Evidence of reliability and construct validity of a motor coordination test with ball (MCTB) for adolescents aged 13 to 15

Evidencia de fiabilidad y validez de constructo de una prueba de coordinación motora con pelota para adolescentes de 13 a 15 años

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Abstract

Objective: The study aimed to present evidence of reliability and construct validity of the Motor Coordination Test with Ball (MCTB) for adolescents aged 13 to 15 years.
Methodology: The sample consisted of 402 students, stratified equally into both sexes and age groups.
Results: The reliability results of the study, carried out using the intraclass correlation coefficient, showed "excellent" reliability in the intra - and inter-rater measurements (≥0.999 (0.999; 1.000) and ICC ≥0.982 (0.961; 0.991), respectively). Regarding the results of construct validity, the exploratory factor analysis showed good fit and adjustment indexes of the final two-dimensional model (BTS= 0.001; KMO= 0.81; factor loading 0.51 to 0.91; communality 0.25 to 0.86; explained variance of 65%; GFI=0.99; AGFI= 0.99; RMSR= 0.02). Confirmation of the model, carried out through confirmatory factor analysis, with X2 = 60.2 significant for p<0.001 and indices of absolute goodness of fit (GFI = 0.99, RMSEA = 0.08), incremental fit (NFI = 0.97, TLI = 0.96, AGFI = 0.99), and parsimonious fit (CFI 0.98), showed adequate adjustment for the tested model. Regarding the individual classification values of the tasks, it was observed, that males presented a higher percentage of correct classification of the original cases (86.6%) and validation crossed (84.1%) compared to females (85.6% and 82.1%, respectively).
Conclusions: Paying attention to the indices of the reliability and construct validity, it is possible to qualify the MCTB as a valid and reliable instrument for evaluating Motor Coordination with a ball, for Brazilian adolescents aged 13 to 15 years of both sexes.

Keywords

Motor coordination; psychometrics; students; teenagers; validation.

Resumen

Objetivo: El objetivo del estudio fue presentar evidencias de la validez de constructo y fiabilidad del Test de Coordinación Motora con Balón (TCMB) en adolescentes de entre 13 y 15 años.
Metodología: La muestra consistió en 402 escolares, igualmente estratificados en ambos sexos y grupos de edad.
Resultados: Los resultados de fiabilidad del estudio, realizados mediante el coeficiente de correlación intraclase, indicaron una fiabilidad "excelente" en las mediciones intra e inter evaluadores ((CCI ≥0,999 (0,999; 1,000) e CCI ≥0,982 (0,961; 0,991), respectivamente). El análisis factorial exploratorio para validar el constructo mostró buenos índices de adecuación y ajuste del modelo bidimensional final (BTS= 0,001; KMO= 0,81; carga factorial 0,51 a 0,91; comunalidad 0,25 a 0,86; varianza explicada 65%; GFI=0,99; AGFI= 0,99; RMSR= 0,02). La confirmación del modelo mediante análisis factorial confirmatorio, con X2 = 60,2 significativo para p<0,001 e índices de ajuste absoluto (GFI = 0,99, RMSEA = 0,08), incremental (NFI = 0,97, TLI = 0,96, AGFI = 0,99) y parsimonioso (CFI 0,98), mostró un ajuste adecuado. En cuanto a los valores de clasificación individual de las tareas, el análisis discriminante mostró que los hombres tenían un mayor porcentaje de clasificación correcta de los casos originales (86,6%) y de la validación cruzada (84,1%) que las mujeres (85,6% y 82,1% respectivamente).
Conclusiones: Atendiendo a los índices de la confiabilidad y validez de constructo, es posible calificar el TCMB como un instrumento válido y confiable para evaluar la coordinación motora con balón, para adolescentes brasileños de 13 a 15 años de ambos sexos.

Palabras clave

Coordinación motora; psicometría; alumnos; adolescentes; validación.

Introduction

Over the years, National Research in the area of motor development has used several assessment instruments that indicated levels below what is expected in schoolchildren and/or sports practitioners, considering gender, age group and/or motor development phase (Nobre et al., 2014; Luz et al., 2015; Brasil et al., 2015; Santos et al., 2016a; Hardman et al., 2017; Oliveira et al., 2017; Castro et al., 2017; Lages et al., 2021; Aburachid et al., 2021; Araújo et al., 2021; Fraga et al., 2021; Moura et al., 2022; Mazzardo et al., 2022; Mazzoccante et al., 2022; Figueiredo et al., 2025).

The evaluation of children's motor proficiency levels requires the use of valid and reliable instruments for specific populations, since the information obtained ensures adequate subsequent care for those evaluated late and supports the design and implementation of effective interventions both in the school context and in sports initiation (Valentini et al., 2022; Fortes & Fiorese, 2022).

Despite the lack of instruments classified as “gold standard” for the evaluation of motor performance, there are currently several studies in the literature with different proposals and types of validation, some of them for the Brazilian sample/population. However, the vast majority present original psychometric processes for populations totally different in geography, culture and society. Among them are: Movement Assessment Battery for Children (MABC-2) (Henderson et al., 2007; Valentini et al., 2014); Test Wiener Koordinationparcours (Wkp) (Warwitz, 1976; 1982; Sousa, 2014); basic motor competencies in primary school test (MOBAK) (Herrmann et al., 2015); Test of Gross Motor Development (TGMD-2) and (TGMD-3) (Ulrich, 2000; Valentini et al., 2016); Oseretsky Bruininks test of Motor proficiency (BOT-2) (Bruininks & Bruininks, 2005; Ferreira et al., 2020); body coordination test for children (KTK) (Kiphard & Schilling, 1974; Moreira, 2016; Nazario et al., 2022); Motor Development scale (MDS) (Rosa Neto et al., 2010); TECOBOL (Silva, 2010); motor coordination test with Ball (MCTB) (Ribas et al., 2022).

Considering as focus the evaluation of motor coordination (MC), the KTK test (Körperkoordinationstest für Kinder) is the best known and is widely used nationally and internationally (Fraga et al., 2021; Castilha et al., 2022; Mazzoccante et al., 2022; Gorla et al., 2022; Lima et al., 2023). Moreira et al. (2019) presented a validity process of this instrument to measure the MC of Brazilian children and adolescents, although other studies (Ribeiro et al., 2012; Nazario et al., 2022) have observed the lack of a KTK reference standard for the context of Brazilian children, since their motor tasks have on average, a moderate ability to discriminate children with different levels of MC. It is emphasized the need to investigate the items of the motor assessment instruments, in order to weigh the motor tasks for better construction of normative tables for the Brazilian population in question.

Although the KTK is an important motor assessment instrument (Vandorpe et al., 2011), when analyzing the specificity of the motor actions performed in sports games, especially in relation to the interaction of the object/individual, it reinforces the insufficiency of the evaluation of MC in this context, since this battery of testing involves the components of balance, rhythm, strength, laterality, speed and agility isolated, without implement (Scordella et al., 2015).

Considering the aforementioned components related to KTK and its weaknesses in the evaluation of MC in the sports context and in an attempt to minimize this gap in the literature, Ribas et al. (2020) presented evidence of content validation of the ball motor coordination Test (MCTB). This instrument evaluates MC through four tasks that use skills and implements belonging to different sports modalities. The MCTB was elaborated according to the theoretical model of the combinations of the requirements of coordinative pressures, integral of the teaching model of the ball School (Kröger & Roth, 2002). Continuing the psychometric process, Ribas et al. (2022) presented evidence of reliability, construct validity and classification tables of the instrument for the Brazilian sample, of both sexes, in the age group of 10 to 12 years.

The use of psychometric processes (Pasquali, 2010) seeks to minimize methodological weaknesses and biases in the interpretation of the results, due to cultural and population distinctions pointed out in the literature (Yun & Ulrich, 2002). In this sense, the aim of the study was to present evidence of reliability and construct validity of MCTB for adolescents aged 13 to 15 years. This work is expected to reduce the gap and shortage of instruments for the evaluation of motor coordination with Ball, increasing the age range of the battery of the MCTB (Ribas et al., 2022).

Method

Sample

The study sample consisted of 402 adolescents aged 13 to 15 years, of both sexes, from the 5 public school system (municipal and state) of the state of Mato Grosso. The participants did not play sports outside of school.

Regarding the sample size required for factor analysis, Pasquali (1999) suggests the evaluation of at least 100 subjects per Factor/task. In this sense, for the experimental sample of the study, the following sample calculation will be adopted: the number of tasks presented 4 (tasks) X 100 (subjects) = 400. Taking into account the stratification of egalitarian with respect to gender and age was 67 subjects per group (male 13, 14 and 15 years old) and a Female of 13, 14 and 15 years old) - a total of 402 individuals. This human-related research complied with all relevant national regulations and institutional policies followed the standards set by the National Health Council (2012) involving human research. It was approved by the Research Ethics Committee of UFMT under CAAE number 54375921.3.0000.8124. Their legal guardians authorized the children's participation in the study through signed informed consent forms, and the children also provided their assent to participate in the study.

Instrument and collection procedure

The instrument used in the validation process of this study was the ball motor coordination Test (MCTB) (Ribas et al., 2022). Originally, the instrument aimed to evaluate the level of motor coordination with ball of children, of both sexes, in the age group of 10 to 12 years.

The protocol consists of four tasks, performed with hand / foot on the right and/or left sides of the body, using fundamental motor skills common in the practice of invasion team sports (bouncing, guiding, kicking, throwing and receiving), under six pressure conditions/demands (time, precision, sequence, simultaneity, variability and burden) (Kröger & Roth, 2002).

The estimated time for an individual assessment with the MCTB is 12 minutes. After performing the tasks, by the evaluated, the evaluator makes an individual diagnosis per task and / or a general classification of the MCTB. At the request of Hernández-Nieto (2002), an important condition for instrument validation are good indices of content validity in terms of language clarity (CVCT = 0.89), practical relevance (CVCT = 0.81) and theoretical relevance (CVCt = 0.86) (Ribas et al., 2020).

In the individual Classification of the tasks of the MCTB, the best results are identified for each task individually, Table 3 is used to assign the grade (1 to 3) of the tasks performed. Being 1 regular rating, 2 good and 3 very good. In tasks 1 and 4 the shortest times (seconds and hundredths) will be used for the individual classification of performance. It is important to use two digits after the comma to measure time. In tasks 2 and 3, the highest results of the weighted scores will be used, since the tasks take into account the evaluation of time (seconds and hundredths) and the amount of hits on the targets. Thus, the weighted scores will be given by the following equation:

Weighted score (WS) = (1 / time) * No of hits on targets

It is important to use three digits after the comma to measure the WS.

Table 1. Time and weighted score of individual Classification of MCTB tasks in relation to sex and factors.

Tasks		Female			Male		
Classification		Very Good (3 points)	Good (2 points)	Regular (1 point)	Very Good (3 points)	Good (2 points)	Regular (1 point)
Factor 1	T1 * hand(s)	≤ 17,99	18 to 26.99	≥ 27	≤ 15,99	16 to 24.99	≥ 25
	T1@foot (s)	≤ 18,99	19 to 27.99	≥ 28	≤ 15,99	16 to 23.99	≥ 24
	T2 (WS)	≥ 0,289	0,288 - 0,187	≤ 0,186	≥ 0,370	0,369 - 0,234	≤ 0,233
	T3 (WS)	≥ 0,351	0,350 - 0,256	≤ 0,255	≥ 0,521	0,520 – 0,371	≤ 0,370
Factor 2	T4SH(s)	≤ 5,99	6 to 11.99	≥ 12	≤ 5,99	6 to 10.99	≥ 11
	T4SAH(s)	≤ 5,99	6 to 11.99	≥ 12	≤ 5,99	6 to 10.99	≥ 11

Subtitle: *classification for hand balls; @ classification for foot balls; T1 to T4 = tasks 1 to 4; tasks 2 and 3= weighted scores (see protocol); < "X" less; ≤ "X" less or equal; ≥ "X" greater or equal; (s) time in seconds and hundredths; (WS) standard score (use formula).
Note: it is in charge of the researcher/teacher the identification of the hand and foot balls used in Task 1.

Classification of factor 1 tasks: after scoring the tasks individually using Table 1, the sum of the points of tasks 1 to 3 is performed, for this the score and classification referring to the tasks of Factor 1 is used (Table 1).

Example factor 1: Score task 1 (Ball 1) + score task 1 (Ball 2) + score task 1 (ball 3) score task 1 (ball 4) + score Task 2 + score Task 3= totaling "X" points. This score represents" X " final classification of Factor 1 tasks (Table 2).

Classification of FACTOR 2 tasks: After scoring the task individually, using table 1, we sum task 4 in (clockwise + counterclockwise), and we use the scores and classification for the task of a Factor of 2 (table 2).

Example factor 2: Score task 4 (Clockwise) + score task 4 (counterclockwise) = "X" points.

Representing" X " classification for Factor 2 tasks (Table 2).

General

Table 2. Classification of the tasks of Factor 1 (bouncing/guiding), factor 2 (Throwing/receiving) and General Classification of the MCTB.

	Scoring	Classification
FACTOR 1 Bouncing / Guiding	15 to 18 11 to 14 ≤ 10	Very good Good Regular
FACTOR 2 Throwing/Receiving	5 to 6 4 ≤ 3	Very good Good Regular
GENERAL	20 to 24 14 to 19 ≤ 13	Very good Good Regular

The collection was conducted by a team of seven evaluators, formed by university students of Physical Education, with course progress above 50% for completion. All evaluators knew the instrument and received prior training for the application of all tasks. The mean time of application of the MCTB was estimated at 45 minutes per group of 4 evaluated, with the 4 tasks being performed concomitantly. Task 1, as it took a longer execution time, used two mounted areas, so that the group of 4 evaluated was divided, 2 evaluated in one task 1 and the other two in the other task 1, thus seeking to follow the execution time of the other tasks, improving the progress of the rotation of the evaluated in the tasks.

Data analysis: MCTB validity process

The validation process used was that proposed by Pasquali (2010). The experimental procedure was carried out, which establishes the steps and techniques of the application of the instrument and the analytical procedure, which comprises the statistical analyzes necessary for the type of validation required.

For the inter-rater evaluation, the two-way mixed-effect model with absolute agreement ICC was used; and for the Intra-Rater evaluation, the two-way random effect, absolute agreement (Koo & Li, 2016). A seven-day interval between evaluations was used for all measures (Hill & Hill, 2002). It evaluates the reliability and the consistency between multiple measurements made by different observers or instruments. In this study, 10% of the total sample (20 female and 20 male students) were evaluated (Tabachnick & Fidell, 2018).

In the ICC values, the respective 95% confidence intervals were considered, which allows to interpret as follows: poor reliability (≤ 0.5) moderate (0.5 to 0.75); good (0.75 to 0.9); excellent (0.9 to 1.0) (Koo & Li, 2016).

For factor analysis, exploratory, confirmatory and multigroup factor analyses were performed. In the exploratory factor analysis (EFA), the eigenvalues (>1.00) determined the number of factors (latent variables or constructs), we used the maximum probability estimator method with a rotation varimax. The cut-off value of 0.50 was used to determine the factor loads included in the model (Marôco, 2014). To measure incremental and absolute adjustment, the GFI was used: goodness of fit index (acceptable value > 0.90), AGFI: adjusted goodness of fit index (acceptable value >0.90); RMSR: Root Mean Square Residual (ideal close to zero or <0.10) (Marôco, 2014). The Barlett Test of sphericity, the Measure of Sampling Adequacy (MSA) and the test of Kaiser Meyer Olkim (KMO) for all variables involved in the analysis.

The following are the indicators of the quality of the model in the confirmatory factor analysis it was used the chi-square test (χ2 p-value); the goodness of fit index (GFI >0,90); a Root mean square error of approximation (RMSEA < 0.05 upper limit of 90% confidence interval, less than 0.10); Bentler-Bonett normed fit index (NFI > 0.90); the Tucker-Lewis index (TLI > 0.90); the adjusted goodness of fit index (AGFI > 0,90); and the comparative fit index (CFI > 0,90); (Hair et al., 2009; Moroco, 2010; 2014). Multigroup analysis was applied, considering sex as a group, to estimate the invariance of the model in 2 levels, metric (equivalence of the models relative to the factor loads for the groups) and scalar (equivalence of the models relative to the intercepts and factor loads for the groups). Chi-square Delta and CFI Delta values were obtained to quantify the differences of the models.

To determine the quality of the individual classification of the tasks of the groups, discriminant analysis was applied. The Wilks Lambda classification model test yielded a significance value of p= 0.001 for both males and females, demonstrating adequate discrimination of groups by gender. The results show the percentage of correct classification of the original cases and cross-validation.

The statistical analysis was performed on JASP (JASP Team 2022) and R (R Core Team 2020) software, such as the use of the "lavaan" (Rosseel, 2012) and "psych" (Revelle, 2018) libraries.

Results

Reliability

Analyzing the results, we observed better coefficients for intra evaluation when compared to inter-rater evaluation (ICC ≥ 0.999 (0.999; 1.000) and ICC ≥ 0.982 (0.961; 0.991) respectively). However, the results were significant and presented an "excellent " rating in all tasks evaluated.

Exploratory Factor Analysis (EFA)

The EFA results showed us a factorial model comprised of two factors, which indicate satisfactory fit, sphericity and percentage of explained variance measures. In addition, the incremental and absolute fit measures performed by means of goodness of fit index (GFI=0.99), adjusted goodness of fit index (AGFI=0.99); RMSR – Root Mean Square Residual (RMSR=0.02), indicate "very good" classification for the proposed model.

Table 3. Measures of fit and quality of the EFA model.

INDEX	Value
Number of factors	2
Bartlett's test (BTS)	<0,001
Kaiser-Meyer-Olkin test (KMO)	0.81
Factor Loadings	0,51 - 0,91
Communalities	0,25 - 0,86
Variance explained	65%
Goodness-of-fit (GFI)	0.99
Adjusted Goodness-of-fit (AGFI)	0.99
Tucker-Lewis Index (TLI)	0.89
Root mean square of residual (RMSR)	0.02

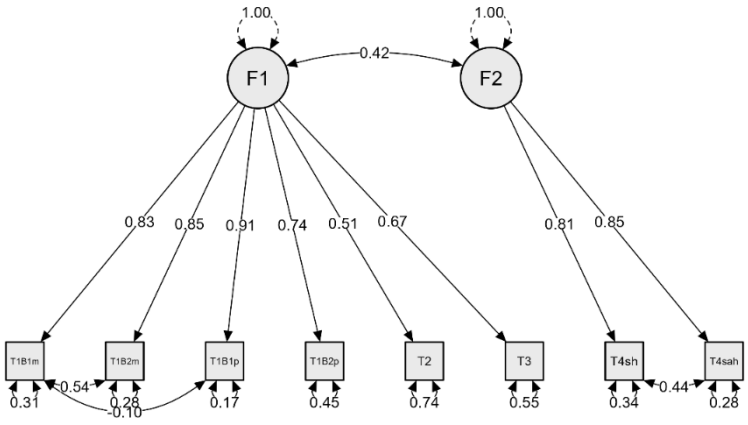
Subtitle: Bartlett test (BTS), Kaiser-Meyer-Olkin Test (KMO), goodness of fit index (GFI), adjusted goodness of fit index (AGFI), Tucker-Lewis Index (TLI), root mean square of residual (RMSR).

Confirmatory Factor Analysis (CFA)

When analyzing the factorial structure of the two-dimensional model of the MCTB, or global adjustment of the model, it was found that the evaluated sample presented an X2 = 60.2 significant for p < 0.001. However, due to their sensitivity, it is essential to observe the other indices as described below.

The other absolute adjustment measures obtained values within the acceptable limits recorded in the literature (GFI = 0.99, RMSEA = 0.08). All incremental adjustment measures (NFI = 0.97, TLI = 0.96, AGFI = 0.99) showed the recommended level (0.90) or higher. Regarding the measures of parsimonious adjustment, the CFI (0.98) reached a level higher than that proposed by the literature (>0.90), showing acceptable adjustments of the proposed model. On a sequential basis, as shown in figure 5, we present the diagram of the factors, and the values of the factor loading obtained from the model bias.

Figure 1. Factorial loading of the two-factor model of the MCTB.



Subtitle: F1: Factor 1; F2: factor 2; T1B1m and T1B2m: task 1 Balls 1 and 2 performed by hand; T1B1p and T1B2p: task 1 balls 3 and 4 performed by foot; T2 and T3= tasks 2 and 3; T4sh= task 4 performed Clockwise; T4sah= task 4 performed counterclockwise.

From the analysis of the standardized solution expressed in Figure 1 (or of the estimated parameters after confirmatory factor analysis) it was verified that the factor saturations showed moderate to excellent values (between 0.51 and 0.91) and significant (p= 0.000). Convergent validity was estimated by average variance extracted (AVE) and was considered adequate >0.50 (F1= 0.57; F2=0.78).

Finally, the model presents a goodness of fit index that reveals very good adequacy for all adjustment measures (absolute, incremental and parsimonious), resulting in a model with a valid and satisfactory fit.

The quality of the Tools Classification Tables

In order to identify the quality of the groupings of the individual classification of the MCTB tasks, discriminant analysis was used. In this sense, the test Wilks Lambda of the classification model selected in both sexes (Table 4) showed a significance of p = 0.001, demonstrating appropriate discrimination of the groups in relation to sex.

Regarding the individual classification values of the tasks, it was observed, through the discriminant analysis, that males presented a higher percentage of correct classification of the original cases (86.6%) and cross-validation (84.1%) compared to females (85.6% and 82.1%, respectively).

For the cutoff points in the discriminant analysis, we used the same ones found in the validation process of the MCTB in the age group of 10 to 12 years (Ribas et al., 2022), since they were adequate to the indices demonstrated in the classifications of the original and cross-validation cases. In light of this we will use the same tables for classifying the instrument.

Table 4 shows the correct classification of the model, original results, cross-validation and Wilks-Lambda discriminant analysis.

Table 4. Classification of discriminant analysis results.

	CORRECT CLASSIFICATION IN THE MODEL				
	MALE		FEMALE		
	Original	Cross-Validation	Original	Cross-Validation	Wilk-Lambda P
F1	85,6%	85,1%	89,1%	87,1%	<0,001
F2	95,5%	95,5%	94,5%	94,0%	<0,001
MCTB	86,6%	84,1%	85,6%	82,1%	<0,001

Subtitle: F1: Factor 1; F2: factor 2; MCTB: motor coordination test with Ball.

The results of the classification of the original cases and the cross-validation are very close, which gives validity to the analysis.

Discussion

The study aimed to present evidence of reliability and construct validity of the Motor Coordination Test with Ball (MCTB) for adolescents aged 13 to 15 years.

Reliability of Intra-and Inter-rater measures

Intra-and inter-evaluator measures it was found that the ICC values of the present study presented excellent significance and magnitudes for all tasks evaluated (> 0.9) (Koo & Li, 2016). Similarly to the results of the present study, in the validation study of the motor coordination test with Ball (MCTB) (Ribas et al., 2022), for the age group of 10 to 12 years old, in assessing the reliability of the instrument, the results of the intraclass correlation coefficient indicated "excellent" reliability in intra-and inter-evaluator measures (ICC > 0.90).

These results are similar or superior to studies that have evaluated the motor performance of children and adolescents, even if they have not studied the same phenomenon, coordination can be considered as a constitutive parameter of motor performance, as observed in the study by Valentini et al. (2022), when they investigated the items of the *Test of Gross Motor Development*-3 (TGMD-3), in children aged 3 to 10.9 years old, belonging to public and private schools in different regions of Brazil. It was observed that the ICC indexes were from 0.70 to 0.99 (intra-evaluator 0.70 to 0.90 and inter-evaluator 0.85 to 0.99).

Nazario et al. (2022) verified in their study the adequacy of KTK motor tasks by analyzing the degree of difficulty and discrimination parameter of each motor task. He observed that the ICC results ranged from 0.80 to 0.99, showing agreement among the examiners.

In order to evaluate the reliability and to determine the validity of TGMD-3 for children and adolescents with visual impairment, the study of Brian et al. (2018) calculated three intraclass correlation coefficients (ICC): gross motor coordination (0.91), locomotor skills (0.92) and ball skills (0.92), all of which achieved ICC scores indicating strong reliability among raters.

In addition to the aforementioned studies, it is noted that the ICC is the most used inferential test to verify intra-and inter-evaluator reliability in motor tests with numerical data and that the results are presented, in most studies, with magnitudes similar to those found in the present research (Smits-Engelsmann et al., 1998; Cools et al., 2009; Valentini, 2012; Lucas et al., 2013; Valentini et al., 2014; Capio et al., 2015; Nobre et al., 2016).

Exploratory Factor Analysis

The EFA results reinforced the two-dimensionality of the instrument by loading the same tasks in factors 1 and 2 (Table 1), with incremental and absolute fit indices classified as very good (Field, 2009; Hair et al., 2009; Marôco, 2014).

This fact can be explained in the description of the methodological approach, considering that the intensity of the coordinative pressure requirements changes according to the characteristics of the context, acting on motor performance in the form of an equalizer (Neumaier, 1999; Kröger & Roth, 2002, Roth, 1998), always according to the specificity of the motor tasks of the test.

In addition to the explanation of the methodological approach, another fact that corresponds to the extraction of the two factors is the similarity of motor skills, manual and pedal, used in the tasks retained in Factor 1 (bouncing/guiding) and factor 2 (Throwing/receiving). These same characteristics in validity processes of other motor tests that evaluate motor performance or sports skills have also been found (Ulrich, 2000; Henderson et al., 2007; Kiphard & Schilling, 1974; Rosa Neto, 2010; Morrow et al., 2013; Kim et al., 2014; Farrokhi et al., 2014; Ribas et al., 2022; Valentini et al., 2022; Valentini et al., 2022).

Confirmatory Factor Analysis

The factorial structure of the theoretical model of MCTB in the present study demonstrated good adequacy, as shown in Figure 1 and in the fit results previously described. The individual reliability values of the items confirmed the saturation indicated in the EFA and were higher than 0.50, an index recommended by the literature (Balbinotti, 2005; Marôco, 2010). Further, a significant chi-square ($p < 0.001$) was obtained (Marôco, 2010).

The factor model is important to the factor loading and fit indices. The study of Santos et al (2017) evaluated the factorial Organization of the MABC-2 for the age group of 8-10 years from the perspective of classical and modern psychometric theory. They tested the factor structure of MABC-2 and a new factor structure with four factors, showing that the new one is not satisfactory. Therefore, factor analysis confirmed the original three-factor model, in which good evidence of validity was produced, with adequate indices.

Considering the KTK as the most used instrument in the world context for motor coordination assessment, the study Moreira et al. (2019) investigated its factorial structure in a Brazilian sample (565 children aged 5 to 10 years); and compared four possibilities for calculating the factorial score of the test: precisely the sum of the scores, sum of the standard scores, weighted method and refined method. The results showed adequate factorial structure to the model for the total sample, by sex, and by age groups. However, the results did not confirm the invariance between genders and age groups. In addition, it was observed that the sum of the raw scores of the subtests could be used as the factorial scoring method in the KTK.

Recently, Nazario et al. (2022) verified the adequacy of KTK motor tasks by analyzing the degree of difficulty and the discrimination parameter of each motor task, in 385 children aged 5 to 14 years. For that purpose, they used confirmatory Factor Analysis (CFA) to test the model elucidated in the EFA, in order to evaluate the fit and suitability of the model through quality indicators, factor loading and individual reliability of the item, including X2 (11.71), RMSEA (0.05), CFI (0.99) and GFI (0.98), indicating good quality of the model fit for the sample.

In addition, the evidence found in the present study corroborates the results of validation studies of instruments established in the literature for the evaluation of motor performance in Brazilian samples (Valentini et al., 2008; Silva, 2010; Rosa Neto, 2010; Valentini, 2012; Valentini et al., 2014; Sousa, 2014; Moreira, 2016; Santos et al., 2016a; Montoro et al., 2016; Ribas et al., 2022; Valentini et al., 2022) and international validation studies with different samples (Kiphard & Schilling, 1974; Ulrich, 2000; Barnett, 2007; Simons et al., 2008; Wong & Cheung, 2010; Ellinoudis *et al.,* 2011; Vandorpe et al., 2011; Wagner et al., 2011; Hua et al., 2013; Farrokhi et al., 2014; Kim et al., 2014; Capio et al., 2015; Brian et al., 2018).

It should be noted that the validation process of the MCTB strictly followed all the procedures and steps indicated by the literature (Pasquali, 1999; Pasquali, 2010; Marôco, 2010, Marôco, 2014), and could confirm in general good psychometric quality of the instrument, for the Brazilian sample, and suitability to the model of coordinative pressure requirements for coordinated movement proposed by Kröger and Roth (2002).

The study was limited to the inclusion of adolescents / schoolchildren from a single geographical location, with similar socioeconomic, cultural and motor practice backgrounds. For future research, it is expected to expand the evaluated regions in order to increase the generalizability of the results.

Conclusions

By observing the results evidenced in the course of the study, it is possible to present the following conclusions.

The instrument showed reliability with significant indices and excellent magnitudes in intra-and Inter-evaluator assessment.

The two-factor model presented good measures of adequacy and good absolute, incremental and parsimonious fit indices, which confirms the applicability of the chosen methodological approach, establishing parameters to expand the use of MCTB in the age group of 13 to 15 years.

It is possible to affirm that the MCTB can serve as an evaluation parameter of motor coordination with ball, for subjects aged 13 to 15 years from other regions, if we consider the similarity in the motor profile of Brazilian children in this age group, presented in studies previously cited (introduction and theoretical review).

Finally, it is expected that the results of this study contribute to new research involving the construct and its practical applications provide information that assist physical education professionals and teachers in the teaching-learning process and sports training in different regions of the country.

Thus, the study provides an advance to the areas related to motor coordination by providing an accessible, valid and reliable instrument for the assessment of motor coordination in the age group of 13 to 15 years, enabling the expansion of assessments in different areas and the use of new data in future and scientific studies.

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