Validity and reliability of the short-form of the assessment battery for children-second edition (MABC-2-SF) in Spanish children aged 4-7 years

Validez y fiabilidad de la batería reducida para la evaluación de la competencia motora (MABC-2) en escolares españoles de 4 a 7 años

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Abstract

Background. Adequate motor competence during childhood influences physical activity, fitness, and overall development, highlighting the importance of early screening. Despite the lack of a universal assessment tool, the Movement Assessment Battery for Children-second edition (MABC-2) is widely used but time-consuming.
Aims. This cross-sectional study of 147 Spanish children aged 4-7 years (age 5.41±0.55; 47.62% girls; ethnicity white) aimed to examine the validity and reliability of the Movement Assessment Battery for Children-second edition short-form (MABC-2-SF) in children.
Methods and procedures. The validity was tested using exploratory factor analysis and convergent validity analysis, and reliability was assessed by concordance and test performance analysis.
Outcomes and results. The results showed that the MABC-2-SF, which consisted of three subtests, is valid, reliable and useful for pre-screening Spanish children's motor competence aged 4-7 with a 94.16% probability of pre-screening children who are not at risk for developmental motor coordination disorder.
Conclusions and implications. The MABC-2-SF allows pre-screening children's motor competence in a more adjusted cost-efficient way of collecting extensive sample data that could facilitate mass pre-screening tests, benefiting clinicians, educators, and researchers working with young children.

Keywords

Motor competence; motor skills; motor skills disorders; children; short form.

Resumen

Antecedentes. Una competencia motriz adecuada durante la infancia influye en la actividad física, la condición física y el desarrollo general, lo que resalta la importancia de una detección temprana. A pesar de la falta de una herramienta de evaluación universal, la Batería de Evaluación del Movimiento para Niños–segunda edición (MABC-2) es ampliamente utilizada, aunque requiere de mucho tiempo para su evaluación.
Objetivos. Este estudio transversal, realizado con 147 niños españoles de 4 a 7 años (edad 5,41±0,55; 47,62% niñas; etnia blanca), tuvo como objetivo examinar la validez y fiabilidad de la versión breve de la Batería de Evaluación del Movimiento para Niños–segunda edición (MABC-2-SF) en niños.
Métodos y procedimientos. La validez se evaluó mediante análisis factorial exploratorio y análisis de validez convergente, y la fiabilidad se analizó a través del análisis de concordancia y el rendimiento en las pruebas.
Resultados. Los resultados mostraron que la MABC-2-SF, compuesta por tres subpruebas, es válida, fiable y útil para la detección preliminar de la competencia motriz en niños españoles de 4 a 7 años, con una probabilidad del 94,16% de identificar correctamente a aquellos que no están en riesgo de trastorno del desarrollo de la coordinación motriz.
Conclusiones e implicaciones. La MABC-2-SF permite realizar una detección preliminar de la competencia motriz infantil de una manera más rentable y ajustada, facilitando la recogida de datos a gran escala. Esto podría favorecer la implementación de pruebas masivas de preselección, beneficiando a clínicos, educadores e investigadores que trabajan con niños pequeños.

Palabras clave

Competencia motriz; habilidades motoras; trastornos de las habilidades motoras; niños; versión breve.

Introduction

The term motor competence can be defined as a person's ability to execute different motor acts, including both gross (fundamental movement skills such as jumping, running, or catching) and fine motor skills (motor precision skills such as writing, painting, or dressing) (Henderson et al., 2007a; van der Fels et al., 2015). Furthermore, it is known that appropriate motor competence in childhood is an important determinant factor of physical activity, physical fitness (Barnett et al., 2009; Jaakkola et al., 2016; Lopes et al., 2012), and therefore, for physical, mental, and social development and children's health and well-being (Clark et al., 2020; Lopes et al., 2020).

A delay in acquiring gross and fine motor skills and impairment in executing coordinated motor skills that interfere with an individual's daily activities it is known as Developmental Motor Coordination Disorder (American Psychiatric Association, 2013; World Health Organization, 2019), which has a prevalence 2 to 20% in children, most of whom do not outgrow their problems when they reach adolescence and adulthood (Blank et al., 2019). Diagnostic criteria for Developmental Motor Coordination Disorder are included in the International Classification of Diseases 11th revision [ICD–11: 6A04 – Developmental Motor Coordination Disorder, in the 2019 update] (World Health Organization, 2019) and in their four diagnostic criteria, according to DSM 5 (currently defined by the Diagnostic and Statistical Manual of Mental Disorders 5th edition [DSM–5: 315.4 – Developmental Coordination Disorder, in 2013] (American Psychiatric Association, 2013), are the following: i) that the acquisition and execution of coordinated motor skills are below that expected given the individual's chronological age and opportunity for skill learning; ii) that the motor deficits in Criterion A significantly and persistently interfere with activities of daily living and impact on productivity, prevocational and vocational activities, leisure and play; iii) onset of symptoms is in the early developmental period; iv) the motor skills deficits are not better explained by intellectual disability or visual impairment and are not attributable to a neurological condition.

The delay in acquiring gross and fine motor skills occurs during the developmental period mainly and it is typically apparent from early childhood, causing significant and persistent limitations in functioning (e.g., activities of daily living, schoolwork, and vocational and leisure activities) (World Health Organization, 2019). Children with low motor competence prefer a less active lifestyle to avoid movement difficulties (Cairney et al., 2006; Wrotniak et al., 2006); and consequently, they have worse physical (Karras et al., 2019; Raz-Silbiger et al., 2015), psychological, and social health (Karras et al., 2019; Poulsen et al., 2008; Raz-Silbiger et al., 2015; Wuang et al., 2012), and lower academic achievement (Raz-Silbiger et al., 2015). This lack of participation in physical activity leads to less active children which in turn leads to less active adults, resulting in less active parents that also tend to educate their children to be less active (Lopes et al., 2020) with all the consequences that this physical inactivity and poor fitness has on health (Blair, 2009).

Early middle childhood is a crucial period in which particular attention must give to motor competence, and screening should perform. Although there is no gold-standard assessment of motor competence (Lopes et al., 2020), there are around 20 different tools to assess motor competence in childhood, of which only half can be used in children under seven years of age (Cools et al., 2009; Scheuer et al., 2019). Of these, only three have been validated previously in the Spanish population: Test of Gross Motor Development third edition (TGMD-3) (Estevan et al., 2017), Motorische Basiskompetenzen im Kindergarten (MOBAK-KG) , and Movement Assessment Battery for Children second edition (MABC-2) (Graupera & Ruiz, 2012). MABC-2 is the only one that allows the measurement of gross and fine motor competence with a diagnostic cut-off point.

The MABC-2 is one of the most widely norm-referenced validated tests used for assessing motor functions in children aged 4 to 16 years and is considered a good instrument for evaluation in clinical, educational, or research settings (Blank et al., 2012; Graupera & Ruiz, 2012). It has recognized psychometric properties and with a level of evidence for suitability in the diagnosis of Developmental Motor Coordination Disorder rated as moderate to sound by the European Academy of Childhood Disability (Blank et al., 2019; Scheuer et al., 2019). Also, it has cross-cultural validity and is easy to use, thanks to its simple design and low training requirements, showing good to excellent inter-rater reliability, good to excellent test-retest reliability, fair to good validity, reasonable specificity, and sensitivity (Barnett & Henderson, 1998; Blank et al., 2019). Indeed, the Spanish validity for the MABC-2

(Graupera & Ruiz, 2012) showed adequate internal consistency for all age bands, particularly age-band I (4 to 6 years) with Cronbach's α = 0.81, test-retest, and inter-rater reliability in the different tasks (intraclass coefficient's >0.70 and >0.92, respectively). The battery comprises eight age-appropriate tasks, categorized into three age bands (4-6 years; 7-10 years;11-16 years), divided into manual dexterity, balance, and aiming-catching skills (Graupera & Ruiz, 2012). The raw scores obtained from the performance of the different tests are converted into standard scores; these are summed to obtain a total standard score, which can be transformed into a percentile score (Graupera & Ruiz, 2012). At this point, the MABC-2 determines the motor proficiency level of the child involved, which is classified in a traffic light category system, and as a result, can identify children with developmental motor coordination disorder (Graupera & Ruiz, 2012).

However, although the MABC-2 is a globally popular assessment used by many experts in the field, it has two significant limitations in measuring large numbers of individuals, making the process long and tedious (Eddy et al., 2020). First, the time it takes to deliver the standardised measurement which requires a demonstration by the assessor and a practice trial followed by a performance test by each child for the eight battery tasks. Secondly, the time it takes to code and process the data for each subject (Henderson et al., 2007b). Therefore, due to the time spend and potential cost of battery administration involved, developing a short version of the MABC-2 test would help clinicians, educators or researchers conduct mass pre-screening tests in young children. Therefore, this study aimed to develop and propose a MABC-2-Short-Form (MABC-2-SF) to measure motor competence and examine its validity and reliability for 4- to 7-year-old Spanish children.

Method

Study design and participants

A cross-sectional study was conducted to validate the MABC-2-SF. For this, 147 children 4 to 7 years old from three schools were randomly selected from the baseline data of a cluster-randomized cross-over trial (Sánchez-López et al., 2015). This clinical trial aimed to assess the effectiveness of a multicomponent physical activity intervention (MOVI-KIDS) in reducing adiposity and improve academic achievement in Spanish students with and without attention deficit hyperactivity disorder. The characteristics of the sample are presented in Table 1.

The study protocol was approved by The Clinical Research Ethics Committee of the 'Virgen de la Luz' Hospital, and all parents of children who were in the third preschool grade (4–5 years) and the first grade of primary school (aged 6–7 years) were invited to participate. Parent or legal guardians signed informed consent forms to participate in the study. In addition, the children were asked to participate before each measurement of the variables.

Instruments and procedures: main outcome and other variables

In September-October 2013, previously trained, nurses and physical activity and sports sciences graduates assessed the following variables of schoolchildren in their schools and during their school day, in addition to socio-demographic variables.

Motor competence was assessed using the validated Spanish version of the MABC-2, first age band –4 to 6 years– (Graupera & Ruiz, 2012; Henderson et al., 2007b). The first age band of the MABC-2 battery is composed of eight tests grouped in 3 dimensions: manual dexterity (3 items: posting coins; threading beads; and drawing trail), balance (3 items: one-leg balance; walking heels raised; and jumping on mats) and aiming-catching (2 items: catching beanbag; and throwing beanbag onto mats). All raw scores from the tests were normalized into scale scores according to the manual (Graupera & Ruiz, 2012), where the higher scores indicate better motor competence. The sum of all standardized scores was used to classify significant movement difficulties in three categories which are classified into two: a standard score of 69 or below as children with Developmental Motor Coordination Disorder, which includes the developmental motor coordination disorder and at risk of developmental motor coordination disorder categories; and a standard score higher than 69 as children with typically developing.

General intelligence was assessed using the Spanish validated Batería de Aptitudes Diferenciales y Generales (BADyG) for children aged between 3-6 (BADyG I) (Yuste, 2008b) and 6-8 (BADyG E1) (Yuste, 2008a) years of age. This questionnaire consists of 138 and 162 items, respectively, structured in different secondary tests to evaluate several cognitive dimensions (spatial, verbal, numerical…).

Physical fitness was assessed using three tests included in the ALPHA-Fitness test Battery (Ruiz et al., 2011): the 20-meter shuttle run test for cardiorespiratory fitness measured with, the standing long jump test for muscle strength and the 4x10-meter maximum speed-agility for speed-agility.

Weight and height were measured twice following standardized procedures using SECA-821 and SECA-222 respectively (Vogel and Halke, Hamburg, Germany), body mass index was calculated as weight (Kg) / height (m2), and body fat mass percentage was estimated using the BC-418 bioimpedance analysis system (Tanita Corp., Tokyo, Japan).

Socioeconomic status was assessed using self-reported occupation and education questions completed by parents. An index of socioeconomic status was calculated based on the parents' education and occupation levels according to the Spanish Society of Epidemiology scale procedures, which classified the family socioeconomic status into five categories; these five levels were collapsed for our analysis into low, middle, and high (Chilet-Rosell et al., 2012).

Statistical analysis and validation process

Exploratory factor analysis

A principal component analysis was carried out including the eight items from the original battery to select those items that will be included in the MABC-2-SF. For the extraction of both the factors and items, it was considered the following criteria: i) the theoretical model supported by the MABC-2, suggests the existence of three factors of motor competence (manual dexterity, aiming-catching and balance); ii) the number of factors that explain at least half of the motor competence variable; iii) the item with the most significant factorial weight for each factor. Varimax with Kaiser normalization was used as the rotation method (orthogonal), and Maximum Likelihood as an extraction method. Subsequently, a MABC-2-SF index was calculated by summing the standardized scores of the selected items. In addition, the scree plot was obtained from the analysis.

Convergent validity

Receiver operating characteristic (ROC) curves were generated to obtain the optimal cut-off point for the MABC-2-SF index, considering the Youden index (Youden, 1950) for predicting the risk of developmental motor coordination disorder in children. We used the MABC-2 original version as diagnostic criteria, which allows the evaluation and pre-diagnosis of motor problems in children.
Considering high motor competence levels have been associated with better values of physical fitness and body composition, while low levels have been associated with poor academic performance (Cameron et al., 2016; Cattuzzo et al., 2016; Emck et al., 2009), the convergent validity of the MABC-2-SF scale was analysed using an ANCOVA model. In that model, the means of the variables of general intelligence, fitness, and body composition were dependent variables with the categories established in the ROC curve as a fixed factor and age and sex as covariates.

Concordance and test performance

The concordance between the original and the short version was assessed; therefore, sensitivity and specificity were calculated to establish the test performance. Sensitivity is the proportion of children with the condition with a positive test, while specificity is the proportion of people without the condition with negative test results. Secondly, positive predictive value (PPV) and negative predictive value (NPV) were calculated, both of which measure the probability that a positive or negative result is indeed correct. Agreement percentage was calculated as the proportion of participants in which both tests obtained the same results. In addition, Cohen's kappa coefficient was used to estimate the inter-scale reliability. An 80% of overall agreement is recommended as the minimum accepted, and kappa results are interpreted as poor (<0.20), fair (0.21-0.40), moderate (0.41-0.60), good (0.61-0.80) and excellent (0.81-1.00) (Brennan & Silman, 1992; Cohen, 1960).

Statistical analysis was conducted using IBM SPSS Statistics v28 (IBM Corp., Armonk, NY, USA), Stata version 16.0 (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC), and MedCalc Statistical Software version 19.4 (MedCalc Software Ltd., Ostend, Belgium) for ROC curve. In all analyses, the statistical significance level was set at $p < 0.05$.

Results

The sociodemographic characteristics of the sample are shown in Table 1. Of the 147 children, 70 (47.62%) were girls. The mean age of participants was 5.41 (SD = 0.55) years. The prevalence of children with Developmental Motor Coordination Disorder (including children at risk of Developmental Motor Coordination Disorder) evaluated by the MABC-2 original version was 18.37%.

Table 1. Characteristics of the sample

	n	Percentage	Mean (SD)
Age (years)	147		5.41 (0.55)
Sex			
Boys	77	52.38	
Girls	70	47.62	
Family socioeconomic status (%)			
Low	12	9.30	
Middle	62	48.06	
High	55	42.64	
Schools (%)			
Public	2	66.67	
Private	1	33.34	
General intelligence (BADyG) †			
3rd grade of preschool	70		52.65 (17.00)
1st grade of primary school	77		89.41 (9.20)
Physical fitness (ALPHA-fitness)			
Cardiorespiratory fitness (20-m shuttle run, stages)	147		2.16 (1.27)
Muscular strength (standing broad jump test, cm)	147		95.37 (17.35)
Speed/agility (4x10 test, s) *	147		17.16 (1.77)
Anthropometric			
Weight (Kg)	147		21.96 (5.38)
Height (cm)	147		116.44 (6.21)
Body fat mass percentage (%)	147		20.16 (5.99)
Waist circumference (cm)	147		56.15 (6.55)
Body mass index (kg/m2)	147		16.03 (2.72)

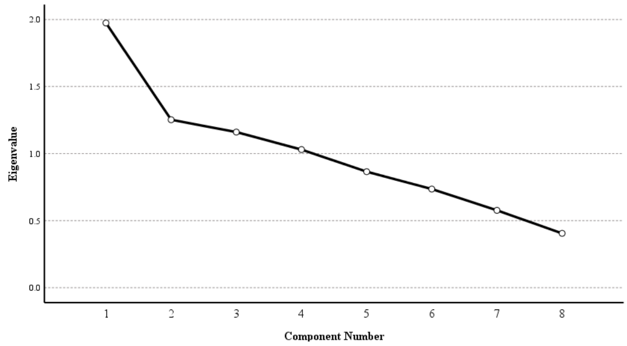
The data are presented as means and standard deviations (SD).
† This questionnaire has two versions: one for children aged 3-6 years (BADyG I) and one for children aged 6-8 years (BADyG E1).
* Lower scores indicate higher levels of speed/agility.

Table 2 shows the rotated factor pattern matrix and scree plot. As a result of factor analyses, three factors were extracted with a cumulative percentage explanation of variance equal to 54.84%. The items with a stronger item-total correlation for each dimension were: posting coins for the first factor, manual dexterity (0.854); one-leg balance task for the second factor, balance (0.981); and catching beanbag task for the third factor, aiming-catching (0.650).

Table 2. Rotated factor pattern matrix and scree plot.

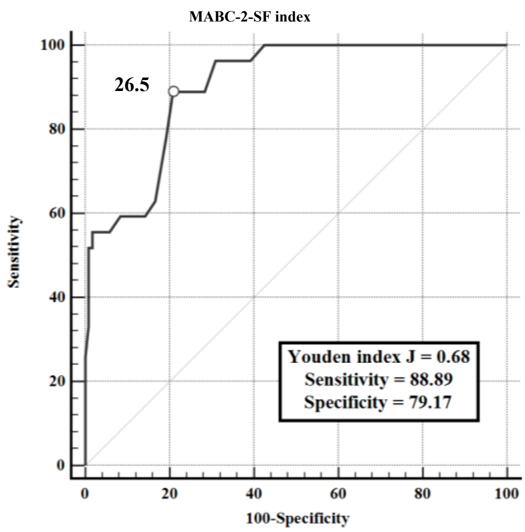
	Factor			Variance Explained*
	1	2	3	
Posting coins	.854	.022	.111	24.68%
Threading beads	.640	.197	.088	
One-leg balance	.098	.981	.162	40.33%
Drawing trail	.126	.163	-.016	
Catching beanbag	.166	-.142	.650	54.84%
Throwing beanbag onto mat	-.042	.049	.375	
Walking heels raised	.021	.226	.289	
Jumping on mats	.140	.099	.230	

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy = 0.559.
Bartlett's test of sphericity: χ^2 = 117.08; degrees of freedom (df) = 28; p < 0.001.
Values in *bold* indicates the greater factorial weight item for each factor.
*The values are expressed as cumulative percentage for each factor.



ROC curve analysis to obtain the optimal cut-off point for the MABC-2-SF index is shown in Figure 1. The area under the curve was 0.903 (SE = 0.03) with a statistically significant $p < 0.001$ (95% CI 0.84-0.95). The best-associated criterion to the Youden index for the MABC-2-SF test was 26.5 standard score with 88.89% sensitivity and 79.17% specificity.

Figure 1. ROC (receiver operating characteristic) curve for the motor competence task index according to the MABC-2-SF cut-off point. (AUC [SE]= 0.903 [0.03]; $p < 0.001$)



MABC-2-SF, Movement Assessment Battery for Children second edition Short Form; AUC, area under curve; SE, standard error.

Table 3 shows the mean differences in general intelligence, physical fitness, and anthropometric variables according to categories established in the ROC curve for the MABC-2-SF index, controlling by age and sex. Children in the category of ≤26.5 points had worse scores compared to the group in the category of >26.5 points, although statistical significance was only reached for general intelligence in preschool children and physical fitness in both preschool and primary school children ($p < 0.05$).

Table 3. Mean differences in general intelligence, physical fitness, and anthropometric variables according to categories established in the ROC (receiver operating characteristic) curve for the MABC-2-SF index, controlling for age and sex.

	n	≤ 26.5 standard scores	n	> 26.5 standard scores	*p*
General intelligence					
3rd grade of preschool (BADyG I) ¥	21	85.22 (1.94)	49	91.21 (1.27)	0.012
1st grade of primary school (BADyG E1) ¥	23	52.03 (3.51)	54	52.91 (2.29)	0.833
Physical fitness					
Cardiorespiratory fitness (20-m shuttle run, stages)	44	1.62 (0.18)	103	2.40 (0.12)	<0.001
Muscular strength (standing broad jump test, cm)	44	87.78 (2.44)	103	98.62 (1.59)	<0.001
Speed/agility (4x10 test, s) *	44	18.19 (0.24)	103	16.73 (0.16)	<0.001
Anthropometric *					
Body fat mass percentage (%)	44	20.97 (0.91)	103	19.82 (0.60)	0.291
Waist circumference (cm)	44	56.28 (0.99)	103	56.09 (0.65)	0.871
Body mass index (kg/m2)	44	16.30 (0.41)	103	15.92 (0.25)	0.440

Abbreviations: MABC-2-SF, Movement Assessment Battery for Children second edition Short Form.
The data are presented as marginal means and standard error.
The *p*-values in bold indicate significant differences between categories ($p < 0.05$).
¥ Not controlled by age, since the test was for the same age range.
† This questionnaire has two versions: one for children aged 3-6 years (BADyG I) and one for children aged 6-8 years (BADyG E1).
* Lower scores indicate better scores of speed/agility and anthropometric values.

The agreement data between the original and short-form of the MABC-2 test are shown in supplementary material. The MABC-2-SF showed a sensitivity of 77.78% (95% CI 57.74-91.38) and specificity of 80.83% (95% CI 72.64-87.44); a PPV of 47.73% (95% CI 32.46-63.31) and a NPV of 94.16% (95% CI = 87.75-97.83); an overall agreement of 80.27%, a moderate agreement expected of 62.70% and a Cohen's kappa of 0.47 (SE = 0.08; 95% CI 0.32-0.62; p < 0.001).

Table 4. Supplementary material. Agreement between the original and short version according to the cut-off points for the MABC-2-SF index.

		MABC-2-SF		
		Positive	Negative	
MABC-2	Positive	True positive	False negative	
		21	6	27
	Negative	False positive	True negative	
		23	97	120
		44	103	

Abbreviations: CI, confident interval; MABC-2-SF, Movement Assessment Battery for Children second edition Short Form.
Sensitivity = 77.78% (95% CI 57.74-91.38); Specificity = 80.83% (95% CI 72.64-87.44).
Positive predictive value = 47.73% (95% CI 32.46-63.31).
Negative predictive value = 94.16% (95% CI = 87.75-97.83).
Overall agreement = 80.27%; Moderate agreement expected = 62.70%.
Cohen's kappa = 0.47 (SE = 0.08; 95% CI 0.32-0.62; p < 0.001).

Discussion

Our results show that the MABC-2-SF is valid, reliable and useful for pre-screening 4- to 7-year-old Spanish children's motor competence with a 94.16% probability to detect children who are not at risk for Developmental Motor Coordination Disorder. That is, only a very small percentage of children (less than 6%) could be at risk for this disorder and not be detected with the short version of the MABC-2.

First, the construct of the MABC-2-SF was supported based on the theoretical model by the original battery (manual dexterity, balance, and aiming-catching) and tested through an exploratory factor analysis, which indicated that three tasks (posting coins, one-leg balance and catching beanbag) explaining 54.84% of the total variance. Second, the convergent validity showed that the optimal cut-off point of the MABC-2-SF index was equal to 26.5 standard score with high sensitivity and specificity values. In addition, children in the category with values below or equal to 26.5 standard score had worse scores in general intelligence (preschool children) and all physical fitness variables (preschool and primary school children) compared to the category with values above 26.5 standard score. These findings are in line with previous studies that have reported that children with lower motor competence tend to have lower academic achievement and cognition (Raz-Silbiger et al., 2015; Sartori et al., 2020) and that fitness is more negatively affected by poor motor competence than children with higher motor competence skills (Rivilis et al., 2011). These findings suggest that the MABC-2-SF scale has acceptable convergent validity for assessing motor competence in this age group.

On one hand, the concordance between the reference battery and the short version showed an overall agreement over 80% which indicates that the MABC-2-SF has a high degree of similarity to the original battery, whereas the agreement expected, and Cohen's kappa shows a moderate similarity. It should be noted here, as the prevalence of Developmental Motor Coordination Disorder is 2 to 20% in children, 18.37% in this study sample (Blank et al., 2019), that kappa values tend to be lower for measurements of uncommon conditions than for common conditions, and this property has to be taken into account when interpreting kappa values (Ensrud & Taylor, 2013).

On the other hand, the indices of specificity and sensitivity of the MABC-2-SF indicate that those children who take part on the tests and scored above 26.5 have a 94.16% chance of not being at risk of Developmental Motor Coordination Disorder (true negative) and 5.84% chance of being at risk of Developmental Motor Coordination Disorder (false negatives). In addition, although the PPV is lower than the NPV, it should be noted that children scoring below 26.5 have a 47.73% chance of being at risk of developmental motor coordination disorder (true positive) and a 52.27% of being false positives. Therefore, given the indices, all children who, according to the MABC-2-SF cut-off point, are positive should have to do the remaining 5 tasks from the original battery to screen them for being at risk of developmental motor coordination disorder.

Conclusions

The present study provides a valid and reliable MABC-2-SF index cut-off point for 4- to 7-year-old Spanish children composed of three subtests, one of each theoretical model supported by the original battery. The MABC-2-SF can screen children who are not at risk for Developmental Motor Coordination Disorder, with a very high probability, therefore, it allows pre-screening children's motor competence in a more adjusted cost-efficient way of collecting extensive sample data. However, it should be considered that the MABC-2-SF does not replace full assessment when necessary.

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Author contributions statement

ART, LL and MSL performed conceptualization. Data curation and formal analysis: ART and VMV. Funding acquisition: VMV and MSL. Investigation: ART, VMV, DG and MSL. Methodology: ART and VMV. Project administration: MSL. Supervision: VMV. Writing – original draft preparation: ART. Writing – review and editing: all the authors.

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