Routledge
Taylor & Francis Group

Measurement in Physical Education and Exercise Science

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/hmpe20

Exploring the Relationship Between Wall Drop Punt Kick and Catch (Tripela Sports) Performance and Manipulative Tests of the Motor Competence Assessment Battery in Early Adolescents

Rui Matos, Nuno Amaro, Nataniel Lopes, Pedro Costa, Miguel Jacinto, Filipe Rodrigues, Raul Antunes, Luís Coelho, Sergio J. Ibáñez, Isaac Estevan & Diogo Monteiro

To cite this article: Rui Matos, Nuno Amaro, Nataniel Lopes, Pedro Costa, Miguel Jacinto, Filipe Rodrigues, Raul Antunes, Luís Coelho, Sergio J. Ibáñez, Isaac Estevan & Diogo Monteiro (30 Jan 2025): Exploring the Relationship Between Wall Drop Punt Kick and Catch (Tripela Sports) Performance and Manipulative Tests of the Motor Competence Assessment Battery in Early Adolescents, Measurement in Physical Education and Exercise Science, DOI: 10.1080/1091367X.2025.2460162

To link to this article: https://doi.org/10.1080/1091367X.2025.2460162

Published online: 30 Jan 2025.

MEASUREMENT IN PHYSICAL EDUCATION AND EXERCISE SCIENCE
https://doi.org/10.1080/1091367X.2025.2460162

Exploring the Relationship Between Wall Drop Punt Kick and Catch (Tripela Sports) Performance and Manipulative Tests of the Motor Competence Assessment Battery in Early Adolescents

Rui Matos[a,b], Nuno Amaro[a,b], Nataniel Lopes[c], Pedro Costa[a], Miguel Jacinto[a,b], Filipe Rodrigues[a,b], Raul Antunes[a,b], Luís Coelho[a,b], Sergio J. Ibáñez[c], Isaac Estevan[d], and Diogo Monteiro[a,b]

[a]Polytechnic University of Leiria, Leiria, Portugal; [b]Research Center in Sport, Health, and Human Development (CIDESD), Covilhã, Portugal; [c]Facultad de Ciencia del Deporte, Universidad de Extremadura, Cáceres, Espanha; [d]Department of Teaching of Physical Education, Arts and Music. University of Valencia, Valencia, Espanha

ABSTRACT

Our aim in this study was to analyze associations between the two manipulative tests of the Motor Competence Assessment (MCA) battery and the Wall Drop Punt Kick & Catch (WDPK&C) motor task. One hundred and twelve early adolescents (60 boys; 52 girls; *M* age = 12.67, *SD* = 1.78 years) participated. Overall, strong correlations were found between the WDPK&C and the MCA manipulative tests, either separately ($r = .802$ for kicking, $r = .762$ for throwing) or collectively ($r = .835$). In boys, correlations between WDPK&C and MCA kicking ($r = .722$) and MCA throwing ($r = .754$) were similar. In girls, MCA kicking was more closely related to WDPK&C performance ($r = .612$) than MCA throwing ($r = .330$). These results reinforce the possible use of WDPK&C as a gross manipulative coordination test, either by itself or when integrated into motor competence batteries.

KEYWORDS
Competence; assessment; development; early adolescents; validity

Introduction

Motor coordination is frequently considered an underlying mechanism of motor competence, which Gallahue et al. (2012) defined as the ability to be proficient in a broad range of locomotor, stability, and manipulative gross motor skills. Due to the close connection and dependence that motor competence has with motor coordination, having adequate coordination is a prerequisite for motor competence. As Barnett et al. (2016) stated, participants who are classified as motor competent are often considered to have gross motor skill competency, which links to fundamental movement skills and motor coordination. Motor coordination is a concept that can be defined in several different ways. Brian et al. (2018) focused on the cooperation of the central nervous and musculoskeletal systems. According to Castañer and Camerino (2022), it is the ability to regulate the intervention of one's own body in the execution of any motor skill in a precise and effective manner. Finally, Rosa et al. (2020) states that it enables the organization, regulation and execution of motor and sensory processes associated with certain motor actions with a specific objective. In the literature, it is generally accepted that motor coordination can be expressed in two different ways: gross motor coordination and fine motor coordination. Gross motor coordination represents the ability to perform single movements that use large muscles, controlling one's own body to exploit different possibilities of action (Kokštejn et al., 2017; Madrona, 2014), while fine motor skills comprise ability in movements that require cooperation between eyes and hands or feet, as well as the ability to move fingers, using small muscles (Carlson et al., 2013).

Childhood is an essential period for developing motor skills. During childhood, and early adolescence, learning motor skills is crucial for later success in structured or unstructured physical activity (Goodway et al., 2019). Motor coordination problems, if not identified and addressed in time, can affect later motor skills in adulthood and lead to motor problems across life with associated health problems (Blank et al., 2012; Clark & Whitall, 1989). For this reason, it is necessary to assess motor skills at a young age, using reliable tests that sample skills in locomotion, stability, and manipulative gross motor movement. Manipulative gross motor skills (e.g., kicking, throwing), even more than locomotor skills, are associated with greater participation in physical activity and positive health-related consequences (K. E. Cohen et al., 2014; Vlahov et al., 2014). Several investigators found low to moderate correlations between pairs of motor competence assessment test

CONTACT Miguel Jacinto miguel.s.jacinto@ipleiria.pt Polytechnic University of Leiria, Leiria 2411-901, Portugal

batteries, which leads to the inference that these different test batteries (a) may not be effectively evaluating the same construct, (b) should not be used interchangeably or (c) yield different results. For example, Lopes et al. (2021), referring to studies by Logan et al. (2011, 2017), stated that the Körperkoordinationstest für kinder (KTK) and Test of Gross Motor Development (TGMD-2) measure different assumptions of what constitutes motor competence, since there was only moderate convergent validity between these two assessment tools. Fransen et al. (2014), comparing results obtained using the Bruininks–Oseretsky Test of Motor Proficiency (2nd version) in its short form (BOT-2SF) and the KTK found some evidence of convergent and discriminant validity between them, but, in view of relatively low correlation values, argued that the assessment of motor competence should not be based only on a single assessment instrument. Ré et al. (2018) and Rudd et al. (2016) reached the same conclusion from their work, as did Logan et al. (2011, 2017) after comparing the TGMD-2 and KTK. In fact, low-to-moderate correlations between these instruments led these authors to suggest that because the TGMD-2 and KTK may measure different aspects or dimensions of motor competence, it may be important to use multiple batteries to comprehensively assess motor competence. Khodaverdi et al. (2020) extended the study of these correlations and convergences to three batteries, the KTK, TGMD-3, and BOT-2SF, and discovered similarly low correlations between them. An additional criticism of these seemingly similar but weakly correlated test batteries is that some may be excessively time-consuming, making them impractical or infeasible to use in physical education classes (Cools et al., 2009).

Among frequently used batteries to assess motor competence, the Motor Competence Assessment (MCA), validated for children and early adolescents in different contexts (Luz et al., 2016; Rodrigues et al., 2019), incorporates, along with locomotor and stability skills sub-scales, a clear and well-defined manipulative skills sub-scale, which comprises two independent tests (ball-kicking velocity and ball-throwing velocity). In these tests, participants throw a tennis ball and kick a soccer ball, for maximum velocity (km/h), assessed by a velocity radar. Despite well-defined and validated, this manipulative component requires the use of a radar, which may not be affordable in all contexts. In addition, these two tests are performed separately, with an apparent reduced need of adjustment to the environment, which, on gross manipulative tasks, is frequently required on practical and daily tasks. Having these features in mind, Matos et al. (2022) created the Wall Drop Punt Kick and Catch (WDPK&C) test. This motor task requires the manipulation of a ball with both the upper (releasing and catching) and the lower (kicking) limbs. This characteristic presents a potential novel contribution for coordination research and, at least, for the manipulative component of motor competence, as it joins the assessment of eye-hand coordination with eye-foot coordination. Nonetheless, several further research steps must be performed before the WDPK&C can be widely used as a research-based gross manipulative coordination test. One of these steps was the determination of its internal item reliability (consistency) and test–retest reliability (reproducibility) over a period of 1 to 2 weeks, as recently accomplished by Matos et al. (2023) in a study with 41 children and early adolescents in which there was a Cronbach's alpha coefficient of 0.945 and a test–retest intra-class coefficient (ICC) value of 0.896 for these two types of reliability, respectively. A second needed step is to determine the convergent validity of the WDPK&C as an upper and lower limb motor coordination test, and this is our purpose in the present study.

We are intending to address here the applicability of the WDPK&C as an upper and lower limb motor coordination test, by analyzing its association with the two manipulative tests of the MCA test battery in a sample of early adolescents. If close associations between these measures are to be determined, then WDPK&C will be a good candidate to incorporate this MCA motor competence battery, with no requirements for special equipment. Furthermore, as no special equipment is required, the test can be administered by any professional, institution or organization, regardless of their financial possibilities, thus making it possible to assess the motor coordination of the upper and lower limbs for everyone. In addition, this test responds to various concerns that have been raised in the field of motor competence assessment, namely the complexity and adaptability of the tasks or limitations in validity (Hulteen et al., 2023). Past research has clearly revealed that boys tend to have better results than girls on manipulative and object control tasks (Barnett et al., 2016). Across a wide age range (3 to 12 years-old), boys usually outperform girls in object control competence and motor coordination. However, several authors (Carvalhal & Vasconcelos-Raposo, 2007; Platvoet et al., 2018; Rodrigues et al., 2019; Valtr et al., 2016; Wicks et al., 2015) found similar results in boys compared to girls on each MCA test. As there remains a possibility of sex differences on this type of measure, we elected to conduct research with boys and girls combined in a larger sample and to extend our analysis to boys and girls separately to determine whether different associations between these variables might emerge.

Method

Participants

We performed an *a priori* power analysis to estimate a required sample size based on two planned analyses: an independent samples t-test and a bivariate Pearson correlation, using the G Power 3.1.9.7 software (Faul et al., 2007, 2009), considering the following parameters: independent samples t-test: effect size: 0.5; $\alpha = .05$, a statistical power of $(1 - \beta) = .80$; bivariate correlation: correlation ρ H1: 0.5; $\alpha = .05$, a statistical power of $(1 - \beta) = .95$. The results indicated the need for 51 subjects in each group for the independent samples t-test and 38 subjects in each group for the bivariate correlations. The suggested effect size and remaining parameters were defined according to similar studies (e.g., Matos et al., 2022, 2023). Considering the purpose of the study, we followed a non-probability sampling method and recruited 112 early adolescents (60 boys, 52 girls; *M* age = 12,7 *SD* = 1.78 years). No participants presented any motor or perceptual limitations. Participant characteristics are reported in Table 1.

Ethical considerations and testing procedures

The study was conducted in accordance with the principles of the Declaration of Helsinki for research involving human participants (World Medical Association, 2013). Before data collection, we obtained ethical approval for the research protocol from our university ethics committee (n. º EA06.2022.CIEQV) and then contacted local elementary schools for consent to recruit participants. The first author explained the study's objectives, and after obtaining authorization from the school administration, we contacted physical education teachers regarding the study objectives. Subsequently, considering the participants' ages, we contacted the early adolescents' parents and informed them fully of the study's objectives and procedures. We emphasized anonymity, data confidentiality, and voluntary participation. Parents or legal tutors who authorized their early adolescents to participate in this study signed informed consent documents with mediation as needed from physical education teachers. With the organizational support of the teachers, we set up the participants' execution of the tests before the physical education class. All participants first engaged in a light warm-up involving both upper and lower body movements. We organized participants into small groups, following recruitment, while they attended physical education classes, and trained examiners administered the tests. Participants were provided verbal explanation of each test, and examiners instructed all participants to perform each task with their maximum effort.

Measures

Height and weight

We used a portable stadiometer scale, model SECA (Hamburg, Germany), to measure both body weight and height. Participants were instructed to stand barefoot on the platform of the stadiometer, maintaining a vertical and conventional positioning of their arms alongside their body. At the same time, the researchers made sure that the person's head was in the Frankfurt plane. Weight measurements were obtained from participants while wearing sports clothing and without shoes, using a digital scale (Tanita BC-50, Arlington Heights, IL, USA).

Wall drop punt kick & catch (WDPK&C)

Participants were required to perform a drop punt kick movement pattern and impact a wall with the ball as many times as possible, with subsequent catches, in 30 s, following Matos et al. (2022) protocol with a slight change that will be explained further on. Specifically, participants were directed to drop the ball and kick it to a wall without any ground rebound. Successful attempts were wall ball impacts with subsequent successful ball catching of the ball. This need for a successful catch so that an attempt might be considered is a novelty from Matos et al.'s (2022) protocol. In fact, back in 2022, Matos et al. (2022) assumed that impacts on the wall would be enough for this assessment. The rationale was that if, for some reason, the subjects might fail to catch a rebound from the wall (i.e., allowing the ball to hit the floor), they would waste time and, therefore that would, indirectly, be reflected in the test's result. Now, the test has become more demanding, as only hits on the wall

Table 1. Participants' anthropometric means (and standard deviations).

Participants	Age in years	Height in cm	Weight in kg
Total Sample (*n*=112)	12.67 (1.78)	155.60 (11.95)	51.36 (15.15)
Boys (*n*=60)	12.62 (1.80)	156.43 (13.51)	50.54 (12.60)
Girls (*n*=52)	12.73 (1.77)	154.63 (9.86)	52.33 (17.77)

with consequent successful catches would be considered for the result. This change stresses that all phases of the performance are important, and even more so because the test requires eye-hand and eye-foot coordination. Therefore, only a complete cycle (i.e., drop, kick, wall impact and catch) is to be accepted as successful and counted for data analysis. Subjects were not to step on or over a line marked on the ground 2 m from the front of the wall during the kicking action. Participants could enter the 2-m zone if the ball was caught there. Each performer was entitled to five warm-up repetitions before attempting two consecutive trials with a 30-s recovery period between trials so that the best performance could be registered. The test was performed with a size 4 ball (Ballground 500; 62 cm perimeter, 350 g weight, and a soft touch). The wall had a clean valid zone 5-m wide, marked with vertical band stripes, and over 4-m high (the minimum required). Any part of the foot (inner part, instep) could be used to perform the task, with no imposition or demonstration by researchers. The participants were not allowed to see the performance of the other participants in the test, so as not to influence the performance strategy used. In the Matos et al. (2023) study, the ICC and the Cronbach's Alpha showed acceptable scores of reliability and internal consistency, $\alpha = .945$ and $ICC = .896$, respectively. *Lin's CCC* was .896, indicating an excellent reproducibility result. Also, in the Matos et al. (2022) study, the authors found an intraclass correlation coefficient (.937) and Cronbach's alpha (.972).

Kicking velocity test (Kicking MCA)

Participants kicked a size 4 ball (Ballground 500; 62 cm perimeter, 350 g of weight, and a soft touch), at maximum velocity (km/h). Although a motor competence protocol typically proposes different ball sizes for different ages, we used the same ball for all participants for two reasons: (a) First, as we sought to correlate this test with the WDPK&C, we sought to use similar objects on the tests; and (b) in later applications, if a child aged by 1 month between two administrations of the test, they would have to use different balls each time, hampering direct comparisons. Maximum velocity (km/h) was captured using a Bushnell Velocity Speed Gun (Speed Radar Gun Model 1,101,911). Subjects took three trials, and we recorded their best effort for subsequent analysis. Intraclass correlation coefficient of .983 was found for the Kicking Velocity Test in the study of Rodrigues et al. (2019).

Throwing velocity test (Throwing MCA)

Participants were instructed to throw a tennis ball, at maximum velocity (km/h), against a cushioned surface. Although the MCA protocol proposes different balls for different ages (tennis or baseball), we used the same size tennis ball was for all ages (see Kicking Velocity Test). We captured maximum throwing velocities (km/h) with a Bushnell Velocity Speed Gun(Speed Radar Gun Model 1,101,911). Intraclass correlation coefficient of .979 was found for the Throwing Velocity Test in the study of Rodrigues et al. (2019). Three attempts were registered, and we recorded the best effort for analysis.

Kicking and Throwing MCA

MCA results are usually interpreted after the transformation of raw values into age and sex-based normative scores. Subsequently, for the determination of sub-scale percentiles, the average of the two tests percentile values of each of the three sub-scales (manipulative, locomotor, and stability) are calculated. However, as percentile values for WDPK&C results are not yet available that transformation would induce errors among participants of different ages and sexes. Therefore, we used only raw scores.

To calculate a combo value that would represent the value of the manipulative sub-scale of MCA, the average of Kicking MCA and Throwing MCA was used, through a variable that was identified as Kicking and Throwing MCA and that represents the global MCA manipulative sub-scale.

Statistical analysis

We conducted all statistical analyses in IBM SPSS STATISTICS (v.29 for Windows, SPSS Inc., Chicago, IL). First, we checked the database for outliers and missing values. We found no extreme values or missing data. Second, we checked for normality of the data distribution with the Kolmogorov–Smirnov test ($n > 50$) as suggested by Ho (2014). As the distribution was normal, we described it with means and standard deviations.

To compare the participants' performance by sex we used independent sample t-tests. We set the statistical significance for rejecting the null hypothesis at 5%. To examine the associations between variables for the total sample and when divided into boys and girls, we calculated Pearson correlation coefficients again using $p < .05$ to reject the null hypothesis (Ho, 2014). The suggested effect size and remaining parameters were defined according to similar studies (e.g., Matos et al., 2022, 2023). In case of statistical significance, we calculated the effect size and considered the following cutoff values: $d = .20$ or $r = .10$ interpreted as small effects, $d = .50$ or $r = .30$ as medium effects, and $d = .80$ or $r = .50$ as large effects (J. Cohen, 1988, 1992).

Table 2. Participants' means (and standard deviations) and *t*-test comparisons across sex on MCA manipulative tests and the WDPK&C.

	WDPK&C (repetitions)	Kicking MCA (velocity, km/h)	Throwing MCA (velocity, km/h)	Kicking and throwing MCA (velocity, km/h)
		Mean (SD)		
Total Sample	10.22 (6.95)	54.60 (11.93)	57.05 (13.18)	55.83 (11.74)
Boys	14.32 (6.17)	60.80 (11.60)	64.20 (11.77)	62.50 (10.75)
Girls	5.50 (4.33)	47.33 (7.35)	48.67 (9.26)	48.00 (7.15)
Independent t-test (boys vs girls)	8.841**	7.479**	7.694*	8.550**
Cohen´ s d	1.635	1.364	1.462	1.564

SD = Standard-Deviation; *p < .05; **p < .01; Cohen´ s d= magnitude of effect.

Table 3. Bivariate correlations of participant performances across measures.

Variables	1	2	3	4	5	6
Total sample						
1. WDPK&C test (repetitions)	1					
2. Kicking MCA (velocity, km/h)	.802**	1				
3. Throwing MCA (velocity, km/h)	.762*	.749**	1			
4. Kicking and Throwing MCA (velocity, km/h)	.835**	.928**	.942*	1		
5. Height (cm)	.276**	.467**	.423**	.474**	1	1
6. Weight (kg)	.112	.259**	.252**	.253**	.667**	
Boys/Girls#						
1. WDPK&C test (repetitions)	1	.612**	.330*	.529**	.296*	.159
2. Kicking MCA (velocity, km/h)	.722**	1	.475**	.822**	.339*	.337*
3. Throwing MCA (velocity, km/h)	.754**	.691**	1	.892**	.498**	.322*
4. Kicking and Throwing MCA (velocity, km/h)	.805**	.918**	.921*	1	.497**	.382**
5. Height (cm)	.280*	.586**	.456**	.566**	1	.667**
6. Weight (kg)	.229	.494**	.435**	.505**	.751**	1

*p < .05; **p < .01; below diagonal line = boys; above diagonal line = girls.

Results

Descriptive statistics and mean comparisons of participants' performances on the WDPK&C test, Kicking MCA test, Throwing MCA test, and Kicking and Throwing MCA are displayed in Table 2.

Boys obtained significantly higher scores ($p < .05$) than girls, with large effect sizes ($d \geq 1.364$) on all considered tests. The results of bivariate correlations between participants' performances are reported in Table 3. We observed significant bivariate correlations between participants' performances on the WDPK&C and MCA manipulative tests, when the MCA manipulative tests were used independently and when they were considered collectively as a subscale on the MCA. Correlations were all strong ($r \geq .722$, $p < .01$) in the total sample and boys' subsample. On the other hand, only one correlation was strong ($r = .612$, $p < .01$) and two moderates ($r = .529$, $p < .01$; $r = .330$, $p < .017$) in the girls' subsample.

Additionally, to MCA and WDPK&C variables, a correlation analysis with height and weight variables was undertaken. With the global sample, as well as by sex, height was revealed to be weakly correlated with WDPK&C and moderately correlated with both MCA manipulative tasks. Extending the analysis to weight, no significant correlation was found with WDPK&C, either with the global sample or by sex. However, weak correlations were found between weight and MCA manipulative tasks, both globally and by sex.

Discussion

We investigated potential correlations between early adolescents' WDPK&C performance and their results on manipulative subscale tests of the MCA, seeking to provide convergent validity of the WDPK&C as a measure of gross manipulative motor coordination. We found strong positive correlations between the WDPK&C and the MCA manipulative tests, when the MCA tests were considered separately and when they were analyzed together as a single domain. These correlations were evident when considering our entire sample and when we analyzed participant performance separately by sex. Among boys, correlations between the WDPK&C and each of the throwing and kicking tasks of the MCA were similar. However, in girls, the kicking task result had a higher correlation with WDPK&C result than the throwing task had. This could be explained by different amounts and qualities of play opportunities with kicking and throwing tasks across boys and girls. As past investigators have often shown, boys tend to spend more time in sports activities and with ball play (Mota et al., 2008; Randler & Kauderer, 2013), and this appears to give boys a distinct advantage in manipulative tasks in which ball play is a central element (Badrić et al., 2015; Harrell et al., 2003). In what comes to correlation results involving participants' height and weight, they seem to reinforce the idea that the correlation between WDPK&C and MCA manipulative tasks is more evident or stronger than with these variables. Furthermore, the higher correlation of height (and weight) with MCA manipulative tasks suggests a higher dependence of these upon anthropometric measures, besides age and probable maturation. In fact, throwing and kicking, in MCA, are to be performed at maximum velocity (km/h). People that are taller, with bigger arms, bigger legs, larger body mass may, in fact, benefit from that. However, with a younger sample, Palmer et al. (2023) found these positive effects of height on throwing and kicking velocity (km/h). However, that may not be the case with WDPK&C, apparently much more dependent on a well-structured coordinative process. The performance, though to be performed quickly, hardly requests full force exertion, as that would raise issues on ball handling and control.

In a separate but related finding, boys' test scores in our study were consistently and significantly higher than girls' on all performed tests. This finding corroborates, among others, several studies that revealed that boys markedly outperformed girls on manipulative and object control tasks (Barnett et al., 2016; Carvalhal & Vasconcelos-Raposo, 2007; Platvoet et al., 2018; Rodrigues et al., 2019; Valtr et al., 2016; Wicks et al., 2015). This may be interpreted as another indicator of conceptual proximity between the WDPK&C and the manipulative subscale of the MCA.

The results represent a further step toward considering the WDPK&C as an alternative gross manipulative coordination test, with the benefits of using both hands and feet in the same task, either independently or when integrated into motor competence batteries. Hoeboer et al. (2018) noted that many motor competence assessments were developed for clinical purposes (Movement Assessment Battery for Children – MABC, BOT, etc.) and are not feasible to administer in a physical education setting. Some are individually administered and excessively time-consuming (Cools et al., 2009). Others (e.g., KTK) require special materials (e.g., three balance beams of different widths). MCA, specifically designed for motor competence assessment, also needs a radar to measure ball velocity (km/h) and assesses upper and lower limb coordination separately. Thus, WDPK&C could be a good alternative to the manipulative component of MCA, as it only requires a ball and a wall and seems to be highly ecological, as its subtests do not appear to be isolated from each other and represent a skill that is the basis of a sport game called Tripela, created in Portugal in 2008 (Matos, 2009). Although we are addressing only one component (manipulative) of the motor competence spectrum (which comprises, also, the stability and the locomotor ones), the WDPK&C may come to constitute a reliable and valid alternative even to motor competence test batteries in general. In fact, stability and locomotor skills seem to be aspects of WDPK&C (e.g., sometimes quickly moving sideways to catch the ball that rebounds from the wall, standing on one foot to kick, or even jumping or running back to catch a ball that has rebounded from the wall). Future research shall provide insight into this possibility.

Limitations and directions for further research

As we did not address the aspects of the WDPK&C that may evaluate stability and locomotor skills, these are things that need to be explored in subsequent research. Additionally, it would be interesting to explore the existence of correlations between WDPK&C and manipulative tests of other motor competence test batteries, perhaps enlarging the spectrum of convergent validity. Of note, different motor competence batteries use different manipulative movement patterns (e.g., throwing and kicking, kicking and catching, throwing and catching) that may introduce some difficulty in establishing correlations among them, contributing to the questions of whether they measure similar constructs, as noted in our Introduction section. Additionally, in future studies, it is important to extend this analysis to process-oriented measurements of manipulative skills to evaluate convergent validity, following Logan et al. (2017) recommendations.

Another limitation of the present study was that we did not gather data or analyze our participants' prior experiences with specific sports or sports practice, and these varied backgrounds may be relevant to this test validation effort. Additionally, it was not possible to compare age- and sex-based normative values, and percentile results of MCA and WDPK&C performances as there remains insufficient data on the WDPK&C to do so. We also did not control or record the part of the foot that participants used to kick the ball, meaning that different participants might have used different strategies that could have relevance for judging the similarity of tasks on these tests. However, almost all were observed to use the instep, which corroborates a recent study with participants of similar age that suggests that the instep is more effective than the inner part (inner part of the foot) on this task (Matos et al., 2024).

Conclusion

In this study, we revealed the WDPK&C, an eye-foot and eye-hand coordination task, to be strongly and positively correlated with the manipulative subscales of the MCA test battery. This correlation was verified with motor coordination generally and the two separated MCA tests. This finding was valid for boys and for girls separately, as well as for the entire sample, although correlations were less strong in girls compared to boys and boys clearly outperformed girls, likely because of boys' greater prior experiences with ball play that is heavily involved in the required skills of the WDPK&C test. Therefore, after previous research affirming the reliability of the WDPK&C (Matos et al., 2023), this study constitutes an important step toward validating the WDPK&C as a gross manipulative segmental coordination task with the unique feature of joining eye-hand with eye-foot coordination. The WDPK&C may offer a valid and practical alternative to other manipulative assessments of motor competence and coordination. However, we discussed its potential limitations and made recommendations for future required research.

Acknowledgments

To all participants of the study.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was funded by the National Funds by FCT – Foundation for Science and Technology under the following project [UIDB/04045/2020] (https://doi.org/10.54499/UIDB/04045/2020).

ORCID

Isaac Estevan http://orcid.org/0000-0003-3748-2288

References

Association, W. M. (2013). World medical association declaration of Helsinki: Ethical principles for medical research involving human subjects. *Jama*, *310*(20), 2191–2194. https://doi.org/10.1001/jama.2013.281053

Badrić, M., Prskaloand, I., & Matijević, M. (2015). Primary school pupils' free time activities. *Croatian Journal of Education*, *17*(2), 299–232. https://doi.org/10.15516/cje.v17i2.1630

Barnett, L. M., Lai, S. K., Veldman, S. L. C., Hardy, L. L., Cliff, D. P., Morgan, P. J., Zask, A., Lubans, D. R., Shultz, S. P., Ridgers, N. D., Rush, E., Brown, H. L., & Okely, A. D. (2016). Correlates of gross motor competence in children and adolescents: A systematic review and meta-analysis. *Sports Medicine*, *46*(11), 1663–1688. https://doi.org/10.1007/s40279-016-0495-z

Blank, R., Smits-Engelsman, B., Polatajko, H., & Wilson, P. (2012). European Academy for childhood disability (EACD): Recommendations on the definition, diagnosis and intervention of developmental coordination disorder (long version). *Developmental Medicine & Child Neurology*, *54*(1), 54–93. https://doi.org/10.1111/j.1469-8749.2011.04171.x

Brian, A., Bardid, F., Barnett, L. M., Deconinck, F. J. A., Lenoir, M., & Goodway, J. D. (2018). Actual and perceived motor competence levels of Belgian and United States preschool children. *Journal of Motor Learning and Development*, *6*(s2), S320–S336. https://doi.org/10.1123/jmld.2016-0071

Carlson, A. G., Rowe, E., & Curby, T. W. (2013). Disentangling fine motor skills' relations to academic achievement: The relative contributions of visual-spatial integration and visual-motor coordination. *Journal of Genetic Psychology*, *174*(5), 514–533. https://doi.org/10.1080/00221325.2012.717122

Carvalhal, M., & Vasconcelos-Raposo, J. (2007). Diferenças entre géneros nas habilidades: Correr, saltar, lançar e pontapear. *Motricidade*, *3*(3), 44–56. https://doi.org/10.6063/motricidade.3(3).662

Castañer, M., & Camerino, O. (2022). *Enfoque Dinámico e Integrado de la Motricidad (EDIM)*. INEFC-Publicacions de la Universitat de Lleida.

Clark, J. E., & Whitall, J. (1989). What is motor development? The lessons of history. *Quest*, *41*(3), 183–202. https://doi.org/10.1080/00336297.1989.10483969

Cohen, J. (1988). *Statistical power analysis for the behavioral Sciences* (2nd ed.). Lawrence Erlbaum Associates, Publishers.

Cohen, J. (1992). Statistical power analysis. *The Current Directions in Psychological Science*, *1*(3), 98–101. https://doi.org/10.1111/1467-8721.ep10768783

Cohen, K. E., Morgan, P. J., Plotnikoff, R. C., Callister, R., & Lubans, D. R. (2014). Fundamental movement skill and physical activity among children living in low-income communities: A cross-sectional study. *International Journal of Behavioural Nutrition & Physical Activity*, *11*(1), 49. https://doi.org/10.1186/1479-5868-11-49

Cools, W., Martelaer, K. D., Samaey, C., & Andries, C. (2009). Movement skill assessment of typically developing preschool children: A review of seven movement skill assessment tools. *Journal of Sports Science & Medicine*, *8*(2), 154–168.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*(4), 1149–1160. https://doi.org/10.3758/BRM.41.4.1149

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*power, 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/bf03193146

Fransen, J., D'Hondt, E., Bourgois, J., Vaeyens, R., Philippaerts, R. M., & Lenoir, M. (2014). Motor competence assessment in children: Convergent and discriminant validity between the BOT-2 Short form and KTK testing batteries. *Research in Developmental Disabilities*, *35*(6), 1375–1383. https://doi.org/10.1016/j.ridd.2014.03.011

Gallahue, D., Ozmun, J., & Goodway, J. (2012). *Understanding motor development: Infants, children, adolescents, adults* (7th ed.). McGraw-Hill.

Goodway, J. D., Ozmun, J. C., & Gallahue, D. L. (2019). *Understanding motor development: Infants, children, adolescents, adults*. Jones & Bartlett Learning.

Harrell, J. S., Pearce, P. F., Markland, E. T., Wilson, K., Bradley, C. B., & McMurray, R. G. (2003). Assessing physical activity in adolescents: Common activities of children in 6th-8th grades. *Journal of the American Academy of Nurse Practitioners*, *15*(4), 170–178. https://doi.org/10.1111/j.1745-7599.2003.tb00259.x

Ho, R. (2014). *Handbook of univariate and multivariate data analysis with ibm SPSS* (2nd ed.). CRC Press.

Hoeboer, J., Krijger-Hombergen, M., Savelsbergh, G., & De Vries, S. (2018). Reliability and concurrent validity of a motor skill competence test among 4- to 12-year-old children. *Journal of Sports Sciences*, *36*(14), 1607–1613. https://doi.org/10.1080/02640414.2017.1406296

Hulteen, R. M., Terlizzi, B., Abrams, T. C., Sacko, R. S., De Meester, A., Pesce, C., & Stodden, D. F. (2023). Reinvest to assess: Advancing approaches to motor competence measurement across the lifespan. *Sports Medicine (Auckland, NZ)*, *53*(1), 33–50. https://doi.org/10.1007/s40279-022-01750-8

Khodaverdi, Z., Bahram, A., Khalaji, H., Kazemnejad, A., Ghadiri, F., & Lopes, V. P. (2020). Performance assessments on three different motor competence testing batteries in girls aged 7–10. *Sport Sciences for Health*, *16*(4), 747–753. https://doi.org/10.1007/s11332-020-00653-3

Kokštejn, J., Musálek, M., Šťastný, P., & Goals, A. (2017). Fundamental motor skills of Czech children at the end of the preschool period. *Acta Gymnica*, *47*(4), 193–200. https://doi.org/10.5507/ag.2017.024

Logan, S. W., Barnett, L. M., Goodway, J. D., & Stodden, D. F. (2017). Comparison of performance on process- and product-oriented assessments of fundamental motor skills across childhood. *Journal of Sports Sciences*, *35*(7), 634–641. https://doi.org/10.1080/02640414.2016.1183803

Logan, S. W., Robinson, L. E., & Getchell, N. (2011). The comparison of performances of preschool children on two motor assessments. *Perceptual and Motor Skills*, *113*(3), 715–723. https://doi.org/10.2466/03.06.25.PMS.113.6.715-723

Lopes, L., Santos, R., Coelho-E-Silva, M., Draper, C., Mota, J., Jidovtseff, B., Clark, C., Schmidt, M., Morgan, P., Duncan, M., O'Brien, W., Bentsen, P., D'Hondt, E., Houwen, S., Stratton, G., Martelaer, K., Scheuer, C., Herrmann, C. & Agostinis-Sobrinho, C. (2021). A narrative review of motor competence in children and adolescents: What we know and what we need to find out. *International Journal of Environmental Research and Public Health*, *18*(1), 18. https://doi.org/10.3390/ijerph18010018

Luz, C., Rodrigues, L. P., Almeida, G., & Cordovil, R. (2016). Development and validation of a model of motor competence in children and adolescents. *Journal of Science & Medicine in Sport*, *19*(7), 568–572. https://doi.org/10.1016/j.jsams.2015.07.005

Madrona, P. G. (2014). Site development and teaching of motor skills in early childhood education. *Journal of Arts and Humanities*, *3*(11), 09–20. https://doi.org/10.18533/journal.v3i11.558

Matos, R. (2009). Tripela, a new team sport made in Portugal. In S. Gonçalves (Ed.), *Creativity and Innovation - Proceedings of IWE2009, 6ht International Week of ESEC, Coimbra, Book of Abstracts* (pp. 409–411). Coimbra Superior School of Education.

Matos, R., Amaro, N., Lopes, N., Costa, P., Jacinto, M., Rodrigues, F., Antunes, R., Coelho, L., Ibáñez, S. J., & Monteiro, D. (2023). The reliability of the wall drop Punt kick and catch test. *Journal of Functional Morphology and Kinesiology*, *8*(2), 72. https://doi.org/10.3390/jfmk8020072

Matos, R., Monteiro, D., Antunes, R., Jacinto, M., Rodrigues, F., Coelho, L., & Amaro, N. (2024). En la prueba wall drop Punt kick & catch, ¿quién gana: La parte interna del pie o el empeine? (On wall drop Punt kick & catch test, who wins: Foot inner part or instep?). *Retos*, *58*, 1000–1005. https://doi.org/10.47197/retos.v58.106850

Matos, R., Monteiro, D., Rebelo-Gonçalves, R., Coelho, L., Salvador, R., Antunes, R., Mendes, D., & Amaro, N. (2022). Wall drop Punt kick & catch: Contributions towards the creation of a new gross manipulative coordination test. *International Journal of Sports Science & Coaching*, *17*(3), 590–598. https://doi.org/10.1177/17479541211037556

Mota, J., Santos, M. P., & Ribeiro, J. C. (2008). Differences in leisure-time activities according to level of physical activity in adolescents. *Journal of Physical Activity & Health*, *5*(2), 286–293. https://doi.org/10.1123/jpah.5.2.286

Palmer, K. K., Pennell, A., Terlizzi, B., Nunu, M. A., Stodden, D. F., & Robinson, L. E. (2023). Performance metrics from product-oriented measures of fundamental motor skills-A comparison and developmental perspective. *Journal of Motor Learning and Development*, *11*(3), 401–423. https://doi.org/10.1123/jmld.2022-0074

Platvoet, S., Faber, I. R., de Niet, M., Kannekens, R., Pion, J., Elferink-Gemser, M. T., & Visscher, C. (2018). Development of a tool to assess fundamental movement skills in applied settings. *Frontiers in Education*, *3*, 1–8. https://doi.org/10.3389/feduc.2018.00075

Randler, C., & Kauderer, S. (2013). Differences in time use among chronotypes in adolescents. *Biological Rhythm Research*, *44*(4), 601–608. https://doi.org/10.1080/09291016.2012.721687

Ré, A. H. N., Logan, S. W., Cattuzzo, M. T., Henrique, R. S., Tudela, M. C., & Stodden, D. F. (2018). Comparison of motor competence levels on two assessments across childhood. *Journal of Sports Sciences*, *36*(1), 1–6. https://doi.org/10.1080/02640414.2016.1276294

Rodrigues, L. P., Luz, C., Cordovil, R., Bezerra, P., Silva, B., Camões, M., & Lima, R. (2019). Normative values of the motor competence assessment (motor competence A) from

3 to 23 years of age. *Journal of Science & Medicine in Sport*, *22* (9), 1038–1043. https://doi.org/10.1016/j.jsams.2019.05.009

Rosa, A. R., García, E. G., & Martínez, H. M. (2020). Análisis de la coordinación motriz global en escolares según género, edad y nivel de actividad física (Analysis of global motor coordination in schoolchildren according to gender, age and level of physical activity). *Retos*, *38*(38), 95–101. https://doi.org/10.47197/retos.v38i38.73938

Rudd, J., Butson, M. L., Barnett, L., Farrow, D., Berry, J., Borkoles, E., & Polman, R. (2016). A holistic measurement model of movement competency in children. *Journal of Sports Sciences*, *34*(5), 477–485. https://doi.org/10.1080/02640414.2015.1061202

Valtr, L., Psotta, R., & Abdollahipour, R. (2016). Gender differences in performance of the movement assessment battery for children - 2nd edition test in adolescents. *Acta Gymnica*, *46*(4), 155–161. https://doi.org/10.5507/ag.2016.017

Vlahov, E., Baghurst, T. M., & Mwavita, M. (2014). Preschool motor development predicting high school health-related physical fitness: A prospective study. *Perceptual and Motor Skills*, *119*(1), 279–291. https://doi.org/10.2466/10.25.PMS.119c16z8

Wicks, L. J., Telford, R. M., Cunningham, R. B., Semple, S. J., & Telford, R. D. (2015). Longitudinal patterns of change in eye-hand coordination in children aged 8-16 years. *Human Movement Science*, *43*, 61–66. https://doi.org/10.1016/j.humov.2015.07.002