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Motor profile of Portuguese preschool children on the Peabody Developmental Motor Scales-2: A cross-cultural study

Linda Saraiva [a,b,d,*], Luís P. Rodrigues [c,e,1], Rita Cordovil [a,d,2], João Barreiros [a,d,2]

[a] Faculdade de Motricidade Humana, Universidade Técnica de Lisboa, Cruz Quebrada, Portugal
[b] Escola Superior de Educação do Instituto Politécnico de Viana do Castelo, Portugal
[c] Escola Superior de Desporto e Lazer do Instituto Politécnico de Viana do Castelo, Melgaço, Portugal
[d] Centro Interdisciplinar para o Estudo da Performance Humana (CIPER/FMH-UTL), Portugal
[e] Centro de Investigação em Saúde, Desporto e Desenvolvimento Humano (CIDESD), Portugal

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ABSTRACT

This study was designed to examine the cultural sensitivity of the PDMS-2 for Portuguese preschool children aged 36–71 months. A total of 540 children (255 males and 285 females) from 15 public preschools of Viana do Castelo, Portugal, were assessed. Age and gender effects in motor performance were examined. Results indicated that PDMS-2 is valid instrument to differentiate Portuguese age groups. Girls presented higher scores than boys in the Grasping and Visuo-motor integration subtests and lower scores in the Object Manipulation subtest. Portuguese preschoolers performed above US norms on Grasping, Visual-motor integration, and Stationary subtests, and bellow on Locomotion and Object Manipulation subtests. Overall, Portuguese children showed better results on the Fine Motor Quotient comparing to the Gross Motor Quotient. These results underline different motor development profiles between Portuguese and American children.

1. Introduction

It is well recognized that development and learning of fine and gross motor skills during early childhood is of paramount relevance for child's overall development (Piek, Hands, & Licari, 2012). Mastery of these motor skills represents an important prerequisite for activities of daily living (e.g., dressing, writing, cutting, playing) (Liberman, Ratzon, & Bart, 2013; Summers, Larkin, & Dewey, 2008), as well as for participation in many types of physical activity during the school-age and throughout the lifespan (Barnett, Beurden, Morgan, Brooks, & Beard, 2009; Cairney, Kwan, Hay, & Faught, 2012; Magalhães, Cardoso, & Missiuna, 2011; Okely, Booth, & Patterson, 2001).

On this issue, recent systematic reviews show that motor competence is linked with physical activity and fitness outcomes (Lubans, Morgan, Cliff, Barnett, & Okely, 2010; Rivilis et al., 2011). Children with low motor competence are generally less physically active and have an increased risk for obesity and cardiorespiratory disease. Although the

* Corresponding author at: Escola Superior de Educação do Instituto Politécnico de Viana do Castelo, Avenida Capitão Gaspar de Castro, Apartado 513, 4901-908 Viana do Castelo, Portugal. Tel.: +351 258806200.
E-mail addresses: lindasaraiva@ese.ipvc.pt, lindambsaraiva@gmail.com (L. Saraiva), lprodrigues@esdl.ipvc.pt (L.P. Rodrigues), ritacordovil@fmh.utl.pt (R. Cordovil), jbarreiros@fmh.utl.pt (J. Barreiros).
[1] Tel.: +351 258 809 678.
[2] Tel.: +351 21 4149249.

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impact of low motor competence on health may not be detected during early childhood, there are strong reasons to predict that children with low competence in early years tend to keep this trend in later stages of development (Gabbard, 2008). Other studies report that these children have additional difficulties in academic performance (e.g., Alloway, 2007; Lingam et al., 2010; Tseng, Howe, Chuang, & Hsieh, 2007), attention (e.g., Lingam et al., 2010; Tseng et al., 2007), emotional aspects (e.g., Emck, Bosscher, Beek, & Doreleijers, 2009; Piek, Baynam, & Barrett, 2006; Rigoli, Piek, & Kane, 2012) and social skills (e.g., Lingam et al., 2010; Skinner & Piek, 2001), which can persist into adolescence and adulthood (e.g., Piek, Barrett, Smith, Rigoli, & Gasson, 2010; Piek, Dawson, Smith, & Gasson, 2008). It is clear that prevention or reduction of these negative effects is dependent on the early identification of motor impairment, and timely intervention. However, effectiveness of this process requires reliable and valid assessment tools specifically designed to able to identify motor problems, even in minor disorders such Developmental Coordination Disorder (DCD).

Among several motor assessment tools available in literature, the Peabody Developmental Motor Scales – second edition (PDMS-2) (Folio & Fewell, 2000) is one of the most widely used instruments in clinical and research settings (Cools, De Martelaer, Samaey, & Andries, 2009; Piek et al., 2012; Slater, Hillier, & Civetta, 2010; Tieman, Palasino, & Sutlive, 2005).

The PDMS-2 is a norm-referenced tool and was designed to assess the fine and gross motor skills of children from birth through 71 months of age. Its normative sample was based on 2003 children residing in forty-six states of the United States and one Canadian province.

According to Folio and Fewell (2000), the second edition of PDMS provides five principal uses: to estimate a child's motor competence in comparison to peers; to identify relative differences within gross and fine motor development; to establish individual goals and objectives for therapy or educational intervention; to monitor the child's individual progress; and to be used as a research tool.

In fact, over last decade the PDMS-2 has been used in several studies to evaluate motor profile of children with typical development (e.g., Darrah, Magill-Evans, Volden, Hodge, & Kembhavi, 2007; Eldred & Darrah, 2010), as well as children with different developmental condition such as developmental coordination disorders (DCD) (Liberman et al., 2013), cerebral palsy (Wang, Liao, & Hsieh, 2006), autism spectrum disorders (ADS) (Provost, Heimerl &, Lopez 2007), and intellectual disabilities (Dusing, Thorpe, Rosenberg, Mercer, & Escolar, 2006; Maring & Courcelle-Carter, 2004). Other studies have applied the PDMS-2 to determinate biological and environmental effects on children's motor development, such as prematurity degree (e.g., Lee, Chow, Ma, Ho, & Shek, 2004; Snider, Majnemer, Mazer, Campbell, & Bos, 2009; Wang, Howe, Hinojosa, & Weinberg, 2011), obesity (Nervik, Martin, Runquist & Cleland, 2011), family environment (Osorio, Torres-Sánchez, Hernández, López-Carrillo, & Schnaas, 2010; Santos et al., 2009) and the effectiveness of intervention programmes (e.g., Chen et al., 2007; Cope, Forst, Bibis, & Liu, 2008; Lin et al., 2011; Wang, 2004).

The test's acceptability amongst the scientific community is in part due to its composite structure that allows a multidimensional interpretation of motor development. The test is composed of six motor subtests: reflexes, stationary, locomotion, object manipulation, grasping, and visual-motor integration. These subtests allow estimating three global indexes of motor performance called composites: Fine Motor Quotient (FMQ), Gross Motor Quotient (GMQ) and Total Motor Quotient (TMQ). Empirical evidence of its validity (content, criterion, construct) and reliability (content sampling, time sampling and interscorer differences) are detailed in PDMS-2 test manual (Folio & Fewell, 2000). Briefly, the test's authors report a good internal consistency for each subtest ($\alpha = 0.89–0.95$) and for each motor quotient ($\alpha = 0.96–0.97$); acceptable test-retest reliability ($r = 0.73–0.96$ depending on the age group); and a high inter-rater reliability varying between 0.97 and 0.99 for each subtest and between 0.96 and 0.98 for the motor quotients. In what respects the criterion validity, the PDMS-2 has a high correlation with the original version ($r = 0.84$ and 0.91 respectively for GMQ and FMQ) and with the Mullen Scales of Early Learning ($r = 0.86$ and 0.80 respectively for GMQ and FMQ). Lastly, Folio and Fewell (2000) report that the test's construct validity was established by confirmatory factor analysis. The validity of PDMS-2 in different groups of individuals (males, females, European Americans, African Americans, Hispanic Americans, as well as children with physical handicap and children with mental retardation) was also confirmed.

Despite these evidences, one question remains: is PDMS-2 tool considered a valid and reliable discriminative measure to evaluate children's motor performance from a different cultural background of the normative sample? Previous cross-cultural studies (Cohen et al., 1999; Crowe, Mcclain & Provost, 1999; Tripathi, Joshua, Kotian, & Tedla, 2008) warn that the interpretation of test results should be performed with caution when assessing children of different cultural background. For instance, Crowe et al. (1999) found that Native American children scored significantly lower than the normative sample in the Peabody Fine Motor Developmental, and when gender was taken into consideration, older girls (30–35 months) had significantly lower scores. In other study, Tripathi et al. (2008) concluded that Indian children scored better on gross motor scale than on fine motor. Depending on the motor subtest and age group, significant differences were also found between Indian children and the PDMS-2 normative sample. These results reinforce that the cultural and regional relevance of the PDMS-2 must be examined before its use.

To our knowledge and to date, there is no evidence concerning suitability (regional relevance) of PDMS-2 for Portuguese children. Therefore, the purposes of this study were: (1) to examine the cultural sensitivity (regional relevance) of the scales for a sample of Portuguese children aged 36–71 months; (2) to analyze the age and sex effects on children's motor performance; (3) to characterize and compare the motor performance of Portuguese preschoolers with the US norms.

2. Methods

2.1. Participants

A convenience sample of 540 typically developing children (255 males and 285 females), aged between three and five years (mean age 53.5 ± 10.7) was recruited from fifteen public preschools located in district of Viana do Castelo, Northwest Portugal. The parents or legal guardians of the preschool children were informed about testing procedures, and corresponding written consent was obtained. Children included in the study met the following criteria: age between 36 and 71 months, absence of any known intellectual, physical or emotional disabilities, as well as without special educational needs as proven by records of special education teams. The identification of children with special needs is a standard procedure in the Portuguese educational system.

The sample was divided in three age groups according to the PDMS-2 age categories: three-year-olds (36–47 months, $n = 162$), four-year-olds (48–59 months, $n = 189$) and five-year-olds (60–71 months, $n = 189$). Child's birth related information and socio-demographic data was based on school records. Overall, the sample exhibited a balanced ratio of the participants according to sex (47% boys and 53% girls) and age (3 years: 30%; 4 years: 35%; 5 years: 35%). The children's parents had different education levels: middle school (35%), high school (33%), and college (32%).

2.2. Peabody Developmental Motor scales-2 (PDMS-2)

Prior to this study, the original PDMS-2 was translated to Portuguese, and its construct validity and reliability was confirmed for Portuguese preschoolers (Saraiva, Rodrigues, & Barreiros, 2011). All PDMS-2 subtests showed good internal consistency (Cronbach's alpha = 0.76–0.95) and good test-retest reliability (intraclass correlation coefficient = 0.85–0.95). The results of the confirmatory factor analysis (Satorra-Bentler $\chi^2 = 3.3$, $p = 0.349$; CFI = 1.0, NFI = 0.99, NNFI = 0.99, RMSEA = 0.013) support that the Portuguese version displays the same construct and number of items as the original PDMS-2 (Folio & Fewell, 2000).

This assessment tool is composed of six motor subtests: Reflexes (for children from birth to 11 months, 8 items), Stationary (ability to sustain control of the body within its center of gravity, 30 items), Locomotion (ability to move from one place to another, 89 items), Object manipulation (ability to manipulate balls by children with 12 months of age or older, 24 items), Grasping (ability to use hands, 24 items), and Visual-motor integration (ability to use visual perceptual skills to perform complex eye-hand coordination tasks, 72 items). Each motor subtest item is scored using a three-point rating scale (0, 1, or 2). The sum of the individual items within each subtest (raw score) can be converted to age equivalent, percentiles and standard scores. Standard scores of each subtest can then be summed and converted into three global indexes of motor performance (composites): Fine, Gross and Total Motor Quotients. The FMQ is calculated by adding 2 subtests: Grasping and Visual-Motor Integration, while the GMQ results from three other subtests: Stationary, Locomotion and Object Manipulation (the latter is substituted by the reflexes subtest for children from birth to 11 months). The Total Motor Quotient (TMQ) is determined by a combination of the gross and fine motor subtests results.

2.3. Procedures

Prior to data collection, informed consent was obtained from the school administration, classroom educators and parents or legal guardians of the children.

The PDMS-2 was administered according to manual guidelines (Folio & Fewell, 2000) by two researchers, who were specifically trained, and achieved an inter-rater agreement for the item scores of 90% before data collection. Each child was individually tested in a quiet area of the school. Depending on the child's age, the assessment duration ranged from 45 to 60 min. Taking account that young children's concentration is very short, each motor subtest of the scales were administered at different times within a 5-day period. The data collection was videotaped for later observation and scoring. For this study, the raw scores of Grasping, Visual-Motor Integration, Stationary, Locomotion and Object manipulation subtests were converted to standard scores. Then, z-scores for all motor subtests and Fine, Gross and Total quotients were calculated, according to the normative data provided in PDMS-2 manual.

The study protocol was approved by the Faculty of Human Kinetics (Technical University of Lisbon, Portugal) Ethics Committee.

2.4. Data analysis

Descriptive statistics (frequencies, means and standard deviations) were calculated to characterize the motor performance of the Portuguese sample on all PDMS-2 motor subtests by age and sex groups. The Welch's ANOVA followed by Dunnett's C post hoc test was used to examine the differences on motor performance among age groups because the homogeneity of variance assumption was violated. The Student's *t*-test was calculated to examine the differences on motor performance between Portuguese boys and girls at each age group. For cross-cultural comparison between Portuguese and US children, the mean *z*-score and respective standard deviations of all motor subtests and quotients for each age group were calculated. Further, a comparison of *z*-score mean with the zero mean reference value was carried out using the Student's *t*-test. The level of significance was set at 0.05 for all statistical tests. In addition, Cohen's *d* measure of effect size was calculated. Effect sizes of <0.5, 0.5–0.8, and > 0.8 were interpreted as small, moderate, and large, respectively (Cohen, 1988). Statistical analyses were performed using the SPSS 19.0 and GraphPad software.

3. Results

3.1. Motor performance of a Portuguese sample on PDMS-2 subtests

Table 1 presents the means and standard deviations of the raw scores on each PDMS-2 subtest by age group.

Analysis of variance showed a main effect of age on all PDMS-2 subtests (minimum Welch's $F = 74.1$, $p < 0.001$) listed in Table 1. As expected, the mean raw scores for each motor subtest increased throughout the age group and Dunnett's C post hoc test confirmed that those increments are significant (p's < 0.001 for all comparisons).

Table 1
Mean raw scores and standard deviations ($M \pm SD$) for each PDMS-2 subtest by age group.

Subtests[a]	3 years (n = 162)	4 years (n = 189)	5 years (n = 189)	Welch's F	Post hoc
Grasping	48.8 ± 2.6	50.9 ± 1.4	51.4 ± 1.0	74.1***	3 years < 4 years < 5 years
Visual-motor integration	123.6 ± 7.0	136.1 ± 5.5	140.5 ± 3.5	387.0***	3 years < 4 years < 5 years
Stationary	48.1 ± 4.2	53.9 ± 3.4	57.2 ± 2.8	280.9***	3 years < 4 years < 5 years
Locomotion	144.5 ± 9.9	160.1 ± 8.3	170.0 ± 5.8	432.6***	3 years < 4 years < 5 years
Object manipulation	29.2 ± 5.6	34.6 ± 6.0	39.7 ± 5.1	165.4***	3 years < 4 years < 5 years

*** $p < 0.001$.
[a] Grasping score (range 0–52); Visual-Motor Integration score (range 0–144); Stationary score (range 0–60); Locomotion score (range 0–178); Object manipulation score (range 0–48).

3.2. Comparison between boys and girls of Portuguese sample

Significant differences were found between girls' and boys' performance in Grasping, Visual-motor integration and Object Manipulation subtests (see Table 2). Girls presented a better performance on: (i) Grasping subtest (3 years: $p < 0.001$, $d = -0.75$; 4 years: $p < 0.001$, $d = -0.55$; 5 years: $p = 0.030$, $d = -0.32$); (ii) Visual-motor integration subtest (3 years: $p = 0.005$, $d = -0.45$; 4 years: $p = 0.020$, $d = -0.35$). Boys showed higher scores on: (i) Object Manipulation subtest (3 years: $p < 0.001$, $d = 0.54$; 4 years: $p < 0.001$, $d = 0.64$; 5 years: $p < 0.001$, $d = 0.86$). No differentiation between sexes was found on Stationary and Locomotion subtests at any age group, neither on Visual Motor Integration in the five-year-old age group.

Table 2
Mean raw scores and standard deviations ($M \pm SD$) for each PDMS-2 subtest by sex and age group.

Subtest[a]	3 years			4 years			5 years		
	Boys (n = 84)	Girls (n = 78)	t	Boys (n = 84)	Girls (n = 105)	t	Boys (n = 87)	Girls (n = 102)	t
Grasping	47.9 ± 2.8	49.7 ± 2.0	−4.70***	50.5 ± 1.7	51.3 ± 1.0	−3.69***	51.2 ± 1.2	51.6 ± 0.8	−2.19*
Visual-motor integration	122.1± 6.5	125.2 ± 7.3	−2.81*	135.1 ± 5.7	137.0 ± 5.2	−2.34*	139.9 ± 4.1	140.9 ± 2.8	−1.97
Stationary	47.6 ± 4.4	48.7 ± 4.0	−1.77	53.6 ± 3.8	54.2 ± 3.1	−1.30	57.2 ± 3.2	57.2 ± 2.4	0.01
Locomotion	145.6 ± 10.7	143.2 ± 8.9	1.52	159.3 ± 9.1	160.7 ± 7.7	−1.12	170.2 ± 5.7	169.9 ± 5.9	0.37
Object manipulation	30.6 ± 6.1	27.7 ± 4.6	3.43***	36.6 ± 6.2	32.9 ± 5.4	4.33***	41.8 ± 4.5	37.8 ± 4.8	5.85***

* $p < 0.05$.
*** $p \leq 0.001$.
[a] Grasping score (range 0–52); Visual-Motor Integration score (range 0–144); Stationary score (range 0–60); Locomotion score (range 0–178); Object manipulation score (range 0–48).

3.3. Comparison between the Portuguese sample and US normative sample

Figs. 1 and 2 illustrate the comparison of motor performance between the Portuguese sample and US normative sample, using z-scores.

Table 3 presents the results of the comparison tests between the Portuguese and US samples on motor subtests and motor quotients.

Data presented in Table 3 indicate that Portuguese preschoolers performed significantly better than their US peers on Grasping in the three and four-year-old age groups (all p's < 0.001); on Visual-Motor Integration in all age groups (all p's ≤ 0.014); and, also on Stationary subtest in the three and four-year-old age groups (all p's < 0.001). Conversely, the Portuguese children performed significantly lower on Locomotion subtest (all p's ≤ 0.026), and Object Manipulation subtest (all p's < 0.001) in all age groups. It is important to note that the effect size of the differences was moderate to large on Grasping (3 years), Visual-motor integration (4 years and 5 years) and Object Manipulation subtest (all age-groups).

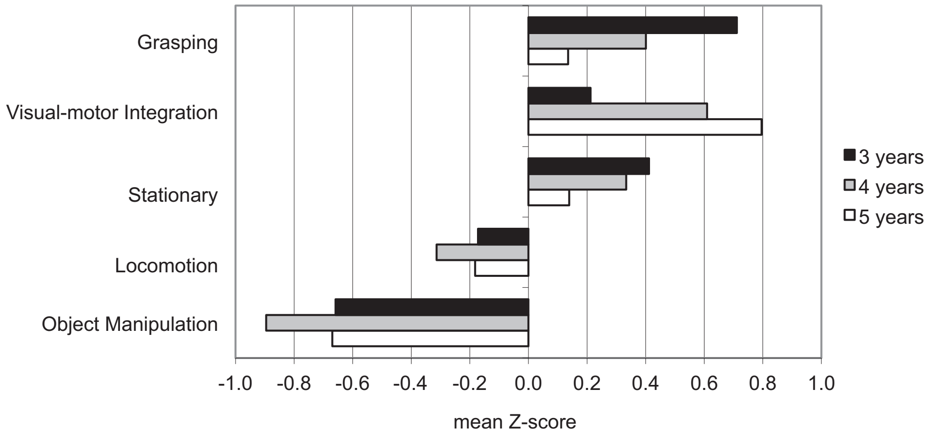

Fig. 1. Comparison of motor performance between the Portuguese sample and US normative sample on all motor subtests.

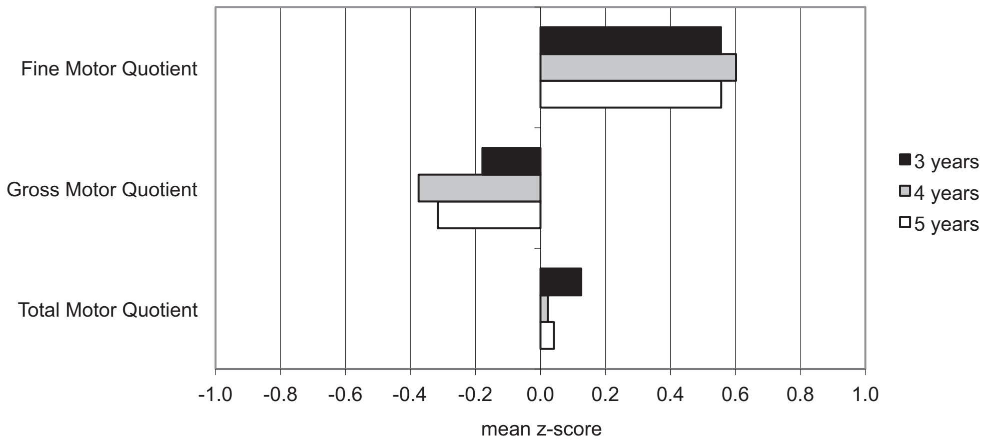

Fig. 2. Comparison of motor performance between Portuguese sample and US normative sample on all motor quotients.

Table 3
Results of comparison (*t*-test values, *p*-values, and Cohen's d) between the Portuguese sample and US normative sample for the three age groups on all motor subtests and motor quotients.

	3 years			4 years			5 years		
	t	*p*	Effect size (*d*)	*t*	*p*	Effect size (*d*)	*t*	*p*	Effect size (*d*)
Motor subtests									
Grasping	7.82	<0.001	0.76	5.16	<0.001	0.49	1.78	0.076	0.18
Visual-motor integration	2.44	0.014	0.24	7.06	<0.001	0.67	9.01	<0.001	0.91
Stationary	4.59	<0.001	0.45	4.09	<0.001	0.39	1.67	0.095	0.17
Locomotion	2.04	0.004	−0.20	3.92	<0.001	−0.37	2.24	0.026	−0.22
Object manipulation	7.73	<0.001	−0.75	10.95	<0.001	−1.04	8.22	<0.001	−0.83
Motor quotients									
Fine motor quotient	6.30	<0.001	0.61	7.44	<0.001	0.70	6.82	<0.001	0.69
Gross motor quotient	2.11	0.036	−0.21	4.74	<0.001	−0.45	3.93	<0.001	−0.39
Total motor quotient	1.49	0.138	0.15	0.30	0.767	0.03	0.52	0.605	0.05

Similar motor performance between Portuguese and American preschoolers was only found on Grasping and Stationary subtests in the five-year-old age group.

Overall, Portuguese children showed significantly higher scores on the Fine Motor Quotient in all age groups (all p's < 0.001, with moderate effect size); and significantly lower scores on the Gross Motor Quotient (all p's ≤ 0.036, with small effect size).

No differences were found on the Total Motor Quotient at all ages (see Fig. 2).

4. Discussion

The main intent of the present study was to examine the cultural sensitivity (regional relevance) of the PDMS-2 for Portuguese children aged 36–71 months and also to analyze the age and sex effects on motor performance. As for age effect, the results of our study suggest that PDMS-2 is a valid and discriminative measure to differentiate the motor competence of Portuguese children aged between 36 and 71 months. As expected, the older age groups performed significantly better than the younger age-group in all motor subtests, which reflects the importance of the child's biological and neurological maturity in the development of motor competence.

Despite these findings, the cross cultural comparison points out that Portuguese and American children have different motor development profiles. Significant differences in all subtests were found, except on the grasping and stationary subtests in the five-year-old age group. Overall, Portuguese children performed above US norms in FMQ and below in GMQ. Differences in rate and sequence of motor development among infants and children from various cultural backgrounds have been reported in many studies (Adolph, Karasik, & Tamis-LeMonda, 2010; Chow, Henderson, & Barnett, 2001; Cintas, 1995; Crowe et al., 1999; Mayson, Harris, & Bachman, 2007; McClain, Provost, & Crowe, 2000; Tripathi et al., 2008). Several factors may help explain the differences in motor development among children from different cultures/countries, such as child's characteristics (e.g., gender, age, race, ethnic, somatic characteristics), family background, child-rearing practices, parental/social expectations (Cintas, 1995), as well as quality and quantity of stimulation provide in home (Cools, Martelaer, Samaey, & Andries, 2011; Hamadani et al., 2010; Sanhueza, 2006; Varzin, Naidu, & Vidyasagar, 1998) and school environments (Anme & Segal, 2003; Barros, Fragoso, Oliveira, Cabral-Filho, & Castro, 2003; Mulligan, Specker, Buckley, O'Connor, & Ho, 1998; Santos et al., 2009; Stipek, Daniels, Calluzzo, & Milburn, 1992).

Concerning the differences between Portuguese and American children, we can speculate that American children have more opportunities for gross motor experiences that promote object manipulation (e.g., throwing, catching) and locomotion skills. The social valorisation of sport, the promotion of physical education programs, and the existence of sport's friendly environment seem to foster sports' practice in American culture, with a special emphasis on ball skills. Furthermore, and for academic and educational reasons, Portuguese preschoolers appear to be more oriented to fine motor tasks (e.g., painting, cutting). In Portugal, because 70.2% of mothers with children under 6 years are employed (OECD, 2012b), the majority of children spend six to eight hours per day in pre-school. Even though pre-school is not compulsory, 73% of 3-year-olds and 93% of 5-year-olds are enrolled in early childhood education (OECD, 2012a). In the US, only 51% of children at age 3 and 74% at age five are enrolled in early childhood education (OECD, 2012a). This might explain the better performance of the Portuguese children in grasping subtest at 3 years old. Probably, Portuguese children receive early stimulation in fine motor tasks (e.g., grasping marker, buttoning or unbuttoning buttons, touching fingers) in their preschool environments. Our results also indicated that differences between US and Portuguese children on visual-motor integration subtest increase with age. This evidence reinforces the effect of school practices and educational policies of the Portuguese educational system on children's fine motor performance. Motor tasks such as building with blocks, copying designs, folding or cutting paper, and using markers are frequent activities in traditional Portuguese education system. The Portuguese curriculum guidelines for preschool education are strongly oriented to promote literacy and numeracy skills in preparation for primary school.

Some important sex effects were also observed. Boys performed better in object manipulation skills, while the girls had superior performance in fine motor skills. Studies using total battery scores usually do not find sex differences (e.g., Kambas et al., 2012), but when specific motor dimensions are analyzed (either fine and gross motor, or their sub-components) the majority of results support our findings. Namely, the better performance of boys in ball skills (e.g., Engel-Yeger, Rosenblum, & Josman, 2010; Giagazoglou et al., 2011; Hardy, King, Farrell, Macniven, & Howlett, 2010; Ikeda & Aoyagi, 2008; Livesey, Coleman & Piek, 2007; Thomas & French, 1985; Toriola & Igbokwe, 1986; Vandaele, Cools, de Decker, & de Martelaer, 2011) and a superior performance of girls in fine manual dexterity (Chow et al., 2001; Düger, Bumin, Uyanik, Aki, & Kayihan, 1999; Kroes et al., 2004; Lejarraga et al., 2002; Livesey et al., 2007; Sigmundsson & Rostoft, 2003). Some standardized tools reflect these differences in their norms (e.g., Koöper Koördinationstest für Kinder, Test of Gross Motor Development, Bruinink-Oseretsky Test of Motor proficiency), but the PDMS-2 does not provide separate norms for boys and girls. Hence, future normative studies with the Portuguese population should take into account sex differentiation.

Lastly, it is interesting to note that the difference between boys and girls on object manipulation increases with age (2.9 points at 3 years, 3.7 points at five years, and 4 points at 5 years). Gender stereotypes (differential use of toys and involvement in children's games), different opportunities for motor experiences, and parental and social expectations are frequently reported as an explanation for the better performances of boys in gross motor skills and of girls in fine motor skills (e.g., Ikeda & Aoyagi, 2008; Thomas & French, 1985). However, in our study sex differences in Grasping, Visuo-Motor Integration and Object Manipulation exist already in 3-year-old children. The evidence of early sex differences in motor ability is not new in the literature and it is difficult to explain based solely on social/cultural influences. Touwen (1976) identified differences between boys and girls in the development of motor milestones in infancy (boys tended to sit and walk earlier than girls, and girls tended to vocalize and grasp sooner). These findings are supported by more recent studies with infants, which have found differences between the two sexes in brain structuring and function (e.g., Liu et al., 2011), indicating that biological differences might also play a role in children's motor performance (Piek et al., 2012).

To our knowledge, this is the first study that characterizes the motor development evaluated by PDMS-2 in a large Portuguese sample, which is a necessary first step to establish its validity for Portuguese children. This study should be replicated with other Portuguese samples and mainly with ages not explored in this study (from 0 to 3 years).The results suggest that Portuguese and US children have different motor development profiles, probably as the result of cultural, environmental, and educational factors that require further investigation. In addition, our data indicate that a possible sex differentiation might be necessary when establishing PDMS-2 norms for the Portuguese population. The cultural differences underline the need to interpret the test results with caution especially if this instrument is used in clinical settings in order to diagnose motor delays and plan future intervention.

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