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ORIGINAL ARTICLE

ADAPTATION AND VALIDATION OF THE PORTUGUESE *PEABODY DEVELOPMENTAL MOTOR SCALES-2* VERSION: A STUDY WITH PRESCHOOLERS CHILDREN

ADAPTAÇÃO E VALIDAÇÃO DA VERSÃO PORTUGUESA *PEABODY DEVELOPMENTAL MOTOR SCALES-2*: UM ESTUDO COM CRIANÇAS PRÉ-ESCOLARES

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ABSTRACT
The purpose of this study was to examine the psychometric properties of the Peabody Developmental Motor Scales II (PDMS-2) (FOLIO; FEWELL, 2000), using a Portuguese sample group. The Portuguese version of PDMS-2 was applied, according to assessment protocol described in the manual of this version, to 540 children, aged 36 to 71 months, from fifteen preschools. The results of the confirmatory factor analysis (S-Bχ2=3.3, p=.349; CFI =1.0, NFI =.99, NNFI=.99, RMSEA =.013) support that the Portuguese version presents a model of two factors (Fine and Gross Motor) as does the original version. Most of the subtests showed a good internal consistency (α = .76 to .95) and good test-retest reliability (ICC = .85 to .95). These findings indicate that the Portuguese version of PDMS-2 is an accurate and valid tool to assess the gross and fine motor skills of Portuguese preschoolers

Keywords: Child development. Motor skills. Validation studies.

INTRODUCTION

Among all several tools to assess children's motor development described in the international literature, the Peabody Developmental Motor Scales-2 (PDMS-2) (FOLIO; FEWELL, 2000) currently stands out for their wide use within clinical and scientific context (SARAIVA; RODRIGUES, 2007). This standardized tool was created on a basis of 2,003 children living in forty-six North-American states and has had a much generalized application in the assessment of the execution of gross and fine motor skills of children aged up to seventy-one months old.

'In its first edition (FOLIO; FEWELL, 1983), the PDMS-2 tool was especially conceived to early detect unadaptativeness or delays in the motor development of children. Currently, the reviewed version (FOLIO; FEWELL, 2000) presents other advantages that specifically allow: assessing the motor competence of the child in relation to his/her peers; identifying motor deficits and unbalances between the fine and gross motor domain; establishing individual goals and objectives in the clinical or educative intervention; and monitoring the individual development of the child.

The authors of the tool also highlight its usefulness as research instrument, proved with its use in various studies and investigation projects over the last decade. A big part of these studies have attempted to determine the influence of several risk factors of biological and environmental order in the development of children (ANGELSEN; JACOBSEN; BAKKETEIG, 2001; ARENDT et al., 1999; EVENSEN et al., 2009; FETTERS; TRONICK, 1996; 2000; MAJNEMER; BARR, 2006; MILLER-LONCAR et al., 2005; GOYEN; LUI, 2002; NELSON et al., 2004; TRASTI et al., 1999; SOMMERFELT et al., 2002;

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RODRIGUES, 2005; SANTOS, 2009). Other studies aimed to characterize the motor behavior of special populations, such as children with cerebral palsy, autism, Down syndrome and Hurler syndrome (DUSING; THORPE; ROSENBERG, 2006; MARING; COURCELLE-CARTER, 2004; PROVOST; LOPEZ; HEIMERL, 2007), or of populations with specific clinical picture (MITCHELL et al., 2005; RAO et al., 2004; SMITH; DANOFF; PARKS, 2002). This instrument was also used in some studies whose objective was to analyze the effect of intervention programs on the clinical context (WILLIS, 2002) or educative context (WANG, 2004).

Its acceptance within the scientific community results from the fact that this instrument allows for a multidimensional interpretation of the motor behavior through the calculation of different motor composites, namely: the fine motor quotient (FMQ), the gross motor quotient (GMQ) and the total motor quotient (TMQ) resulting from the first two. The segmentation of the TMQ is especially interest to differentiate individual characteristics and, particularly, to monitor the effect of intervention programs.

According to Folio and Fewell (2000), the PDMS-2 constitutes a significant improvement in relation to the original version for the representativeness of the norms and its psychometric properties. As for the level of precision of the tool, the manual reports a good index of internal consistence for every subtest ((α=0.89 to 0.95) and for every motor quotient (0.96 to 0.97), an acceptable test-retest reliability (r=0.73 to 0.96, depending on the age group) and an elevate intra-rater reliability, which ranged from 0.97 to 0.99 for the subtests, and between 0.96 and 0.98 for the motor quotients. About its validity, two factorial confirmatory studies conducted with two sub-samples of the North-American measurement (up to 11 months, and 12 to 72 months) identified a measurement model consisting of two factors – fine motor skill (FMS) and gross motor skill (GMS), defined, respectively, by two fine motor tests (visual-motor integration, fine hand grip) and three gross motor subtests (postural control, locomotion and handling of objects, or reflexes, for children up to eleven months old), in another study with Taiwanese children, Chien and Bond (2009), when specifically analyzing the dimensionality of the fine motor scale through the Rasch model concluded that the reduction of some items and the grouping of their two marking tests (fine hand grip and visual-motor integration) would make the scale more consistent and more useful, from a clinical point-of-view. These results evidence that the measurement model validated for the North-American sample might not be adequate or identical for another different population; for this reason, it is advisable to carry out its transcultural adaptation before applying it.

About the concurrent validity, the authors of the instrument concluded that the PDMS-2 present an elevated correlation with their 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). In addition, Bean et al. (2004), when assessing children at development risk, aged between two and fifteen months old, registered elevated correlations ((r=0.90 to 0.97) between the results of tree subtests (reflexes, locomotion and postural control) of the scale of gross motor skills of the PDMS-2 and the total motor quotient of the Alberta Infant Motor Scale. In turn, Connolly et al. (2006) analyzed the concurrent validity between the PDMS-2 and the Bayley Scales of Infant Development II (BSID-II) with children aged twelve months old. The results evidenced low correlation between the standard values of the motor quotients of the PDMS-II and the Index of Psychomotor Development of the BSID-II (r=0.30, 0.22 and 0.32 respectively for GMQ, FMQ and TMQ). In the values referring to age for the locomotion test, only an elevated correlation was found (r=.71, $p<0.05$). Based on these results, the authors of that study advise prudence in the interpretation of the standardized values or of the values referring to age when making clinical decisions based on a single assessment tool.

The sensitivity of the instrument was confirmed by the authors of the scales by age, gender, ethnicity (European-Americans, African-Americans and Hispanic-Americans) and motor and mental deficits. Additionally, Wang, Liao and Hsieh (2006) sought also to test the

sensitivity in a sample of children with cerebral palsy, aged between two and five years old. The results suggest some sensitivity to developmental modifications for an interval of six months. This seems to be an important improvement of the reviewed version, since Palisano et al. (1995) had reported that the Scale of Gross Motor Skill of the original version of the PDMS was not capable of detecting any changes in the motor development of children with cerebral palsy within a six-month interval.

In spite of all metric evidence, some authors (CROWE; MCCLAIN; PROVOST, 1999; PROVOST et al., 2004; TRIPATHI et al., 2008; VAN HARTINGSVELDT; CUP; OOSTENDORP, 2005) have alerted that the application of the PDMS-2 and, particularly, the interpretation of their standardized values for certain special/clinical groups or in contexts culturally different from those to which the instrument was originally developed, will have to be performed with caution, and recommend a transcultural adaptation and validation of the instrument to the population under investigation. It is possible that the North-American referential is reasonably different from that one found in culturally and geographically different populations; for this reason, the present study aims to test the psychometric properties of the Portuguese version of the PDMS-2 in a sample with Portuguese preschoolers. The validity of this measurement instrument for the national context is an indispensable condition for its usefulness and credibility in the clinical, educative and scientific spheres.

METHODOLOGY

The transcultural adaptation of the PDMS-2 for the Portuguese population was authorized by the PRO-ED press, from Austin, Texas. This process sought to follow the methodological procedures recommended in the specific literature on translation and adaptation of an assessment instrument (HAMBLETON; MERENDA; SPIELBERGER, 2005; AMERICAN EDUCATIONAL RESEARCH ASSOCIATION; AMERICAN PSYCHOLOGICAL ASSOCIATION; NATIONAL COUNCIL ON MEASUREMENT IN EDUCATION, 1999). All the procedures adopted aimed to ensure linguistic, conceptual, operational and psychometric equivalence between the translated Portuguese version and the original version. Succinctly, this study comprehended two distinct stages: 1st) Translation process of the PDMS-2; 2nd) Analysis of the psychometric properties of the Portuguese version of the PDMS-2.

In the translation stage, the forward-translation design protocol was implemented, conjugated with an expert review group (HAMBLETON; PATSULA, 1999; PEÑA, 2007). The chapter of the manual relative to the structure and dimensions assessed, the administration and rates of the scales (Examiner's Manual PDMS-2) and the administration form and individual record (Examiner Record Booklet) were translated by two authors of this study who were familiar with the languages and cultures involved and had expertise in the construction of measurement instruments. These two translations were compared and, after consensus, the first version of the Portuguese PDMS-2 was obtained. This version was submitted to the appreciation of a group of experts composed of specialists in the area of infant motor development (five professors and three general practitioners) and education in childhood (two educators). The educators were included in the group aiming to verify the clarity and adequacy of the instructions destined to the children. The alterations proposed by the experts were incorporated into the first version. In different moments, several pilot studies were also conducted (SARAIVA; RODRIGUES, 2006; 2008), in order to clarify aspects related to the administration and rates of the scales and, simultaneously, to test their comprehension and viability for the population in question. The Portuguese version of the PDMS-2 obtained in the end of this stage present an identical structure and the same number of items as the original version.

The Portuguese version of the PDMS-2 was applied to a sample of 540 preschoolers, aiming to test their psychometric equivalence. This empirical analysis included three studies: the study of sensitivity to development; the study of precision (internal consistency and temporal stability of the results) and, lastly, the study of the construct validity.

Instrument

The composite structure of the PDMS-2 includes five subtests distributed by two motor components/scales: gross motor skills and fine motor skills. Its results are expressed in three domains of motor behavior: the fine motor quotient (FMQ), the gross motor quotient (GMQ) and the total motor quotient (TMQ); the latter is a result from the first two. The FMQ is found by summing the two sets of subtests, namely, fine hand grip and visual-motor integration; for the GMQ, three sets are used: postural control, locomotion and object handling (the latter is substituted for the reflexes subtest for children up to eleven months old). Each one of these subtests is constituted of items (motor tasks) adjusted to age and arranged in ascending level of difficulty. The child starts the test by a certain item, according to his/her age, and continues the sequence until failing the execution of three consecutive items. Each item is classified according to an assessment scale of three values: 0=non-executed, 1= minimum proficiency, 2=excellent proficiency. The value of the sum of all items in each of the subtests is located in the reference table for age, then resulting in a standardized value and a percentage value that can be compared between the ages. Subsequently, the sum of the standardized values of the subtests grouped allows obtaining the total, fine or gross motor quotient, through consultation to a second table. The scales standardized to the North-American infant population establish the average value of 10 scores (± 3) for each test, and the average value of 100 scores (± 15) for the motor quotients. The standardized values can also be converted in a qualitative classification of seven categories (between “Very Good” and “Very Poor”).

Sample

A total of 540 children were assessed (255 male and 285 female), from 15 public preschools of the urban, semi-urban and rural area of Viana do Castelo, Portugal. For the selection of the sample, as inclusion criteria, the children should be aged between 36 and 71 months old and Portuguese; all children who presented diagnosis of intellectual, physical or emotional deficiency, as well as those with special educative needs confirmed by the assessment performed by the staff of special education, were excluded from the study. Table 1 summarizes the main sociodemographic characteristics of the sample, by age group.

Table 1 – Sociodemographic characterization of the 540 Portuguese children

		36-47 Months (n=162)	48-59 Months (n=189)	60-71 Months (n=189)	Total (n=540)
Age (Mean ± SD)		41.95±3.4	53.41±3.5	64±91	53.5±10.7
Gender, N (%)					
	Male	84 (51.9)	84 (44.4)	87 (46)	255 (47.2)
	Female	78 (48.1)	105 (55.6)	102 (54)	285 (52.8)
Area of residence (%)					
	Urban	76 (46.9)	101 (53.4)	120 (63.5)	297 (55)
	Semi-urban	55 (34)	54 (28,6)	37 (19,6)	146 (27)
	Rural	31 (19.1)	34 (18)	32 (16.9)	97 (18)

Procedures of data collection

Previously to the application of the instrument, the authorizations necessary were obtained from the school's administration and the responsible educators. Those in charge of the education were also asked to sign an informed consent form containing the explanations on every procedure and the purpose of the study.

Two investigators especially trained assessed the children individually; the intra-rater reliability stood at 90% in the rate item by item before data collection. The administration of the scales lasted 30-45 minutes per children, depending on the age group. The assessment was carried out in a kindergarten room, a little intrusive environment and adequate to the protocol described in the manual of the PDMS-2 (FOLIO; FEWELL, 2000). All moments of the data collection were filmed for posterior analysis. The raw scores obtained in the subtests were converted into standard scores, and the respective gross, fine and total quotients were calculated based on the reference values of the manual. In order to determine the temporal stability of the results, twenty-two children of the sample were assessed two times within an interval of five days.

All of the procedures were submitted to the Ethics Commission of the Faculty of Human Kinetics and were approved by it, respecting every international norm of experimentation with humans expressed in the Declaration of Helsinki.

Statistical procedures

The sensitivity to development was assessed through indicators of central tendency and dispersion (mean, standard deviation, maximum, minimum and amplitude) for each one of the age groups. The temporal stability between the values of the test-retest was determined by Cronbach's alpha (a), having as a reference the cutoff value ≥.70 (NUNNALLY; 1978). The construct validity was tested through a confirmatory factorial analysis (CFA). To estimate the adjustment parameters of the model to the data of the sample, the Maximum Likelihood (ML) method was used, recurring to robust techniques (SATORRA; BENTLER, 2001), since the data do not present a normal multi-varied distribution (Mardia's coefficient=9.78). In the assessment of the model, two indexes of absolute adjustment were considered (Santorra-Bentler Scaled Chi-Square [S-Bx2], Root Mean Square of Error Approximation [RMSEA] and three indexes of incremental adjustment (Comparative Fit Index [CFI], Normed Fit Index [NFI], Non-Normed Fit Index [NNFI]. The S-Bx2 assesses the discrepancies between the co-variance matrix of the data and the co-variance matrix of the model tested. Non-significant values of p ($p>0.05$) indicated good adjustment. The RMSEA expresses the degree of "error" of the model, assessing thus the extent to which it is adjusted (or not) to the data, and compensating it to the effect of the complexity (sensitive to the number of parameters and insensitive to the size of the sample). Values below 0.06 indicate adequacy to the model (HU; BENTLER, 1999). The CFI estimates the improvement of adjustment to the model specified over a null model in which the adjustment to the model proposed is better than the adjustment to the null model; and the NNFI must be interpreted likewise, but it includes an adjustment to the complexity of the model. Values of CFI, NFI and NNFI above 0.95 indicate a good adjustment (HU; BENTLER, 1999). The statistical software used was SPSS 16.0 and EQS 6.1.

RESULTS

Study of the sensitivity to development

To better know the data of the sample, the analysis of the sensitivity to development was conducted by means of the interpretation of the raw scores obtained in the different subtests by age group (Table 2).

Table 2 – Mean standard deviation (SD), minimum-maximum value and amplitude of the raw scores obtained in the subtests by age group

Subtests		36-47 Months (n=163)	48-59 Months (n=189)	60-71 Months (n=189)
Fine hand grip	Mean (SD)	48.7 (2.6)	50.9 (1.4)	51.4 (1.0)
	Min – Max*	40-52	44-52	45-52
	Amplitude	12	8	7
Visual-motor integration	Mean (SD)	123.6 (7.0)	136.2 (5.5)	140.5 (3.5)
	Min – Max*	109-140	113-144	113-144
	Amplitude	31	31	31
Postural control	Mean (SD)	48.1 (4.2)	53.9 (3.4)	57.2 (2.8)
	Min – Max*	38-59	44-60	46-60
	Amplitude	21	16	14
Locomotion	Mean (SD)	144.5 (9.9)	160.1 (8.3)	170.1 (5.8)
	Min – Max*	118-169	133-177	145-178
	Amplitude	51	44	33
Object handling	Mean (SD)	29.2 (5.6)	34.6 (6.0)	39.7 (5.1)
	Min – Max*	18-45	20-48	27-48
	Amplitude	27	28	21

- Maximum scoring possible: Fine hand grip =52; Visual-motor integration=144; Postural control=60; Locomotion=178; Object handling=48

In a brief analysis of the data, it is possible to confirm that the mean values obtained in each of the subtests register a desired increase along the age groups, which constitutes an evidence of sensitivity to development. The expected variability of the results is also visible in all of the subtests, except in the fine hand grip test, which only registers a standard deviation of 1.4 and 1.0 in the age groups of four and five years old. Besides, in this subtest, a clear ceiling effect is perceivable, since most children at the age group of 5 years old (117 children, 61.9%) reaches the maximum scoring possible of 52 scores.

Precision study

The study of precision of the instrument comprehended the analysis of internal consistency of the subtests, and of the temporal stability of the results obtained by twenty-two children of our sample after a retest, within an interval of five days. Table 3 displays the results referring to these parameters of precision

Table 3 – Internal consistency and temporal stability of the subtests

Subtests	Internal consistency (*a Cronbach*) n=540	Temporal stability (ICC) n=22
Fine hand grip	[illegible]	[illegible]
Visual-motor integration	.91	.95
Postural Control	.89	.87
Locomotion	.95	.85
Object handling	.87	.94

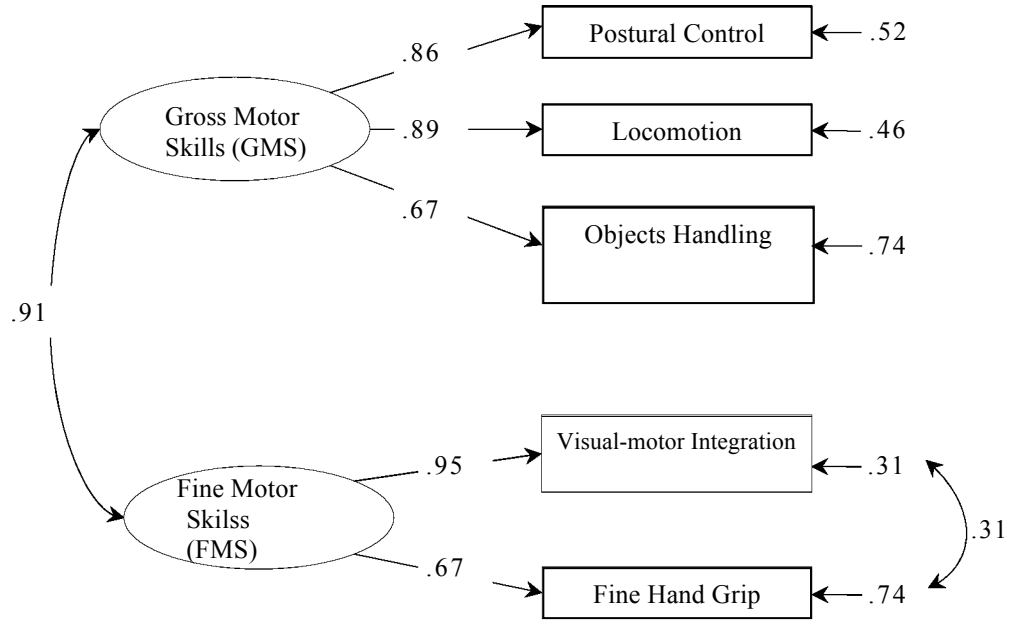
With the interpretation of the values of *a Cronbach*, it is inferable that most of the subtests obtained a good index of internal consistency, oscillating between .76 and .95. The subtests of visual-motor integration and locomotion registered elevated levels of internal

consistency (*a*=.91 and *a*=.95, respectively), and the fine hand grip subtest reached an acceptable level only (*a*=.76).

Regarding the temporal stability estimated through the intraclass correlation coefficient (ICC), Table 3 shows that the values ranged between .85 for the locomotion subtest and .95 for the visual-motor integration subtest. These values point out that the subsample of twenty-two Portuguese children present good test-retest stability in all of the subtests.

Study of the construct validity

The factorial model of the PDMS-2 tested for the Portuguese sample was identical to the originally proposed by the authors (Figure 1); that is, it is postulated that the existence of two latent factors (gross motor skills and fine motor skills) defined respectively by three items (postural control, locomotion and object handling) and two items (fine hand grip and visual-motor integration). Its adjustment was tested through a confirmatory factorial analysis. Because the results of the Langrange Multiplier Tests suggested the existence of correlated measurement errors between the items of visual-motor integration and fine hand grip (Figure 1), a new specification of the measurement model inspected was carried out.



S-Bχ2=3.3, *df*= 3, *p*=.349; CFI=1.0; NFI=.99; NNFI=.99 and RMSEA (90% CI) =.013 (0.00-0.07)

Figure 1 - Factorial structure of the PDMS-2 measurement model for the Portuguese sample aged between 36 and 71 months old.

Note: In the diagram of the factorial structure, the values of item-factor and factor-factor saturation are presented, and on the right side of the items, the respective residual error. SBχ2 (*Santorra-Bentler Scaled Chi-Square*); CFI (*Comparative Fit Index*); NFI *(Normed Fit Index);* NNFI *(Non-Normed Fit Index);* RMSEA (90% IC) *(Root Mean Square of Error Approximation, 90% Confidence Interval*).

In the first reading of the results presented in Figure 1, it is possible to verify that the value of Santorra-Bentler Scaled Chi-Square (SBχ2=3.3, *df*=3, *p*=.349) suggests an adequacy of the model to the data examined. The other indexes of the model confirm, indeed, a good adjustment (CFI=1.0; NFI=.99; NNFI=.99 and RMSEA=.013).

Besides these evidences, the standardized solution of two factors found for the Portuguese sample reveals that all the items present item-factor saturation values (loadings) between very

good and excellent, and there are no values below .67. An elevated correlation (.91) between the two latent factors was equally identified.

DISCUSSION

Broadly speaking, it was verified that the Portuguese version of the PDMS-2 presents psychometric characteristics equivalent to those of the original version. In the study of the sensitivity to development, it was confirmed that the visual-motor integration, postural control, locomotion and object handling subtests presented capacity to discriminate the motor development of the Portuguese children aged between 36 and 71 months old. The average scores (raw scores) of these subtests registered an increase by age and their respective standard deviations (superior to 2.6) confirm the variability of the results obtained in the sample under study. The same cannot be reported in relation to the fine hand grip subtest, because the raw scores reached by the children of four and five years old only presented a variability of 1.4 and 1.0, respectively. Besides, in this subtest, a clear ceiling effect is perceivable, since most of children aged 5 years old (117 children, 61.9%) reach the maximum scoring possible of 52 scores. This seems to be, indeed, a limitation of the instrument, regardless of the population in question, because this ceiling effect was equally reported for Taiwanese children (CHIEN; BOND, 2009) and Flemish children (VANVUCHELEN; MULDERS; SMEYERS, 2003) at preschool age. From the clinical point-of-view, Van Hartingsveldt, Cup and Ostendorp (2005), when assessing eighteen Dutch children aged four and five years old, concluded that the fine motor scale of the PDMS-2 demonstrated lower sensitivity to discriminate children with light fine motor issues comparatively to the Movement Assessment Battery for Children.

About the accuracy of the instrument, it is possible to infer that the Portuguese version of the PDMS-2 revealed, as a whole, very satisfactory indexes and comparable to those of the original version. All of the subtests reached an alpha value substantially superior to the cutoff score of .70 proposed by Nunnally (1978).

As for the test-retest precision, it was verified that the subsample of twenty-two Portuguese children, within an interval of five days in between both applications, also registered elevated stability coefficients (ICC≥Ã5) in all of the subtests. These precision indexes of the PDMS-2 have been confirmed in other psychometric studies (KOLOBE; BULANDA; SUSMAN, 2004; PROVOST et al., 2004; LI-TSANG; LEE; HUNG, 2006; VAN HARTINGSVELDT; CUP; OOSTENDORP, 2005; WANG; LIAO; HSIEH, 2006).

As for the construct validity, the results of the confirmatory factorial analysis support that the Portuguese version of the PDMS-2 presents a two-factor model: gross motor skill and fine motor skill, just as the original version proposed by Folio and Fewell (2000). The indexes of adjustment to the Portuguese model (S-Bx2=3.3, p=.349; CFI=1.0; NFI=.99; NNFI=.99; RMSEA=.013) were generically more satisfactorily than those of the North-American version (TLI=.96; RMSEA=.08). About the adjustment indexes, it is important to make clear that the authors of the PDMS-2 did not choose the CFI, NFI and NNFI indexes, but the Tucker-Lewis index (TLI), which is comparative to the NNFI index inspected by us. Finally, it is worth highlighting that the Portuguese factorial structure registered higher values of item-factor saturation (λ =.67 a .95) comparatively to the original structure (λ =.54 to 89), which demonstrates a greater relevance of the values of the items (subtests) in the determination of the respective latent factors (gross motor skill and fine motor skill).

CONCLUSION

The Portuguese version of the PDMS-2 proved an accurate and valid instrument to assess fine and gross motos skills of Portuguese children at preschool age. The different

empirical analyses conducted in the sphere of this study confirmed that the Portuguese version presents psychometric characteristics that are similar to those of the original version when it comes to its sensivity, precision and theoretical construct, which viabilizes its use in national context.

The PDMS-2 scales are a particular promising instrument in the scientific context for the understading of the different dimensions of children's motor behavior. In the future, in order to take advantage of the potentialities of the instrument, the consolidation of the process of validation and measurement of the PDMS-2 for the Portuguese population will be of great importance. The replication of this study with other Portuguese sample is a suggestion, particularly with those of age groups not explored in the present study

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