Making dots, 15. Sum, 16. Cutting circle, 17. Drawing line, crooked path, 18. Copying triangle, 19. Copying horizontal diamond, 20. Drawing line, curve path, 21. Visual motor control: Graphomotor skills

Measurements

The Bruininks- Oseretsky Test of Motor Proficiency (BOTMP: Bruininks, 1978) was developed to evaluate motor proficiency of children 4½ to 14½ years old. It may provide clinicians, practitioners and researchers with information concerning the: a) motor skills, b) placement in appropriate educational setting and c) the evaluation of movement and developmental disorders (Bruininks, 1978). It is one of the most commonly used battery tests, since it measures important skills of motor development (Burton & Miller, 1998, Goodway, Crowe & Ward, 2003; Wilson et al., 2000).

The Complete Battery (BOTMP-LF) includes eight subtests and is comprised from 46 items.The short form (BOTMP-SF), includes 14 items of the completed form and it has been designed to provide an index of general motor behaviour. The short form requires 35-45 minutes and incorporates the following items: 1) running speed and agility, 2) standing on preferred leg, 3) walking forward heel- to- toe on balance beam, 4) tapping feet alternately while making circles with fingers, 5) jumping up and clapping hands, 6) standing broad jump, 7) catching a tossed ball with both hands, 8) throwing a ball with preferred hand, 9) response speed (stopping a falling stick) 10) visual – motor control with drawing a line through a straight path with preferred hand, 11) visual – motor control with copying a circle with preferred hand, 12) visual – motor control with copying overlapping pencils with preferred hand, 13) upper - limb speed and dexterity with sorting cards with preferred hand 14) upper-limb speed and dexterity with making dots with preferred hand.

After the entire test was completed, the raw scores were converted to point scores and then to derived scores. The total sum for the 14 subtests of BOTMP-SF determined the motor performance. Moreover, the sum of: a) the three graphomotor skills of BOTMP-SF and b) the five graphomotor skills of BOTMP-LF, were used in order to evaluate the total graphomotor performance of our sample.

The reliability and validity of BOTMP-SF was examined with factorial analyses based on the performance of 194 children (96 boys and 98 girls), aging from six to eleven years old (Hassan, 2001). The statistical analysis produced four factors, named: a) gross and fine motor performance, b) upper – limb coordination, c) balance and speed and d) visual motor control supported the validity of the BOTMP-SF (Hassan, 2001). Finally, Kambas, Aggelousis, Proviadaki, Mavromatis and Taxildaris (2004) examined the validity and internal consistency of the Bruininks Oseretsky Test of Motor Proficiency-Short Form (BOTMP-SF)(Bruininks, 1978), in a sample of 403 kindergarten and elementary school children, attending public schools, in Greece. The researchers found that the internal consistency was satisfactory while the validity evidence was not adequate. The researchers concluded that the BOTMP-SF may be used with the Greek public school population.

Venetsanou, Kambas, Aggelousis and Fatouros (2006) examined the detection of children with motor problems through: a) the BOTMP-SF and b) BOTMP-LF. The researchers found that 72,2% of students with motor problems were identified with both measuring instruments. However, 27,8% were not detected with the above instruments, suggesting that modifications of the BOTMP-SF scoring system and the evaluation of the BOTMP-LF total score may be necessary. Finally, Wilson, Kaplan, Crawford and Dewey (2000) examined the reliability of the BOTMP-LF. The researchers concluded that there were sufficient evidence of inter rater reliability for children with and without learning, attentional and/ or motor coordination problems.

Procedure

A purposive sampling design was used (Thomas & Nelson, 2003; Grammatopoulou, Skordilis, Koutsouki, 2007; 2008) to select the sample, from public kindergarten and elementary schools. According to Thomas and Nelson (2003) in purposive sampling selection the researcher establishes certain criteria for inclusion in the study and then finds the sample that meets the above criteria. In the present study, the primary researcher initially visited the schools, informed the directors for the purposes of the study and asked for their permission. Accordingly, the researcher visited the classes, informed the teachers and students and asked them to participate. An informed consent was distributed to all students, seeking for the signature of their parents in order to participate in the study.

Accordingly, the examination of the kindergarten and early elementary school students occurred during February and March of 2006. The BOTMP-SF was administered initially, with the active support of the school's physical educator. The five graphomotor skills of the BOTMP-LF (1: cutting out a circle with preferred hand, 2: drawing a line through a crooked path with preferred hand, 3: drawing a line through a curved path with preferred hand, 4: copying a triangle with preferred hand and 5: copying a horizontal diamond with preferred hand) were administered afterwards, with the presence of the teachers.

The students were classified afterwards, according to their BOTMP-SF total scores. Specifically, we used the criterion of Wilson, Kaplan, Crawford and Dewey (2000), and classified the students according to their BOTMP-SF scores in the high, medium and low motor performance groups. Students with a score higher than + one standard deviation from the respective BOTMP-SF mean, constituted the high group ($n_1 = 151$). Students with a score below -1 standard deviation from the respective BOTMP-SF mean constituted the low group ($n_2 = 11$). Finally, students who scored in between $\pm$ 1 standard deviation from the respective mean constituted the average group ($n_3 = 113$). The research objectives were to: a) compare the three groups of students, according to their motor performance (high, average and low), in

the graphomotor skills and b) predict the total graphomotor score from their gross motor skills.

The primary researcher was responsible for: a) the review of literature, with studies using the BOTMP-SF (Bruininks, 1978), b) the communication with the authors and getting their agreement to use the measuring instrument, and finally c) the training of our research team. Accordingly, and based on the demands of the present study, a seminar was organized in the Laboratory of Adapted Physical Activity/ Developmental and Physical Disabilities, in the National and Kapodistrian University of Athens. During the seminar, the primary researcher presented the measuring instrument to the research team and used different examples (from video taping) of assessing kindergarten and early elementary school students. Further, the research team was responsible for informing the teachers and physical educators in the schools selected, concerning the measuring instrument and the evaluation process. Finally, the objectivity was examined in a pilot sample of 20 kindergarten and elementary school students. Specifically, the three members of our research team, under the guidance of the primary researcher, assessed the students and compared their assessment scores. The percentage of agreement among the three researchers was above 80%, confirming this way the objectivity of the pilot assessment (Thomas & Nelson, 2003).

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) (Norusis, 1993) was used to analyze data. Specifically, univariate (ANOVAs) analysis examined the differences among students who were classified to the high, average and low motor performance groups in their graphomotor skills (Tabachnick & Fidell, 2001). Finally, stepwise multiple regression analysis was used to predict the graphomotor performance from the six gross motor items of the BOTMP-SF. The .05 level of significance was selected for statistical analyses.

Results

The differences of students with high, average and low motor performance in graphomotor skills were examined. The values of the three groups (high, medium, low) were standardized in a z scale to minimize the effect of chronological age. The results revealed significant differences between the three groups ($F = 19.726$, $p < .001$, $\eta^2 = .150$). Further, post hoc analysis with the Least Significant Difference-LSD method was used to examine the differences. According to our findings, the high group (Mz = 1.02, SD = .82) had significantly higher score compared to the average group (Mz = .60, SD = .87). Further, the average group scored significantly higher than the low motor performance group (Mz = -.70, SD = 1.51). The above findings are presented in table 3 and figure 1.

Table 3: Analysis of variance examining the differences among students in the high, average and low motor performance groups, on their Graphomotor Skills

Effect	SS	df	MS	F	p
BG	30.283	2	15.111	19.726	.000
WG	171.943	224	.768		
Total	202.225	226			

LSD post hoc test: $X_h > X_{av} > X_{low}$ - SS= sum of squares - df=degree of freedom – MS=Mean square

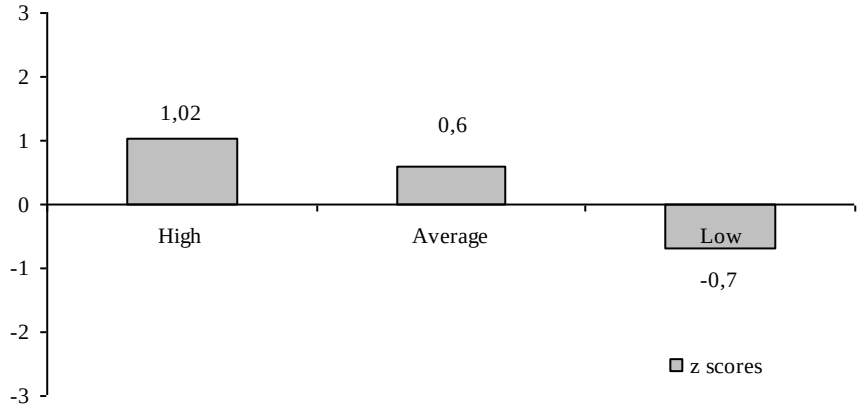

Figure 1. Differences among students in the high, average and low motor performance groups, on their graphomotor skills ($F = 19.726$, $p < .001$, $\eta^2 = .150$) (Mhigh > Maverage & Maverage > Mlow)

A stepwise multiple regression analyses was used to predict the graphomotor performance, from the six gross motor items of our students. The following five gross motor items were significant predictors: a) running speed and agility (beta $_{rsa} = .258$, $p < .001$), b) static balance (beta $_{sb} = .117$, $p < .05$), c) dynamic balance (beta $_{db} = .99$, $p < .05$), d) tapping feet alternative while making circles with fingers (beta $_{tfa} = .154$, $p < .01$) and e) standing broad jump (beta $_{sbj} = .289$, $p < .001$). Only the jumping up and clapping hands item did not significantly predict the graphomotor skills. The respective regression equation, with the unstandardized coefficients was: $Y = 9.121 + .294*Xrsa + .376*Xsb + .373*Xdb + 1.20*X_{tfa} + .538*Xsbj$.

Discussion

Students with high, average and low motor performance differ in their graphomotor skills. Specifically, the highly skilled group scored higher than the average group which, in turn, scored higher than the low motor group. Further, the graphomotor skills are associated with the gross motor skills of kindergarten and early elementary school students. The above findings are in agreement with Jongmans et al. (2003) who claimed that students with motor difficulties may present perceptual motor problems and overall learning disabilities. According to Toth (2000), perceptual motor problems, in turn, may be associated with the student's low graphomotor skills (Toth, 2000). Finally, the prediction of graphomotor performance from the gross motor items is consistent with Karabourniotis et al. (2004) who found that an intervention physical activity programme improved a variety of skills, such as fine perceptual motor skills, in a sample of 45 children from the 'general' population.

The results of the present study are also in agreement with Anagnostatou et al. (1998), Marr et al. (2001), Kambas et al. (2002) and Smits – Engelsman, Wilson, Westernberg and Duysens (2003). Specifically, Anagnostatou et al. (1998) found that the effect of an intervention psychomotor programme in kindergarten students, improved a variety of skills, such as static and dynamic balance, aiming skills, fine motor skills, motor stability and dominant hand use. Anagnostatou et al. (1998) considered that the development of these skills is a prerequisite for the development of writing skills in primary school.

Marr et al. (2001) stated that there is significant relationship between perceptual-motor and graphomotor skills, in children aging from 4 to 7 years old, with and without writing problems. The researchers examined the relationship between cognitive, visual-

motor and graphomotor skills and found significant results. Marr et al. (2001) concluded that a replication study, with students exhibiting writing and speech problems simultaneously, may be necessary in the future.

Kambas et al. (2002) examined the effect of a psychomotor programme in four graphomotor skills (copying circle, triangle, rhombus and pencils). For the purpose of the study the researchers used a sample of 35 kindergarden students, classified to the experimental and control groups. Kambas et al. (2002) found that the programme had a significant positive impact in the graphomotor skills of the experimental group.

The present findings are subjected to certain limitations and may not be generalized without caution. First, our research team was not aware of children diagnosed with either LD, DCD, ADHD, etc (Smits – Engelsman et al., 2003). Smits – Engelsman et al., (2003) stated that learning disabilities and motor problems may be present in children with developmental disabilities, such as DCD. Further, students exhibiting a variety of developmental disabilities, such as LD and ADHD, may differ in their motor performance (Beyer, 1999). In the present study, we only addressed the school administrators for the above reason, but we received no relevant information. Few children however, especially in the low motor performance group, may have experienced some type of developmental disorder, but our research team had no information about that.

Second, our research team was not aware whether students participated in any out-of-school activities which could affect their motor and graphomotor performance. Finally, the present study was conducted in different schools, with the presence of the teachers and physical educators. The primary researcher attempted to control for the above limitation by communicating with parents and staff, explaining the purposes of the study and building a pleasant environment for the children to participate.

Based on the present findings, physical educators and teachers must be aware of the relationship between motor and graphomotor skills. Further, students with low motor performance exhibited low graphomotor skills which may be associated to learning disabilities (Goodway et al. 2003), school failure (Toth, 2000; Buck, 2005), developmental disorders (Wall, McClements, Bouffard, Findlay & Taylor, 1985), delinquency (Koutsouki, 2001), etc. Physical educators, therefore, need to assess students upon entrance into the public schools and identify those with low motor performance which may affect their academic progress. Finally, it may be useful for teachers and physical educators to focus upon the individualized needs of their kindergarten and elementary school children. The above needs will emerge from the assessment, among others, of their motor and graphomotor skills.

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