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ORIGINAL ARTICLE

Assessment of gross and fine motor skills in preschool children using the Peabody Developmental Motor Scales Instrument

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Abstract

The purpose of this study was to identify the motor development level in preschool children through the administration of the Peabody Developmental Motor Scales-2 battery. The field research was conducted to schools and one hundred and fifty-six 3 to 6-year-old children participated in the study. The children's performances were assessed by gender, age group and type of motor skill. The statistical analyses computed showed that the state of the total motor quotient of the children was judged to be satisfactory, with slight differentiations per age group, with the older age-groups performing better than the younger in the fine motor quotient. Furthermore, the girls excelled in locomotion, stationary and visual-motor integration skills and the boys in object manipulation skill. The findings highlight the need for assessment batteries in the planning of suitable programmes for the improvement of children's motor skills.

***Keywords*:** PDMS-2, motor skill assessment, gross and fine motor skills, early childhood

Introduction

In recent decades the scientific community, having realised the major significance of normal motor development for the development of various skills such as cognitive and social skills, particularly in young children (Cools, De Martelaer, Samaey & Andries, 2009), has turned to the systematic assessment of motor skills. Motor ability plays an important role in a child's fundamental skills, because through movement a child can learn and explore the surrounding environment, associate objects with their use in the environment and, in the end, be able to cope in an ever-changing situation (Chien, 2007). Research has shown that assessment of a child's motor skills can help in the identification of problems as much in motor as in more general development (Chien, 2007; Chow, Hsu, Hendersen, Barnett & Lo, 2006; Giagazoglou, 2013; Giagazoglou et al., 2011; Hardy, King, Farrell, Macniven & Howlett, 2010; Saraiva, Rodrigues, Cordovil & Barreiros, 2013).

Assessment of motor skills can be conducted in a number of ways, such as with the use of test batteries. These instruments can detect the level of a child's motor development, making the process of diagnosing problems, and consequently the designing of suitable individual intervention programmes by the therapist, or group-specific interventions by the teacher in the school, easier and more precise (Chow et al., 2006; Connolly et al., 2006; Hardy et al., 2010; McKenzie, Sallis, Nader, Broyles & Nelson, 1992). Each child develops fundamental motor skills at his/her own rate and it is important that the focus of the educational programmes, that concentrate on motor development, is on the needs of each child separately (Gallahue, 1996).

Over the last few years many research studies have been conducted in Greece using assessment batteries, which were standardised abroad, for the measurement of children's motor skills. The only battery for motor skills that has been standardised in Greece was Griffiths II (Griffiths, 1984). The original form of the battery was standardised for the first time in the 1960s for children aged from birth to 2 years old and it was then extended up to the age of 8 (Bedford & Walton, 2013). In Greece it was applied in 2003 with the aim of its standardisation by the research team of Giagazoglou and colleagues (Giagazoglou, Fotiadou, Tsimaras & Aggelopoulou-Sakantami, 2003). More precisely, 930 children were examined and it was discovered that the mean of the developmental indexes for gross and fine motor skills was higher in relation to Griffiths' corresponding sample.

Another battery administrated in Greece was the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP), which was published in the USA for the first time in 1978, and then in revised format in 2005 (Bruininks, 1978; Bruininks & Bruininks, 2005). The BOTMP measures the development of gross and fine motor skills in individuals from 4 to 21 years old. The battery was checked in Greece for its validity and reliability, giving priority to the comparison of the long form (BOTMP-LF) with the corresponding short form (BOTMP-SF). In particular, it was observed that firstly the 27.8% of the children that, according to BOTMP-LF had motor difficulties, were not detected by the BOTMP-SF (Venetsanou, Kambas, Aggelousis & Fatouros, 2006) and secondly that the BOTMP-SF needs to be adapted in order to improve its validity for preschool age children (Venetsanou, Kambas, Aggelousis, Fatouros & Taxildaris, 2009).

The Bayley Scales of Infant Development II (BSID) was published in 1993 (Bayley, 1993) and consists of a series of standardised measurements that concern the assessment of motor (gross and fine motor skills), cognitive and linguistic development of children from birth through their first three years of life. The battery was applied in Greece by the medical community in research that concerned children from 2 to 7.5 years old (Thomaidis et al., 2012), and it showed that children born after a preimplantation genetic diagnosis did not demonstrate differentiations in the average development of their motor skills compared with children in the initial standardised battery sample.

A comparative study (Papadopoulos, Kambas, Christoforidis, Fatouros & Taxildaris, 2007) of motor skills in children between the ages of 4 and 6 in a German kindergarten and children of the same age in a Greek kindergarten was supported by the Karlsruher Motorik-Screening für Kindergartenkinder (KMS 3-6) (Bös, Bappert, Tittlbach & Woll, 2004). The results of the study showed that the children in the German kindergarten presented more developed motor skills in comparison with the Greek children and it highlighted the need for the greater development of motor skills in the Greek kindergarten.

Some other research studies (Giagazoglou et al., 2011; Kourtessis et al., 2008) related to special needs education and the study of motor skills in children with Developmental Coordination Disorder (DCD) were supported by the use of the Motor Assessment Battery for Children (M-ABC), a tool which was published in 1992 in the USA as a diagnostic and educational tool for the identification of the features of the motor functioning of children from 4 to 12 years old (Henderson & Sudgen, 1992). The results from this research highlighted initially the predominance of DCD in children at a rate of 3-22%, while according to the Diagnostic and Statistical Manual-IV the corresponding percentage was estimated to be 5-6% for the overall pupil population (Kourtessis et al., 2008). Then, through a comparison of the data recorded by the researchers in Greece and the data from the original standardisation in the USA, it emerged that the two pieces of research did not have statistically significant differentiations, making the M-ABC a valid tool for application in Greece, something which is in agreement with the research results gathered in other countries (Ellinoudis et al., 2008). Finally, other research showed that the children with conventional/normal development perform better on psychomotor tests than children with DCD, thus confirming the original supposition of the research team that children with DCD present statistically significant differences in their cognitive and motor development in relation to the children without DCD (Asonitou, Koutsouki, Kourtessis & Charitou, 2012).

The Motoriktest für vier-bis sechsjahrige Kinder (MOT 4-6) has been applied in Greece on a number of occasions with the aim of serving various research needs, one of which was to form the basis for the creation of an assessment battery which would exclusively concern the Greek case. The battery was named 'Democritus–Psychomotor Assessment Tool for Preschool Children', and addressed children aged 4 to 6 years old and was created by Kambas, Venetsanou and Aggelousis in 2007. Another research study in Greece using MOT 4-6 revealed that children responded to the requirements of the battery and the intraclass correlation coefficient for test–retest criterion was found to be .87 in Greek conditions, indicating a high reliability of the MOT Test Raw Scores (Kambas et al., 2012). In addition, it highlighted the relationship of age to performance in the battery tests, since the greater the age of the child examined, the greater the scores they noted, while gender did not influence the results since statistically significant differences between boys and girls were not noted. Data gathered using MOT 4-6 in other research confirmed the hypothesis that an intervention programme of a psychomotor nature aimed at the strengthening of coordination skills in preschool age children can help significantly in the prevention of accidents in the space of the kindergarten (Kambas et al., 2004). Finally, the MOT 4-6 was used to confirm the hypothesis that developmentally suitable music positively influences the development of the jumping skill, as well as the skill of dynamic balance in preschool age children (Zachopoulou, Tsapakidou & Derri, 2004).

The Test of Gross Motor Development–2 (TGMD) (Ulrich, 2000) is an instrument that is used for the qualitative assessment of locomotor skills (running, galloping, skipping, continuous jumping, leaping, hopping and side-sliding). In Greece the first edition of TGMD was evaluated by Evaggelinou, Tsigilis and Papa (2002) and it has been used with preschool age children chiefly as a means of assessing the effectiveness of physical education programmes (Deli, Bakle & Zachopoulou, 2006; Tsapakidou, Tsompanaki & Lykesas, 2013). In reference to the above bibliographic search of the assessment batteries that have been applied in Greece, we decided to apply a battery new for Greece, the Peabody Developmental Motor Scales–Second Edition (PDMS-2), which studies the overall motor development in children from birth to 72+ months and is recognized internationally due to its reliability and its validity. The first edition went into circulation in 1983 while in 2000 the second improved version was published (Fewell & Folio, 2000a). Our choice to use PDMS-2 instead of the above-mentioned batteries was based on three main reasons: a) the PDMS-2 is a tool for the evaluation of the motor development of young children which provides separate tests and grading scales as much for the child's gross motor skills as for his/her fine motor skills; b) the standardisation of the battery was carried out with a total of 2003 children in the USA and Canada and constitutes the first battery standardised on a national level; c) it is the only tool to combine evaluation with planned intervention. It provides a planned programme of 104 motor teaching and therapy activities which are organised based on the child's development. The programme can be used to help in the development of skills, provided that first an evaluation of the child's skills based on the battery has been completed (Fewell & Folio, 2000a).

Therefore, the purpose of the present study was the application of PDMS-2 to children aged 3 to 6 years old, within the framework of the school, to identify their motor development level. Within this context, possible differences in the children's performance in various tests/skills according to their gender and age were also detected.

Method

Participants

A total of 156 children with a mean age of 56.26 months (SD=9.01), with normal motor development and who had not been diagnosed with neurological, sensory or motor problems, took part in the study. The sample was made up of 82 boys and 74 girls and they were not distinguished by any particular ethnic characteristics. During the processing of the data, the sample was divided into five groups corresponding to the stratification by age of the PDMS-2: the 1st group from 37 to 42 months, the 2nd group from 43 to 48 months, the 3rd group from 49 to 54 months, the 4th group from 55 to 60 months and the 5th group from 61 to 72 months.

The sample was convenient and all those who participated in the research were, when the assessment took place, pupils at four schools in Achaia Prefecture in Western Greece. They had agreed to take part in the research team's measurements after their parents had been invited to do so, informed and had given their permission, securing the anonymity and protection of the research participants.

Measures

We used the PDMS-2 evaluation battery (Fewell & Folio, 2000a) for the motor assessment of children. The PDMS-2 is a well organised instrument, valid at the level of structural validity, content validity and synchronic validity (Fewell & Folio, 2000a: 53). Regarding internal consistency, it is characterised by its reliability with a Cronbach's alpha coordinate equal to 0.90 in 80% of measurements, 0.80 in 90% of measurements and 0.70 in 100% of measurements (Fewell & Folio, 2000a: 46). A number of research that have been published on the instrument (Cup, Van Hartingsveldt & Ab Oostendorp, 2005; Tieman, Palisano & Sutlive, 2005; Wang, 2004) mention its reliability, its application to special needs children and its application as a tool for the evaluation of the effectiveness of teaching interventions in physical education programmes.

The structure of the PDMS-2 items is based on Harrow's taxonomy of the psychomotor domain (1972) and is divided into six subtests that measure interrelated motor abilities that children develop early in life: reflexes, stationary, locomotion, object manipulation, grasping and visual-motor integration. In the present study the children were graded across five subtests (Table 1) as there was no need to conduct tests in the 'reflexes' category since all the participants were over 11 months old and this category is considered to have been acquired.

Table 1. Items per subtest*

Stationary	sitting, raising to sit, sitting up, kneeling, standing on one foot, standing on tiptoes, imitating movements, sit-ups, push-ups
Locomotion	walking up/down stairs, walking backwards/sideways, running, standing, walking line/on tiptoes, jumping forward/up/down/hurdles/sideways, running speed, jumping forward on one foot, running balance/coordination, hopping, walking line backwards, rolling forward, galloping, turning jump, skipping, hopping speed
Object manipulation	kicking/throwing/catching ball, throwing ball overhand/underhand, hitting target overhand/underhand, bouncing ball, catching bounced ball
Grasping	grasping cubes, grasping marker, buttoning/unbuttoning buttons, touching fingers
Visual-motor integration	building tower/train/bridge/wall/steps/pyramid, snipping with scissors imitating horizontal strokes, stringing beads, folding paper, copying circle/cross/square, cutting paper/line/circle/square, lacing string, dropping pellets, tracing line, connecting dots, coloring between lines

**PDMS-2 (Fewell & Folio, 2000b, Guide to Item Administration)*

The total number of items is 249. Each item includes information on: a) the age at which at least 50% of the normative sample has acquired the skill being examined, b) the complete description of the item, c) the starting position in which the subject should be found before the testing of the exercise begins, d) the testing procedure, e) the illustration of the activity, f) the scoring criteria and g) the materials.

Since the examination of all these items is extremely time-consuming, three restrictions have been created for their selection in relation to the age of the subject: a) the 'entry point' that refers to the suitable age for the execution of an exercise, which is the age where 75% of the standardisation sample successfully completed it, b) the 'basal level', which concerns the last sequence of three consecutive items that are graded with value 2, before the child is graded with another score, and c) the 'ceiling level', which is determined when the subject is graded with a 0 value in three consecutive items.

The criteria for scoring the items were determined by the authors (Fewell & Folio, 2000a) using a three-point scale. The subject is awarded a '2' when he/she performs the item according to the criteria specified for mastery. A '1' corresponds to the subject's performance when it shows a clear resemblance to the item mastery criteria but does not fully meet the criteria. The subject is given a '0' when he/she cannot or will not attempt the item, or the attempt does not show that the skill is emerging.

Procedure

In total 48 visits were made to the schools over nine (9) months. On each visit the space where the item administration was to take place was modified based on the requirements of the battery. For the item administration, the materials recommended by the authors were used and its application was carried out once by each child individually. The child was isolated from the rest of the class and then taken to the modified space for the procedure. Each meeting lasted from 20 to 40 minutes.

Two researchers who had been suitably trained in the use of the battery according to the instructions of its creators took part in the research. To secure that both were scoring the same way, trial measurements with 10 children were conducted. During trial measurements each researcher administered the test five times to five different pupils and at the same time both of them were scoring in different scoring sheets. After each assessment a discussion took place in order to give feedback and to compare scores. No divergences were noted. It is worth noting that the researchers had been suitably trained to create a climate of trust while keeping all the parameters that could influence the behaviour and performance of the children stable, from the modification of the space to their manner of communication with the children.

At the end of all the measurements, the class teachers were informed about the programme of motor activities they could implement in their classroom and extensive discussion took place concerning the importance of the children's motor development.

Statistical Analyses

The processing of the quantitative data that was collected, took place with the use of the SPSS v.21 programme. To interpret the findings, we used the auxiliary tables provided by the battery (Fewell & Folio, 2000a) for the conversion of the raw scores into standard scores and quotient scores (Table 2). The choice of using the subtest standard scores and composite quotients instead of just comparing the initial raw scores was based on the guidelines provided by Fewell and Folio in the Examiner's Manual stating that "standard scores allow examiners to make comparisons across subtests" (2000a: 30), while "raw scores are of little clinical value" (2000a: 29). Finally, the careful use of standard scores and quotients would allow us to investigate where our sample's motor ability stands in comparison to the battery's original standardization sample.

Table 2. Guide to interpreting PDMS-2 Subtest Standard Scores*

Standard Scores	Quotient Scores	Description
17-20	131-165	Very Superior
15-16	121-130	Superior
13-14	111-120	Above Average
8-12	90-110	Average
6-7	80-89	Below Average
4-5	70-79	Poor
1-3	35-69	Very Poor

**PDMS-2 (Fewell & Folio, 2000a, Examiner's Manual, pp. 31,32)*

In order to examine the potential differentiation in the performance of motor skills in relation to the participants' gender, we analysed the data with the independent samples t-test. Finally, we examined the potential differentiation in the performance of motor skills in relation to age group with the One Way Anova (Field, 2013). Post hoc comparisons were performed using the Bonferroni test. The significance threshold was set at .05. Finally, in order to determine the effect size in each case the η^2 coefficient was measured. According to Cohen (1988) coefficients η^2 at least .14, are considered sufficiently large to be of any importance.

Results

According to the PDMS-2 Examiner's Manual (Table 2), the children's performance meets at least the *average* level (i.e. a satisfactory level of motor skills) when:

- the mean value of the standard scores in the five subtests of motor skills (stationary, locomotion, object manipulation, grasping, visual-motor integration) reaches at least the value of 8,
- the mean value of the quotient scores in gross motor quotient (GMQ), fine motor quotient (FMQ) and total motor quotient (TMQ) reaches at least the value of 90.

In relation to these criteria, and as is apparent from the data in Table 3 and specifically the indicators for the mean value (M), the mean performances of the participant children in the standard scores, as well as in the quotient scores, were judged to be *satisfactory* because they reached the average level.

Table 3. Results for the subtests and the composites across the whole sample (N=156)

	Mean	SD	CI 95%	
Standard Score Stationary*	9.51	1.79	9.22	9.79
Standard Score Locomotion*	9.56	1.56	9.32	9.81
Standard Score Object Manipulation*	9.86	1.34	9.65	10.07
Standard Score Grasping*	11.12	1.59	10.86	11.37
Standard Score Visual Motor Integration*	11.46	2.10	11.12	11.79
Gross Motor Quotients**	97.92	8.15	96.63	99.21
Fine Motor Quotients **	107.38	9.15	105.93	108.83
Total Motor Quotients **	101.72	9.33	100.25	103.20

* min:1 max:20, ** min:35 max:165

Differentiation of the children based on gender

The girls seemed to score higher performances on the stationary subtest compared with the boys and this differentiation was statistically significant (Table 4). Concerning the locomotion subtest, a statistically significant difference in the children's performance was observed, with the girls performing better than the boys. The opposite was observed in the object manipulation subtest, since the boys demonstrated statistically significantly higher performances compared with the girls. In the grasping subtest, no statistically significant differences between boys and girls were noted. In this case, to check the difference, we accepted Levene's correction (Field, 2013). In addition, with reference to the visual-motor integration subtest, the girls appeared to show statistically significantly higher performances than the boys. However, we underline that these differentiations do not seem to be strong, according with the threshold of .14 for the η^2 coefficient.

The results related to the degree of differentiation in performance of the two genders showed that there was no statistically significant differentiation between boys and girls as far as GMQ is concerned (Table 4). The same seems to be true for TMQ. However, a statistically significant differentiation in the children's FMQ was observed with the girls doing better than the boys. In this case, to check the difference we accepted Levene's correction.

Table 4. Means, standard deviations and students' test values for each motor skill by gender (Boys: 82 & Girls: 74)

	Boys	Girls	t	p	η^2
Standard Score Stationary*	9.10 ± 1.83	9.96 ± 1.65	-3.07	0.003	0.058
Standard Score Locomotion*	9.28±1.39	9.88±1.68	-2.42	0.017	0.037
Standard Score Object Manipulation*	10.10±1.31	9.59±1.33	2.37	0.019	0.035
Standard Score Grasping*	10.93±1.87	11.32±1.19	-1.59	0.113	0.016
Standard Score Visual Motor Integration*	10.94±2.14	12.03±1.92	-3.32	0.001	0.067
Gross Motor Quotients **	97.16± 8.04	98.77± 8.25	-1.23	0.219	0.010
Fine Motor Quotients**	105.09±9.96	109.92±7.42	-3.45	0.001	0.070
Total Motor Quotients **	100.80±8.55	102.74±10.09	-1.29	0.196	0.011

* min:1 max:20, ** min:35 max:165

Differentiation of the children based on age group

The sample was divided into 5 groups corresponding to the age stratification of the battery. Table 5 presents the mean values, the standard deviation and the 95% confidence intervals for the standard scores and the quotient scores of the subtests and composites, respectively, per age group.

Statistically significant differences were observed among the age groups, regarding the stationary subtest [$F(4,151)=4.806$, $p=0.001$, $\eta^2=0.113$]. The confidence intervals with the lowest values belonged to the youngest (37-42 months) and the oldest age group (61-72 months), suggesting that these two groups were lacking in the development of this skill, when compared to the other age groups. Specifically, the Bonferroni multiple comparisons test showed statistically significantly lower measurements of the 37-42 and 61-72 age groups against the 49-54 age group.

Concerning the locomotion subtest, statistically significant differences were also observed, depending on the age group of the children [$F(4,151)=7.985$, $p=0.001$, $\eta^2=0.175$]. When comparing the confidence intervals of the age groups, it looked like the oldest age group (61-72 months) lacked in performance in comparison to the other age groups. The Bonferroni multiple comparisons test showed statistically significantly lower measurements of the 61-72 age group against the 43-48, 49-54 and 55-60 age groups.

Concerning the object manipulation subtest, again statistically significant differences were observed in relation to the age group of the children [$F(4,151)=6.435$, $p=0.001$, $\eta^2=0.146$]. In particular, when comparing the confidence intervals of the age groups it was noted that the two youngest age groups (37-42 and 43-48 months) delivered a higher performance in this motor skill compared with the older age groups. The Bonferroni test showed statistically significantly lower measurements of the 55-60 and 61-72 age groups against the 37-42 and 43-48 age groups.

Table 5. Means, standard deviations and 95% confidence interval for each motor skill per age group

Skills	Age (Months)	N	M	S.D.	CI 95%	
Standard Score Stationary*	37-42	14	8.64	1.906	7.54	9.74
	43-48	17	9.41	2.033	8.37	10.46
	49-54	36	10.53	1.89	9.89	11.17
	55-60	32	9.47	1.545	8.91	10.03
	61-72	57	9.12	1.536	8.72	9.53
Standard Score Locomotion*	37-42	14	9.29	1.684	8.31	10.26
	43-48	17	10.18	1.468	9.42	10.93
	49-54	36	10.33	1.394	9.86	10.8
	55-60	32	9.88	1.338	9.39	10.36
	61-72	57	8.79	1.448	8.41	9.17
Standard Score Object Manipulation*	37-42	14	10.71	0.726	10.29	11.13
	43-48	17	10.82	1.131	10.24	11.41
	49-54	36	9.97	1.32	9.53	10.42
	55-60	32	9.28	1.326	8.8	9.76
	61-72	57	9.61	1.306	9.27	9.96
Standard Score Grasping*	37-42	14	8.93	2.056	7.74	10.12
	43-48	17	11.18	2.921	9.67	12.68
	49-54	36	11.61	1.573	11.08	12.14
	55-60	32	11.69	0.965	11.34	12.04
	61-72	57	11	0	11	11
Standard Score Visual Motor Integration*	37-42	14	9.5	1.557	8.6	10.4
	43-48	17	10.29	2.085	9.22	11.37
	49-54	36	12.06	1.897	11.41	12.7
	55-60	32	12	1.814	11.35	12.65
	61-72	57	11.6	2.154	11.03	12.17
Gross Motor Quotients**	37-42	14	97.07	7.869	92.53	101.61
	43-48	17	100.94	8.074	96.79	105.09
	49-54	36	101.89	7.84	99.24	104.54
	55-60	32	98	8.215	95.04	100.96
	61-72	57	94.68	7.189	92.78	96.59
Fine Motor Quotients**	37-42	14	95.29	7.966	90.69	99.88
	43-48	17	104.12	13.407	97.22	111.01
	49-54	36	111.06	8.085	108.32	113.79
	55-60	32	109.69	7.515	106.98	112.4
	61-72	57	107.7	6.478	105.98	109.42
Total Motor Quotients**	37-42	14	95.79	8.059	91.13	100.44
	43-48	17	101.53	8.931	96.94	106.12
	49-54	36	107	9.159	103.9	110.1
	55-60	32	103.06	4.812	101.33	104.8
	61-72	57	99.16	10.178	96.46	101.86

*min:1 max:20, ** min:35 max:165

Additionally, statistically significant differences occurred regarding the grasping subtest among the age groups [$F(4,151)=10.715$, $p=0.001$, $\eta^2=0.221$]. The comparison of the confidence intervals, as also the Bonferroni test, showed that the youngest age group (37-42 months) did not perform as well as the other age groups. The oldest age group (61-72 months) presented a stable and high performance, suggesting that all the participants of this age group had successfully completed the development of the grasping subtest.

Finally, the visual-motor integration subtest also presented statistically significant differences among the age groups [$F(4,151)=6.416$, $p=0.001$, $\eta^2=0.145$]. Notably, the confidence intervals of the two youngest age groups (37-42 and 43-48 months) suggested that they did not perform as well as the other age groups at this particular motor skill. The Bonferroni test similarly showed statistically significantly lower measurements of the 37-42 age group against the 49-54, 55-60 and 61-72 age groups and statistically significantly lower measurements of the 43-48 age group against the 49-54 and 55-60 age groups.

In regards to the quotient scores of the children examined and starting with the GMQ [$F(4,151)=5.585$, $p=0.001$, $\eta^2=0.129$], a comparison of the confidence intervals showed that the oldest age group (61-72 months) delivered the lowest performance. Furthermore, the Bonferroni test showed statistically significantly lower measurements of the 61-72 age group against the 43-48 and 49-54 age groups. Concerning the FMQ [$F(4,151)=10.818$, $p=0.001$, $\eta^2=0.223$], a confidence interval comparison showed that the children belonging to the age group 49-54 months scored the highest quotients and at the same time the children of the youngest age group (37-42 months) scored the lowest quotients. The Bonferroni test showed statistically significantly lower measurements of the 37-42 age group against all the other age groups and statistically significantly lower measurements of the 43-48 age group against the 49-54 age group. When comparing the TMQ confidence intervals of the age groups [$F(4,151)=6.291$, $p=0.001$, $\eta^2=0.143$], it was observed that the children of both the youngest (37-42 months) and the oldest (61-72 months) age group scored the lowest quotients. Specifically, the Bonferroni test showed statistically significantly higher measurements of the 49-54 age group against the 37-42 and 61-72 age-groups. Finally, we underline that the differentiations in the measurements for Stationary and GMQ per age group did not appear to be strong, according to the threshold .14 for the η^2 coefficient.

Discussion

The research results provided useful data as much for the state of the children's motricity that was judged satisfactory, as for the categorisations that emerged according to the particular features of the sample. The gender of the participants seems to explain their performance. The data reveals the faster development of the girls in hand related skills, like visual-motor integration. Moreover, the girls seem to have refined to a greater degree both their stationary skills, like balance, and their locomotor skills, like hopping, galloping, skipping, jumping, and so on. In contrast, the boys seem more skilled in items to do with the manipulation of objects, like kicking, throwing or catching a ball. These results are in agreement with other similar research that supports the superiority of the two genders in corresponding skills (Breslin et al., 2012; Engel-Yeger et al., 2010; Fisher et al., 2005; Foulkes et al., 2015; Giagazoglou, 2013; Giagazoglou et al., 2011; Hardy et al., 2010; Kourtessis et al., 2008; Livesey et al., 2007).

An important factor that may influence the children's motor development is their involvement in physical activities (Vale, Silva, Santos, Soares-Miranda & Mota, 2010; Williams et al., 2008). The kind of activity and the games the children take part in, determine the motor skills that will develop more rapidly (Giagazoglou, 2013; Giagazoglou et al., 2011; Hardy et al., 2010). This type is not related only to the skills of motor development, but also to social factors. In many societies certain stereotyped perceptions are created on the roles the two genders have in society. Something like this, consequently, influences the kind of games that are acceptable for each gender. In a number of cases, intense physical activity is indicated only for the boys while the girls are not encouraged even by the close family environment (Livesey et al., 2007; Spessato et al., 2012). This means that we separate the kind of exercise in which children become involved based on their gender (Kourtessis et al., 2008; Saraiva et al., 2013). This is often confirmed since girls generally choose aerobic gymnastics, dance, and activities like drawing. Boys prefer team sports, using a ball, like football or basketball (Frömel et al., 2008). These results may be related to the different temperament of the two sexes. Per Giagazoglou et al. (2011), the temperament of the boys promotes a more spontaneous, informal, playful and physically active conduct. In contrast, the girls are not so spontaneous, since they think more before acting and devote more time to the processing of the choices they have available to them for exercise, and as a result they usually choose games like drawing, crafts or dolls (Giagazoglou, 2013; Zachopoulou & Makri, 2005).

Finally, the absence of differences in these ages between the two genders in TMQ (Mboy=100.80, Mgirl=102.74, see TMQ for the two sexes, Table 4), seems to be in agreement with the corresponding literature. Body development until the first years of puberty is the same for the two genders (Livesey et al., 2007; Spessato et al., 2012) as boys and girls have a similar height, weight and build (Cratty, 1994). In addition, according to Cleland and Gallahue (1993), boys and girls have common experiences from the age of 4 to 8 and there are no great differences in their motor development. Saraiva et al.'s research (2013) also supports the absence of statistically significant differences between the two genders in total motor quotient while Venetsanou and Kambas (2016) conclude that the motor proficiency of the two genders in early childhood can be characterised as similar rather than different.

Bearing in mind that the research participants' raw scores were processed and converted into standard scores/quotients based on the battery's weighting, the highest scores were not observed in our initial measurements but in the standard scores/quotients. When examining the motor development of each age group, it becomes evident that the oldest children experience difficulty with activities that have to do with gross motor skills and especially with the stationary and locomotion skills. At the same time, these children present the highest performances at the fine motor skills (grasping and visual-motor integration). Especially with grasping skills, the oldest age group (61-72 months) delivered perfect scores, suggesting that by the time of the assessment they had already perfected the development of the skill in question. On the other hand, the youngest children obtained higher scores at the gross motor skills and especially at the object-manipulation subtest. A third observation can be made here concerning the fact that although all age groups, respectively, have performed at a satisfactory level, none of them managed to surpass it. In regards to the TMQ of the children, the lowest scores for motor development were recorded by the youngest (37-42 months) and the oldest (61-72 months) age group. The lower scores of the older children in GMQ and TMQ are in contrast to the results of other research studies that refer to the same age group (Engel-Yeger et al., 2010; Giagazoglou, 2011; Livesey et al., 2007; Saraiva et al., 2013; Zachopoulou & Makri, 2005), which claim that older children are expected to display greater control and gradual refinement of their movements.

With reference to the differentiation depending on age, one possible explanation could be that as children grow they adopt a more sedentary way of life (Janz et al., 2002, as cited in Tersi et al., 2008). In addition, the Kindergarten curriculum in Greece places a lot of emphasis on cognitive subjects, with the aim of preparing children for primary school, and less on their motor development. This may also explain the higher scores of older children in FMQ.

During the research, the children were particularly receptive to the whole testing process, as they seemed to have fun doing the organised motor activities, and indeed to long for them due to their restricted application, as their teachers informed us. The data which emerged from the application of the PDMS-2 assessment battery to preschool children in Greece, offers certain indications as far as its improvement is concerned and its further application and standardisation in the future in the Greek context.

Some research poses the question of the creation of two different norms related to motor skills depending on the gender of the child (Livesey et al., 2007; Saraiva et al., 2013; Van Waelvelde, Peersman, Lenoir, Smits Engelsman & Henderson, 2008), because they believe that the boys develop different motor skills more quickly than the girls. However, the present research does not support such a statement, since whatever differentiations emerged were probably the result of social rather than biological factors. For this reason, it is important that the examiner gather information from the teachers and parents so as to have a fuller picture of the children's motor development. From the application of the battery the significance of the presence of two examiners emerged for the more objective gathering of data. While the first examiner records the performance, the second is in direct contact with the child, encouraging him or her and making him or her feel at ease, so he/she can perform to the best of his/her abilities.

Finally, we should point out that the use of standardised assessment batteries in the field of education does not only help in the diagnosis of problems, but chiefly in the planning of suitable programmes and teaching interventions for the improvement of the motor skills of all children and they can therefore constitute a valuable tool in the hands of teachers.

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