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Original Article

EVIDENCES OF CONSTRUCT VALIDITY, CRITERIA AND VALIDATION OF THE MOTOR COMPETENCE ASSESSMENT BATERY OF TESTS IN PRESCHOOLERS

EVIDÊNCIAS DE VALIDADE DE CONSTRUTO, CRITÉRIO E FIDEDIGNIDADE DA *MOTOR COMPETENCE ASSESSMENT* EM PRÉ-ESCOLARES

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RESUMO
A literatura tem evidenciado a necessidade de estudos de validação de testes motores para avaliação da competência motora (CM). Assim, Luz e colaboradores propuseram uma bateria de testes *Motor Competence Assessment* (MCA) para avaliação da CM em crianças e adolescentes portugueses. Objetivou-se investigar as evidências de validade da MCA em uma amostra de pré-escolares brasileiros e testar a correlação entre resultados da CM avaliados com a MCA e o Test of Gross Motor Development -2 (TGMD-2). Participaram 251 pré-escolares de ambos os sexos, de seis Centros de Referência em Educação Infantil de João Pessoa-PB. Os dados foram coletados por meio da MCA e do TGMD-2. Os resultados da análise fatorial confirmatória (AFC) mostraram dois modelos, um com índices de ajuste adequados; Os coeficientes de correlação interclasse variaram entre 0,77 e 0,96, indicando confiabilidade excelente; a correlação entre a MCA e o TGMD-2 foi significante com magnitude moderada ($r = 0{,}57$, $p<0{,}01$). A estrutura de três variáveis latentes do construto CM na MCA foi confirmada pela AFC. Entretanto, sugere-se um modelo bidimensional. A MCA e o TGMD-2 parecem medir aspectos semelhantes da CM. A confiabilidade permitiu concluir que o protocolo da MCA aplicado a pré-escolares mantém estabilidade temporal.
Palavras-chave: Desempenho psicomotor. Destreza motora. Validade dos testes.

ABSTRACT
The literature has evidenced the need for validation studies of motor tests to assess motor competence (MC). Luz et al (2016) proposed a battery of tests, that is, the Motor Competence Assessment (MCA) to evaluate MC in Portuguese children and adolescents. The purpose of the present study was to investigate the evidences of this MCA validity in a sample of Brazilian preschoolers, in addition to assess the correlation between the MC results obtained through MCA and the Test of Gross Motor Development-2 (TGMD-2). 251 male and female preschool-age children from six reference Centers in Early Childhood Education in the city of João Pessoa-PB participated in study. Data were collected by using MCA and TGMD-2. The results of the Confirmatory Factor Analysis (CFA) showed two models, one of them with appropriate adjustment indexes. The interclass correlation coefficients ranged between 0.77 and 0.96, which indicates an excellent reliability; the correlation between MCA and TGMD-2 was significant with a moderate magnitude ($r = 0.57$, $p < 0.01$). The structure of three latent variables of the MC construct in the MCA was confirmed by the CFA. However, a two-dimensional model is suggested. MCA and TGMD-2 seemed to measure similar aspects of MC. Reliability enabled us to conclude that the MCA protocol applied to preschoolers maintains temporal stability.
Keywords: Validation. Motor Competence. Preschoolers. Reliability.

Introduction

Motor competence has been the focus of attention in recent years due to its significance for maintaining and developing an active healthy lifestyle. Being motor competent provides an individual greater autonomy for participating in motor practice and sports contexts, which promotes positive influences in children's health and prevents obesity[1-3].

Despite this evidence and the growing interest of the scientific community in the sense of exploring motor competence, an issue specifically about its evaluation has been raised, Assessing motor competence is especially worthy during childhood because it contributes to an early and broad view of the children's motor skills development, since this is a sensitive phase when considering the acquisition of fundamental motor skills, besides being critical for the development of healthy behavior[4-6].

However, the assessment of motor competence is reported as a difficult procedure[7] and part of this difficulty is due to the diversity of the instruments used in research. The *Motoriktest für Vier-bis Sechjärige Kinder*[8], *Movement Assessment Battery for Children - 2*[9], *Körperkoordinationtest für Kinder*[10], *Test of Gross Motor Development-2*[11] and *Bruininks-Oseretsky test of Motor Proficiency*[12] are some of the instruments widely used for the assessment of preschoolers' motor skills. This diversity can hinder the development of longitudinal research, the comparison of results in studies and their respective correlatrelations with other significant variables[2,7]. In addition, several tests have initially been developed with the purpose of diagnosing motor disorders[5].

Although the instruments have widely been used in scientific research and applied to the most diverse contexts, the validation process must be confirmed by using more than one approach and multiple techniques. Therefore, obtaining a comprehensive evidence is essential so as to establish reliability before using an instrument in practice[13,14].

The need for validation studies to improve the psychometric quality of existing tests, especially in educational contexts, was suggested by Scheuer et al[15]. In a recent review that aimed to analyze the areas of application and psychometric properties of motor test batteries for preschoolers, the authors showed that both, the application of existing motor tests for specific theoretical structures and the use of the corresponding terminology have not been consistent so far[15].

According to Luz et al.[16] there is a discrepancy between the theoretical structure of motor competence and its clinical application or use in scientific research to which MC is a subject of interest. This shows the lack of a strong conceptual model that can be used in different contexts and ages. The authors proposed a battery of tests for the quantitative assessment of motor competence with a practical and rapid application. Making use of tasks from instruments and protocols widely applied in the literature, this battery consists of six motor tasks: two locomotion tasks, two manipulation tasks and two stabilization tasks validated for 6-14-year-old Portuguese children[16]. Although this battery of tests was created for middle childhood, the authors suggest its application in a wide age group, which could benefit the development of longitudinal studies and, consequently, enable researchers to obtain knowledge on motor competence in different stages of life. For these reasons, the battery of motor tests proposed by Luz et al.[16] is a quite promising instrument for testing motor competence throughout childhood and adolescence.

There is no empirical evidence so far that the battery of tests proposed by Luz et al.[16] to assess MC facilitates a valid reproduction for preschool-age children. Therefore, the relevance of the present investigation is due to the lack of validated instruments that could be used to evaluate preschoolers' MC in Brazil. Thus, the purposes of this study were: (1) investigating the evidences of construct validity and some test-retest reliability aspects of the tasks proposed by the Motor Competence Assessment battery of tests in a sample of Brazilian preschoolers; (2) assessing the criterion validity by considering the motor competence results obtained through two batteries of tests, that is, the Motor Competence Assessment and the Test of Gross Motor Development-2.

Methods

Participants

The present investigation analyzed the secondary data of the project entitled 'Movement's cool', whose research protocol was approved by the Research Ethics Committee from the Health Sciences Center of the Brazilian university referred to as *Universidade Federal da Paraíba* (Opinion number: 2.727.698; CAAE: 88995778.7.0000.5188).

In the city of João Pessoa, the preschool public education area is divided into nine sectors, where 86 Reference Centers for Early Childhood Education (CREIs) are located. In these sectors, fifty institutions have 3-5-year-old children enrolled, however only ten of them have an appropriate area for performing motor tests. A representative number of CREIs was calculated per sector and six institutions were randomly selected for the present study. In view of a population of 573 children, a representative sample was calculated per sector, CREI and age, considering an estimated prevalence of 50%, a confidence interval of 95%, a maximum tolerable error of 5% and a design effect of 1.0.

The sample was randomly selected, thus, 251 preschoolers (50.60% boys) participated in the first stage of the study, and 53 preschoolers participated in the second stage for the test-retest reliability assessment. Parents and guardians signed the Free Informed Consent Form to attest they agreed with the child's participation.

Instruments and Procedures

Motor competence (MC) was measured by using two batteries of tests: (1) Motor Competence Assessment (MCA)[16], and (2) Test of Gross Motor Development - Second Edition (TGMD-2)[11]

The MCA battery was proposed based on a theoretical model[16], which involves skills in the categories of stability, locomotion and object control; it includes the following tests:
(a) Lateral Jump: the child performs the largest amount of jumps with two feet together on a small wooden beam (60 x 50 x 0.8 cm) over a wooden pole (60 x 4 x 2 cm) in 15s; 1 point is scored for each correct jump. Two attempts are made, and a short time interval (approximately 1 min) is given for the participant to recover. The best performance between the two attempts (the highest score) was used as the test final result.
(b) Platform shifting: the child moves sideways as fast as possible for 20 seconds, using two wooden platforms (25cm x 25cm x 2cm). The participant starts with both feet on the right platform, grasps the left one with both hands and carries it to the right side, then he/she places the feet on this platform and so on. Each successful transfer from one platform to the other scored two points (one point for each stage).
(c) Shuttle run: the child runs across a straight line at maximum speed between points separated 10m apart; he/she picks up a wooden block and places it behind the starting line. Then, the child repeats the procedure to recover a second wooden block. The participants performed two attempts and only the best result was considered.
(d) Standing long jump: the child jumps with both feet together as far as possible. The distance (in meters) is marked between the starting line and the back of the heel at landing. The final score was the result corresponding to the longest distance after two attempts.
(e) Throwing velocity: the child throws a baseball (circumference: 22.86 cm; weight: 142 g) at a maximum speed against a wall using an overarm action without a preparatory race.
(f) Kicking velocity: after a preparatory run, the child kicks a soccer ball (no. 4, circumference: 64 cm, weight: 350 g) against a wall with as much strength as possible.

Considering the last two tasks, each participant made three attempts and the final result was given by the maximum speed in km/h obtained using the radar pistol (Bushnell, model 10-1911, USA). The total MC score was calculated by the average of the scores for all categories, based on Luz et al.[17].

The Test of Gross Motor Development - Second Edition (TGMD-2)[11] is one of the best known tests used to assess children's motor performance; moreover, it is valid and reliable for being applied to Brazilian children[18]. This test assesses gross motor performance in 3-10-year-old children and includes two subtests: six locomotion skills (run, gallop, hop, leap, horizontal jump and slide/side run) and six skills for object controll (striking a stationary ball, stationary dribble, catch, kick, overhand throw). According to the protocol proposed by Ulrich[11], trained appliers provided verbal instruction and showed the ability so as the child could make an attempt (trial). After identifying the child's understanding, two attempts of each skill were filmed and the same procedure was reproduced throughout the application process. A checklist is needed to decode the footage, in which the criteria for the quality of movements (ranging from 3 to 5) are described for each skill; if the criterion is met, a point is assigned, or zero when it is not met. Finally, the gross score was obtained per specific skills (between 6 and 10 points), per subtests (locomotor and object control that vary between 0 and 48 points), and the general score (between 0 and 96 points), obtained through the total of points in both subtests. The analysis of the videos was performed by two evaluators, thus, obtaining high intra- and inter-rater reliability (ICC values between 0.93 and 0.98).

Statistical analysis

Initially, descriptive analyzes were performed by using mean and standard deviation for the variables. Exploratory factor analysis (EFA) was performed to verify the data suitability by using the parameters suggested by Hutcheson and Sofroniou[19]: Kaiser Meyer Olklin test (KMO), which must be> 0.70, and Bartlett's test of sphericity, which must have $p < 0.05$. In order to examine the factorial validity of MCA in a sample of preschoolers, the correlations of latent factors were examined in confirmatory analysis in two models by using the Maximum Likelihood Estimation method. The analyzes were carried out using the SPSS AMOS 7.0 statistical package (v. 21.0, SPSS, *Statistical Packages for Social Sciences*, IBM® *company*).

For assessing the adjustment quality, the following indices were taken into account: X^2 (chi-square); RMSEA (Root Mean Square Error of Aproximation); GFI (Goodness-of-fit Index) and TLI (Tucker-Lewis Index). In addition to the X^2 adjustment values, the CFI adjustment index (Comparative Fit Index) and the SRMR (Standardized Root Mean Square Residual) were also ascertainied. Index values are considered desirable when RMSEA is close to or below 0.08; TLI greater than 0.90; 0.95 for CFI and 0.80 for SRMR[20].

Once the normality assumptions were considered acceptable, the correlation coefficients between the total scores of TGMD-2 and MCA were evaluated using Pearson's test. The z score inverse values of the shuttle run skill were used, since higher values represent lower performance.

In order to examine reliability, Intraclass Correlation Coefficient (ICC) analyzes were used for test-retest measurements, determined by the total scores of each item in two tests at different periods of time with an interval of approximately 15 days between each of them.

The SPSS software (v. 21.0, SPSS, Statistical Packages for Social Sciences, An IBM® company) was used, and a 0.05 significance level was adopted.

Results

Table 1 shows the description of the sample according to the sex of the participants. The final sample of the present study included 251 children with a mean age of 4.53 (± 0.77) years. According to the descriptive data shown, higher values were seen for boys in most variables, with the exception of the shuttle run variable.

Table 1. Descriptive statistics (mean and standard deviation) of the age and motor skills variables of the 3-5-year-old participants (n = 251) separated according to sex. João Pessoa (PB), 2018

Variables	Boys (n=127) 50.60%	Girls (n=124) 49.40%
	Mean (SD)	**Mean (SD)**
Age (years)	4.40 (0.66)	4.46 (0.62)
Motor Competence (TGMD-2)		
Locomotion (points)	19.39 (6.78)	18.05 (6.50)
Object control (points)	18.20 (5.98)	16.09 (5.78)
Total score (points)	37.59 (11.07)	34.15 (10.82)
Motor Competence (MCA)		
Lateral jump (points)	10.21 (4.08)	9.80 (3.39)
Platform shifting (points)	9.63 (4.03)	9.17 (3.44)
Shuttle run (s)	19.30 (3.46)	20.14 (3.35)
Standing long jump (cm)	70.40 (31.45)	64.54 (23.86)
Throwing velocity (km/h)	15.07 (10.10)	11.61 (10.33)
Kicking velocity (km/h)	18.18 (9.60)	12.94 (10.50)

Note: TGMD-2: Test of Gross Motor Development; MCA: Motor Competence Assessment; (s): seconds; (cm): centimeters; (km/h) kilometers per hour; SD: standard deviation
Source: The authors

Regarding exploratory factor analysis, Kaiser-Meier-Olklin measure (KMO) = 0.81 (95% CI, 85-0.88) and Barlett's Test of Sphericity (X^2 = 563.807; p <0.001) show that the Factor Analysis model for these data is suitable.

Figure 1 shows the model with three latent factors according to the original model proposed by Luz et al.[16]. It was seen that the lateral jump task had the greatest factor load in the stability subtest (0.81); the standing long jump task showed a greater factor load in locomotion (0.80), whereas kicking had a factor load of 0.81 for object control.

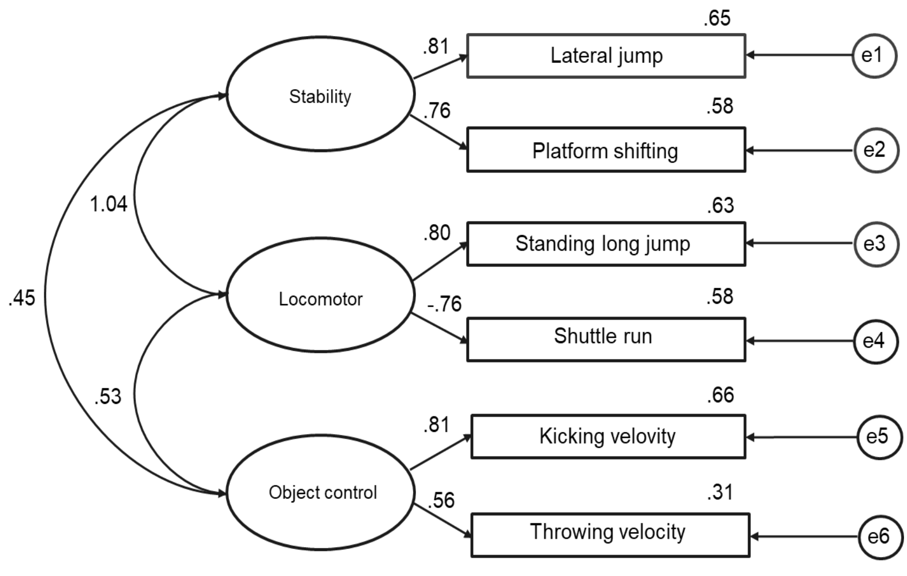

Figure 1. Result of the confirmatory analysis for the model initially hypothesized by Luz et al. (2016)
Note: e1 to e6 represent the variable errors
Source: The authors

This model showed appropriate adjustment indexes [x^2 = 0.425 p> 0.000; RMSEA = 0.000 (90% CI: 0.00-0.82); GFI = 0.92; TLI = 1.00; CFI = 1.00 and SRMR = 0.01], which supporting the three-factor model for MCA. However, a high correlation was seen in the factor load between latent stability and locomotion factors (1.04).

Due to the high correlation found between the latent factors, that is, stability and locomotion, a two-dimensional structure model was tested (Figure 2), which showed a better suitability of the adjustment indices [x^2 = 7.929 p> 0.440); RMSEA = 0.001 (90% IC 0.00-0.81); GFI = 0.98 TLI = 1.00; CFI = 1.00 and SRMR = 0.02], similar to those found in the three-factor model. This standardized solution is shown in Figure 2 by a structure that contains a Loc/Est factor: lateral jump; platform shifting , standing long jump and shuttle run, in addition to a second object control factor: kicking and throwing. The shuttle run variable has a negative value depending on its characteristic; the best values are expressed in the shortest periods of time in the test, that is, the higher the time, the worse the performance. It was seen that kicking skill had the highest factor load (0.86), whereas throwing had the lowest factor load (0.54).

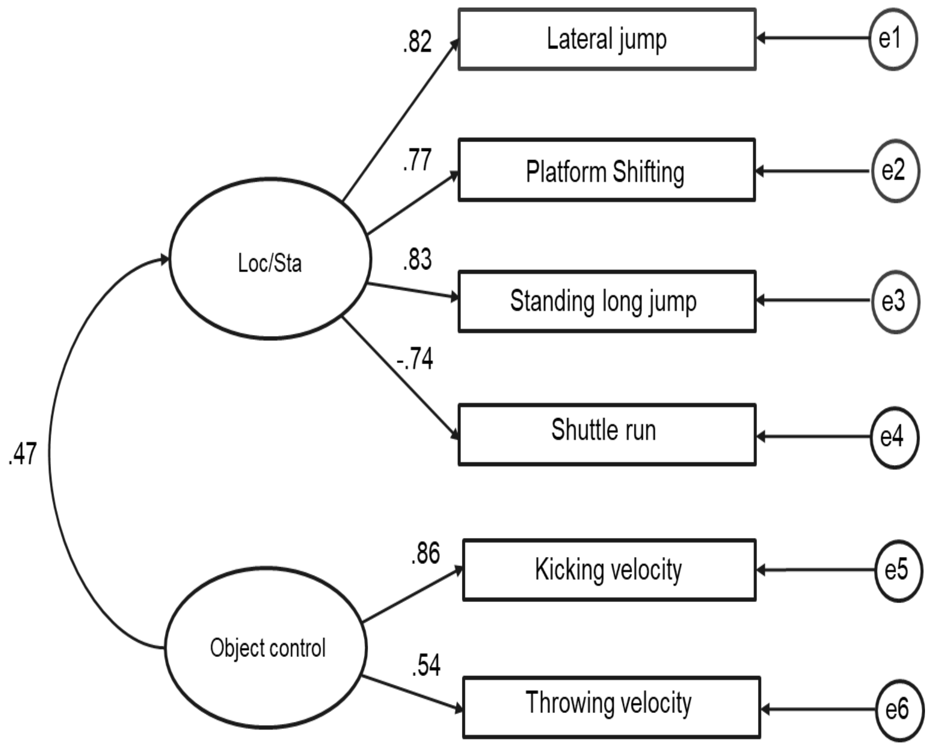

Figure 2. Result of the confirmatory analysis for the model containing two dimensions
Note: Loc: locomotion; Sta: stability; e1 to e6 represent the variable errors
Source: The authors

Considering the bivariate correlation, a significant association of moderate magnitude (r = 0.57; p <0.001) was found between the MCA and TGMD-2 batteries of tests.

Table 2 shows the results concerning reliability, in addition to the statistical data of the means, standard deviation and the 95% confidence intervals for the ICCs. Considering the test-retest analysis, the lowest values occurred for the lateral jump and throwing velocity, however, the ICC values reached are acceptable.

Table 2. Means and standard deviation of the test-retest scores and 95% confidence interval for intraclass correlation coefficients. João Pessoa (PB), 2018 (n = 53)

Test items	Test		Retest			
	Mean	(SD)	Mean	(SD)	ICC	CI 95%
Lateral Jump (points)	10.06	3.32	10.58	3.33	0.77	0.60 – 0.86
Platform shifting (points)	9.06	3.35	8.62	2.96	0.91	0.85 – 0.95
Shuttle run (s)	20.23	3.33	20.34	3.39	0.95	0.92 – 0.97
Standing long jump (cm)	0.63	0.27	0.65	0.24	0.96	0.94 – 0.98
Throwing velocity (km/h)	17.77	9.59	14.85	10.07	0.79	0.64 – 0.88
Kicking velocity (km/h)	18.11	10.66	16.42	9.22	0.86	0.75 – 0.93

P.S.: SD = standard deviation; ICC = Intraclass Correlation Coefficient; CI = 95% confidence interval
Source: The authors

Discussion

This study assessed significant aspects of the construct validity, criteria and reliability of MCA[16] in Brazilian preschoolers. The results found show two models for MCA factorial structure in preschoolers, a three-dimensional model and a two-dimensional one. Although the two solutions produced a good model fit[20], the present study provides evidence for using the battery based on a two-dimensional model (locomotion/stability and object control) of MC in early childhood, considering a reduced number of factors (just two). One of them encompasses locomotion and stability skills. Even revealing a contemporary trend, the inclusion of balance/stability abilities into the batteries to assess MC[21], the stabilization skills have traditionally been categorized as the ones underlying locomotor skills[22].

Such results corroborate with the theoretical taxonomy base developed for TGMD-2[11], which uses two subdomains to assess gross motor skills (locomotion and object control)[23]. Burton and Miller[24] only consider the locomotion and object control classifications because they are the most commonly used in the literature, besides being the basis for most of the tools that have been developed to assess MC in children and adolescents. In addition, they are considered fundamental to be applied to sports, games and other physical activities specific to the context[3,25].

However, these findings differ from the initial study on MCA carried out in Portugal with a specific population of children and adolescents, which suggests a solution with three factors. The difference in the latent factors found in the present study, compared to the original investigation, is likely to be related to the age range of the participants. The complexity of the assessment of movement skills reflects a multifactorial identity of the motor system[5]. This result can be explained by the fact that the latent trait underlying motor assessment can be divided into multiple domains due to maturation and environmental experiences.

The comparison between the findings of the present study and the results found in the literature is complex, since there are no studies that have applied MCA. Despite this, the presentation of a two-dimensional model is shown as a valid alternative for assessing MC in preschool-age children, associated with practicality and the application of tasks widely used in other tests (KTK and TGMD-2), which may include MC construct.

Despite the fact that both batteries have similar tasks, the result of the correlations between MCA and TGMD-2 is likely to be related to the specificities found in each battery. MCA is a battery that evaluates the product, whose results related to skills are quantitatively measured. On the other hand , TGMD-2 provides a qualitative assessment of the execution of skills.

Previous research has shown evidence[26] that evaluations oriented to processes and products measure similar constructions[27]. The results shown herein seem to reinforce this finding, although the evaluations were carried out with different age groups. Both assessment strategies provide a useful assessment of MC and should be concurrently used to obtain a more holistic assessment of MC in preschoolers[21].

Considering the repeated administration of the protocol of the six items/tasks in the same participants, the results were expected to be acceptable, since the objective nature of the measures generally guarantees a high level of reliability among the evaluators over time[28]. The present results confirmed this information, thus, showing that they are consistent over time in preschool-age children, whose ICCs varied between 0.77 and 0.96 for the items, which indicates excellent reliability.

Despite this, the motor performance assessment is particularly prone to variability in consistency in different motor tasks[29]. When seen among preschoolers, such tasks can also be associated with inconsistent performance and fatigue in the performance of tests. In addition, 3-4-year-old children are often easily bored with repetitive activities and are not worried to do them to please evaluators[30]. Considering throwing, specifically, a certain difficulty in capturing the dice with the use of the radar pistol was seen, since this equipment requires a minimum speed, which sometimes can not be reached by younger children. Defining an adaptation criterion material (ball) and/or the number of valid repetitions is significant to prevent 3-4-year-old children from making tasks that are more difficult to be measured. These practical considerations must be taken into account when selecting a protocol for evaluating MC in preschoolers.

Conversely, high consistency in locomotion skills, shuttle run and standing long jump was seen. Similarly to this phenomenon, test-retest reliability was also confirmed in Brazilian children[18] and high values were found for locomotion skills. Locomotion movements have a phylogenetic basis, which enables the humans to reach the initial and elementary stages of these movements before other movements[31]. This is likely to be a possible explanation for the occurrence of this phenomenon in the sample evaluated.

The present study assessed significant aspects of construct validity with regard to the assessment of MC with MCA[16]. In addition, the correlation between MCA and TGMD-2 bateries of tests widely used in the literature was verified. The use of different procedures, such as the exploratory and confirmatory factor analysis, reliability and correlation between tests is highlighted as the main aspect, since evidence of validity must be provided by using multiple techniques and evidences so as to make interpretations and argue on solid decisions[23]. Another point that deserves to be highlighted is that the results of this study represent an important step towards the use of a battery with motor tasks widely used in previous research scenarios as representative of MC[7,10,32], oriented to the product and at the same time objective and easy to be applied to preschoolers. A product-oriented assessment can be part of process-oriented assessments, enabling a more comprehensive analysis of MC, as recommended in some studies[21,27,33].

Finally, in spite of the fact that a model different from a three-dimensional one for assessing motor competence was found, it is worth mentioning the sample size and the study sampling process. The sample was randomized, representative by age and sex due to the epidemiological design of this investigation and to the institutions that were located in different regions of the city of João Pessoa. However, some limitations must be recognized. A significant limitation of the present study is that the adaptation of specific materials regarding the object control ability was not made respecting the physical characteristics of the participants in early childhood. It is suggested that further studies investigate the two-dimensional model shown in this study by using six motor tasks for the investigation of the motor competence of preschoolers. Assessing the model invariance would be useful over time. This process is essential to monitor the development of children's MC and wheher this construct changes throughout childhood[34].

Conclusions

In view of the results found in the present study, the latent structure represented by three variables of the MC construct in the Motor Competence Assessment was confirmed by the confirmatory factor analysis. Despite this, a two-dimensional model showed better adjustment rates for the sample of Brazilian preschoolers. MCA and TGMD-2 have a significant correlation of moderate magnitude, which indicates that the two batteries seem to measure, in part, similar aspects of MC. The protocol of MCA tasks when applied to preschool children with typical development maintains temporal stability. The findings of the present study may impact the practice of Physical Education professionals and researchers, since a two-dimensional model is shown as an option for assessing MC of preschoolers.

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