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ORIGINAL

DESIGN AND VALIDATION OF ASSESSMENT TOOL FOR MOTOR COORDINATION IN PRIMARY EDUCATION

DISEÑO Y VALIDACIÓN DE INSTRUMENTO PARA EVALUAR LA COORDINACIÓN MOTRIZ EN PRIMARIA

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ABSTRACT

Motor coordination is a complex evolutionary process which is gradually acquired. The optimum age for the achievement of these coordination processes is between 6 and 11 years old (Primary Education).

The aim of this study is to design and validate a tool which will allow assessing the motor coordination level of the students.

Method: Subjects and Sample. Students from Primary Education public schools. 'Convenience' sampling, with a total of 2512 subjects.

Tool: Qualitative observation test and objective evaluation of the implementation of the abilities developed in 7 tasks.

Results: Reliability: Internal Consistency (Cronbach Alpha 0.827), test-retest reliability (correlation coefficient; 0.99) and inter-observer agreement (correlation coefficient; 0.95). Validity has been verified by the experts' intuitive perception, issuing a largely favourable opinion.

Conclusion: The 3JS test is a reliable, valid and effective tool for measuring the motor coordination development in students between 6 and 12 years old.

KEY WORDS: Motor coordination, assessment, Physical Education.

RESUMEN

La coordinación motriz es un proceso evolutivo complejo de adquisición progresiva. La edad óptima para la adquisición de esos procesos coordinativos es de 6 a 11 años (Educación Primaria). El objetivo del presente estudio es diseñar y validar un instrumento que permita evaluar el nivel de coordinación motriz del alumnado.

Método: Los sujetos son alumnado de Primaria en centros públicos. Muestreo por conveniencia, con una muestra total de 2512 sujetos. Instrumento: Test cualitativo de observación y evaluación objetiva de la ejecución de la habilidad desarrollada en 7 tareas.

Resultados: La Consistencia interna (Alfa de Cronbach 0.827), estabilidad temporal (coeficiente correlación: 0.99) y concordancia inter-observadores (coeficiente correlación: 0.95). La validez se comprobó mediante la opinión intuitiva de expertos, siendo la opinión mayoritariamente favorable.

Conclusión: El test 3JS es un instrumento fiable, válido y eficaz para medir el desarrollo de la coordinación motriz en el alumnado de 6 a 12 años.

PALABRAS CLAVE: Coordinación motriz, Evaluación, Educación Física.

INTRODUCTION

Motor coordination is a complex evolutionary process of progressive acquisition, which, as mentioned by Beraldo and Polleti (1991) in Conde and Viciana (2001), generates great controversy as regards its scope, limits and contents. This fact appears particularly obvious at the optimum age for the acquisition of these coordination processes (6-11 years).

That life stage corresponds to Primary Education and, as far as motor coordination is concerned, is known to be a period of major physical development as well as abilities and skills improvement aimed at the athletic development. Generally, an increased maturity and effectiveness are noticed in basic motor abilities owing to the boost of motor coordination (Granda y Alemany, 2002).

Using the definition suggested by Hernández and Velázquez (2004) and by Castañer and Camerino (1990), motor coordination can be defined as: “the ability to accurately, effectively, economically and harmoniously order and organize motor actions geared towards a specific goal, which requires the function of the nervous system that integrates all the necessary motor, sensitive and sensory factors for the appropriate performance of movements” (Muñoz Rivera, 2009).

Berruezo (2002) defines motor coordination as: “the possibility we have to produce actions implying a wide range of different movements that involve the activity of certain segments, organs or muscle groups and the inhibition of other body parts. As a result of this organized process we get precise gestures and actions that suit the established practical objectives. Coordination enables the independence and interdependence of segmental movements during the production of an action previously performed”.

A maturation deficit of coordination regarding the levels corresponding to chronological age shows in students with deficiencies in the development of coordination abilities a series of learning disorders that Haubesntricker (1982) and Cratty (1989), in Ruiz (2005), describe as: inconsistent actions, a constant performance of an action although no longer required by the situation (persistence); inability to separate their actions from those they produce as examples; asymmetric body actions; dynamic balance problems, unstable rhythm; inability to control strength and difficulties in the motor planning of the actions.

Several and various limitations and aspects can affect motor coordination, which can represent a large amount of factors that could modify the findings during such coordination assessment. In this sense, Hernández and Velázquez

(2004) establish the following factors as the most significant within the field of motor coordination: the legacy, general physical condition level, age, physical and psychical fatigue, learning level (the automation extent of the movements), body segment involved (the arms normally have higher coordination capacity than the legs), symmetry of movements (hemilateral or ambilateral), movement sense of direction (movements are normally easier to coordinate forwards and horizontally), etc. Traditionally, two big groups of neuromuscular coordination capacities are clearly and separately identified: general dynamic coordination and segmental coordination (Hernández, J. and Velázquez, R., 2004) (Escribá y Navarro, 2002).

An optimum development of motor coordination is crucial for the full training of pupils through Primary Education. It is therefore important to find a valid, reliable and effective tool for their assessment. Simultaneously, in order to make it user-friendly, such tool must be easily set up and applied in as little time as possible.

Various means (quantitative and qualitative) are regularly used to evaluate these types of coordination capacities. Numerous studies have been achieved since the first tests conducted by Ozeretzki in 1929 until now: Bender Test (1938); steeplechase according to Schnabel (1963), Fetz and Kornexl's test (1976); Thiess' ability race (1963), Yela's visual-motor coordination test (1971); Lutter and Schöeder's steeplechase (1972), Haag and Dassel (1995); steeplechase agility test from INEF in Madrid (1973); Crawford and Col.'s dexterity test (1975), Anastasi and Urbina's test (1998); Arnheim and Sinclair's motor ability test (1976); Harre's test (1976), Weineck's test (1988), Hamm-Marburg's child's body coordination test (1976); González's test (2001); Picq and Vayer's psychomotor profile (1977); Porta and Cols.' General Dynamic Coordination test (1988); Barcelona's INEF coordination entry test, Aragón and Valbuena (1989); Beraldo and Polleti's coordination test (1991); Henderson and Sugden's test (1992); Roig-Fusté's visuomanual and motor coordination test (CVM1) (1993); Posada's specific dynamic coordination tests (2000); Granada's FCCAFD ball adaptation entry test (2000); Ruiz, Graupera and Gutiérrez's ECOMI scale for child's motor competence (2001); Beery's visual-motor intregration test (2004); Lorenzo's motor coordination test (2009).

This issue has been dealt with in different fields such as medicine (rehabilitation), psychology (psychomotricity), pedagogy (children with motor and/or sensory deficits) or sport. Another aspect that needs to be considered is that most of them are focused on individual analysis (or few subjects), which hinders or prevents them from being used with a bigger population (25 pupils per class for instance) and with little time available like in schools. Physical Education in schools lacks rigorous scientific research that analyzes and describes the level of motor coordination in the population. Studies that can evaluate with the same tests all the pupils and allow for a later longitudinal analysis providing data that determine the level of coordination of all the school population.

Ulrich's Test of Gross Motor Development (TGMD-2) (2000) has been used over the last years, which is designed to assess the gross motor development of 3 to 10-year-old children. This test is focused, as many others, on identifying children whose motor ability development is quite more delayed than the rest of their classmates. The 12 tasks included in the test make it very difficult and slow to apply in a school.

The Körperkoordinations Test Für Kinder (KTK) is one of the other widely used tests in Physical Education and Sport in populations without motor concerns. It consists of 4 subtests that measure gross motor coordination in subjects aged from 5 to 15 years. Its main downside (Vandorpe et al., 2011) is that 15 minutes are required for each subject, whose educational application to 25-pupil-classes proves unfeasible at the moment.

The search for tools that allow us to assess motor coordination is not a totally controlled and accepted issue: "Physical assessors have strived to design tests in order to measure the different levels of coordination but their attempts have proved poorly satisfying in practice due to the complexity of the matter" (Diaz, 1998).

Thus, since none of the tests and experiments previously mentioned failed to prove fully reliable and satisfying, we have tried to create a new tool in order to cover that need.

Such a new tool must be specific to our field of study and easy to apply and assess. It must be adapted to age and the tasks need to be motivating and significant for later learning sessions. It is also highly important to do it fast, effectively and comfortably. Therefore, we want to have a reliable and rigorous scientific tool that allows us to check the efficiency of the teaching process in the development of motor coordination.

This study aims to design and validate a tool for Physical Education teachers in primary schools, which allows them to assess the pupils' motor coordination level.

METHOD

Subjects and Sample

The basic informant within this research (Colas and Buendía, 1998) were the Public Primary Schools pupils aged between 6 and 11 years, distributed according to their dates of birth for their later analysis as regards chronological age (born between the years 2000 and 2005, both inclusive). An opportunity sampling technique was used, with a total sample of 2512 subjects, from whom the yearly percentage varied between 18% born in 2013 and 16% in 2000. So the representativeness within each age group was similar. In connection with

gender, 51% were male children and 49% females, which matched the representative percentage of the school population in Andalusia.

All the pupils took the test in their own schools. During the first stage, 11 schools in the provinces of Seville and Cádiz were selected through an opportunity sampling. 300 pupils took the test experiment in one of them. During the second stage, other 300 subjects were tested twice by the same observer in a school and, later, the same subjects were tested again by a different observer. The data was collected by the expert Physical Education teachers themselves who taught the subject in each school after receiving a day of personal training. During that day there were exhaustively explained the application of the tests and the observation and unification protocol of the assessment criteria of each task, through the analysis of the previously videotaped production of 3 boys and 3 girls, in order to achieve skillful and unified observation and assessment of the tasks.

Since the pupils involved in the certification of this tool were below the age of mojority and in accordance with the ethical standards for research with human beings, parents were fully informed in written form about the tests' characteristics and realization procedures that their children would take. After that, they had to sign an "informed consent" sheet, in which they clearly expressed their desire and agreement that their son or daughter take part in this study.

TOOL

It is a test in which the development of motor, general dynamic and visual-motor coordination are assessed though a qualitative observation and evaluation procedure which is the goal of the production of the ability performed in each task.

Tasks selection

It is a test in which the development of motor, general dynamic and visual-motor coordination are assessed though a qualitative observation and evaluation procedure that is the goal of the production of the ability performed in each task.

A group of experts was created in order to design the test. There were supervised by four of the five authors including 8 physical education teachers (two of whom were also Physical Activity and Sport graduates) with a teaching experience of between 10 and 20 years. An analysis of the necessity to create easily applicable, valid and rigorous scientific tools, the main contents to deal with at this stage of the curriculum and critical analysis of the TGMD-2 and KTK tests were conducted. From there, we proceeded with the development of specific task banks for the assessment of coordination. Then four stages were developed where field work and critical analysis with the group of experts were combined: 1st stage: suggested test with different tasks for each one of the

three cycles; 2nd stage: suggested test with the same tasks for all Primary; 3rd stage: refinement of the tasks and their space organization; 4th stage: pilot experiment; (total: 496 pupils).

In the final design pupils go through a circuit where they carry out 7 consecutive activities without breaks in between the intervals. For each one of them, they carry out a different motor task through the performance of a motor ability in which a different type of coordination appears: in three general dynamic tasks and other four visual-motor coordination ones. These were the selected tasks:

Task 1- Vertical Jump (general dynamic coordination): from a bipedal and static position, the subject jumps over the first obstacle, from behind the line, and falls simultaneously with both feet (hung stick) on the back line. Similarly and continuously, they jump a second and third obstacle which consists of other similarly placed sticks.

Task 2- Turn on the longitudinal axis (general dynamic coordination): stepping on the cross and more precisely the line in parallel to the back line, the subject jumps vertically and turn simultaneously on the longitudinal axis. The maximum objective is to make a complete 360º turn. The closer to maximum levels, the highest the score. The pupil can follow the direction they want.

Task 3- Precision Throw (visual-motor coordination): the subject takes a tennis ball, gets into a 1.5 x 1.5 m square and throw the ball so as it touches the post of a handball goal that is located five meters away. Then, they get out of the square, take a second ball and throw it back again at the target.

Task 4- Precision hit (C. visual-motor coordination): the subject carries out the same operation as in the third task but this time kicks a ball that must be stationary before kicking which must touch the goal's post.

Task 5- Slalom (general dynamic coordination): the subject runs performing a slalom, from the moment they leave the hit-throw square until they get to the point of the next task through three cones with the first one placed at 9 m from the back line, the second one 13.5 m and the third one 18 m away from the back line.

Task 6- Bouncing (C. visual-motor): the subject takes the basketball that is inside a hoop and goes the round-trip circuit of the three pivots used for the slalom race while they bounce the ball. It is advisable to warn the subject that they have not look at the ball and use both hands in a coordinated manner. The ball is put back inside the hoop after overcoming the last obstacle.

Task 7- Control (C. visual-motor): once again the subject goes through the round-trip distance of the three pivots but without the slalom while they controls a football. The subject arrives at the last obstacle and goes back in the pivots'

opposite direction. The test finishes when the ball overpasses the last post and the subject puts it back into the hoop.

Assembly and location

The area where the test is carried out must be an outdoor or indoor space, with 10 x 20 m dimensions, on a homogenous and soft surface. The most advisable option would be half a handball court (Figure 1):

1. Measure 3.60 m from the goal's post and towards the corner kick point. Put up the first hurdle, each of which is made up of a pivot with a different color from the floor, weighing 800 g and 50 cm high, with a hole in the upper part for a stick of any diameter and on the sides for sticks of 25 mm diameter, with 3 heights, 4 faces, 12 holes. The stick used as hurdle is set on the first level, 20 cm above the floor. The sticks are round with a different color from the floor, with a 25 mm diameter and a length of 120 cm. The second stick is placed 0.5 m away from the first hurdle and the third 0.5 m away from it. Similarly, a 2 x 1 m mat with a different color from the floor and of high density is placed for the performance of the second task. A 1 x 1 m cross is marked on the central point of the mat with a 0.15 m piece of insulating tape with a contrastive color with that of the mat. Then a visible arrow is marked on the floor showing the direction to follow in task 3.

2. A 1.5 x 1.5 m square is marked 6 m away from the back line with the vertex being the perpendicular line of the center of the right post of the 3 x 2 m handball goal. On the right side (towards the goal), a 72 cm-diameter hoop is placed 1 m away from the central point of the square line. It weighs 270 g and has a color that contrasts with that of the floor. 2 yellow tennis balls with a diameter no bigger than 6.35 cm and no smaller than 6.67 cm and weighing between 58.5 and 56.7 g are placed inside the hoop.

3. Similarly, two 7-a-side footballs (weighing 340 - 390 g and with a 62 – 66 cm circumference are needed in order to achieve task 4. They are placed alongside the two tennis balls inside the hoop on the floor.

4. One of the two posts and bar is placed a meter from the central point of the square rear line (towards the goal), each of which consists of a 800 g and 50 cm high pivot with a hole in its upper part for a stick to slot in. The stick has to be round with a 25 mm diameter and 120 cm length. Its color must contrast with that of the floor. The first of these posts and bar is placed 9 m away from the starting back line, the second and third ones 13.5 m and 18 m away from it respectively.

5. Another hoop similar to the previous one is placed on the floor 1.5 m away from the last post. A brown, 500–540 g and 72-74 cm-circumference basketball is put inside it for the performance of task 6 as well as a white 7-a-side football weighing 34 –390 g and with a 62-66 cm circumference for task 7.

6. Apart from the equipment described earlier and in order to conduct the test successfully, it is necessary to have a computer for the storage of the obtained data and a meter to mark the space and the circuit of the test.

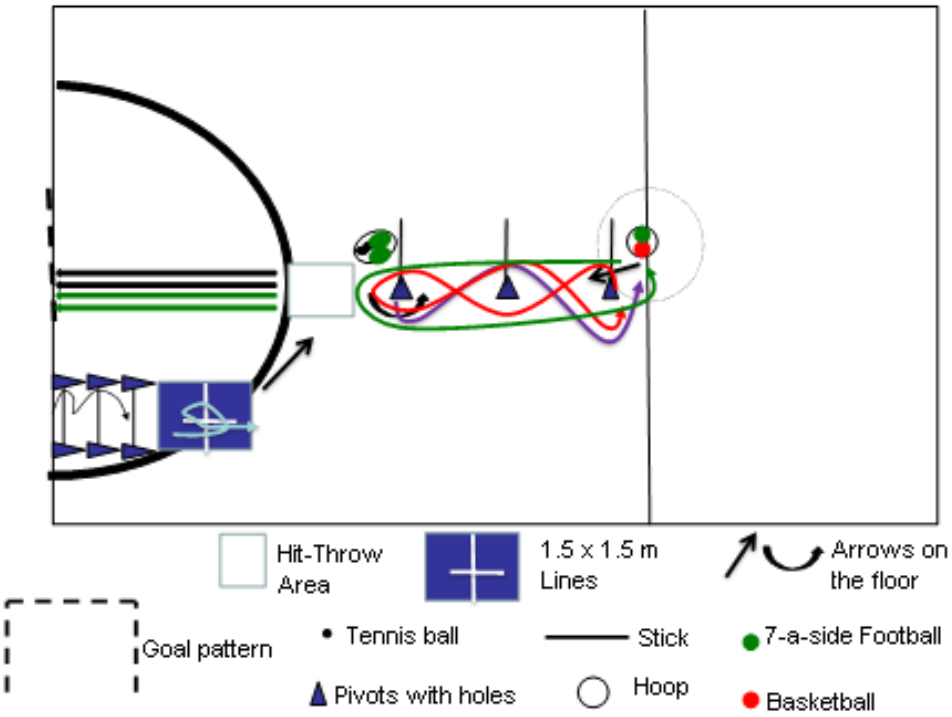

Figure 1. Graphic description of the coordination test.

Application protocol of the test

1. Presentation and description of the performance to the pupils: all the tasks that make up the test and their order as well as the score system.
2. Prior practice of the test. The pupils must go through the circuit once before carrying out the final test. Another circuit could be set up on the other half of the court for this introductory performance so as to cater for a gentle contact with the different tasks.
3. Position in the starting zone. After an approximate 4-minute recovery from the prior practice, the subject must get into a static and bipedal position at the starting line. After the teacher's signal ("whenever you want"), they start the task when they want (the response time is not assessed nor taken into account).
4. The teacher or assessor gets themselves positioned next to the Throw-Square and will move sideways along the circuit.
5. Performance of the test. In the course of the test the performer may be reminded about the order of the tasks but under no circumstances can they receive comments or corrections on their performance. In case of an invalid move, the subject will have to wait for two minutes before they can do the test again. A move is considered invalid when the pupils get wrong with the

direction or do not carry out some of the tasks in the specified order. The assessor observes and scores objectively in line with the assessment criteria of each of the seven circuit tasks. Once each task is done, the score is written down in the corresponding space on the control sheet.

Assessment criteria of the test

This is a qualitative assessment test of motor function. So it will be assessed through objective observation and assessment of the production of the performed tasks and abilities, for which the following assessment criteria are established (table 1).

Task / Marks		Assessment criteria / Score
1º. To jump with both legs together over the sticks placed at a height.	1	The subject does not jump with both legs simultaneously. They do not bend their trunk.
	2	The subject bends their trunk and jumps with both legs. They do not fall with both legs simultaneously.
	3	The subject jumps and falls with both feet, but does not coordinate the simultaneous extension of the arms and legs.
	4	The subject jumps and falls with both legs simultaneously with coordination of the arms and legs.
2º. To jump and turn on the longitudinal axis.	1	The subject performs a turn of between 1 and 90º.
	2	The subject performs a turn of between 91 and 180º.
	3	The subject performs a turn of between 181 and 270º.
	4	The subject performs a turn of between 271 and 360º.
3º. To throw two balls at the post of a goal from a distance without getting out of the square.	1	The trunk does not turn sideways and the throwing hand is not moved backwards.
	2	The elbow is moved a little and there is external rotation of the shoulder joint (very small contraction of the arm).
	3	The arm is contracted and the object is moved behind the head.
	4	The subject coordinates a fluid movement from the legs and trunk to the wrist of the arm opposite the foot that is held back.
4º. To kick two balls to the	1	The subject does not place their supporting leg next to the ball. There is no bending nor stretching of the knee corresponding to the kicking leg.

post of a goal from a distance without getting out of the square.	2	The subject does not place their supporting leg next to the ball and kick it moving their leg and foot.
	3	They balance themselves on the supporting leg placing it next to the ball. They swing the leg kicking the ball in a sequential movement of the hip, leg and foot.
	4	They balance themselves on the supporting leg and swing the kicking leg following a sequential movement from the trunk to the hip, muscle and foot.
5º. To perform a slalom race	1	The legs are stiff and the walking pace is uneven. Very reduced air stage.
	2	The absorption and jump stages are differentiated but with a limited movement of the arm (the elbow is not bent).
	3	The arm is moved and the elbow is bent. The arm movements hinder the fluidity of the supports (the frequency of the arm movements is not the same as the one for the supports.
	4	The subject coordinates their arms and legs while running and adapts to the established circuit changing the direction correctly.
6º. To bounce a basketball in a round-trip achieving a simple slalom race and changing direction moving round a pivot.	1	The subject needs a grip on the ball in order to keep on bouncing it.
	2	The height at which the ball bounces is not homogeneous or it is hit (the contact with the ball is not accompanied).
	3	The elbow and wrist are contracted and stretched in order to bounce the ball. A single hand or arm is used.
	4	The subject coordinates the bounce correctly using the most appropriate hand/arm to move during the slalom. Both hands/arms are correctly used
7º. To control and guide a ball with the foot in a round-trip achieving a simple slalom and changing	1	The subject needs a grip on the ball with the hand in order to keep on handling and moving it around.
	2	The kick power is not homogeneous. There are differences in the distance with which the ball is moved after each kick.
	3	The subject only uses one leg to constantly control the ball using the most suitable contact surface and adapting the power of the kicks.

direction moving round a pivot.	4	The subject constantly controls the ball using the most appropriate leg and the most suitable surface. The subject adapts the power of the kicks and keeps their eyes on the circuit (not on the ball).

Table 1. Assessment criteria of the tasks in the test

RESULTS

The metric features obtained through the tasks for the validation of this test in the previous sample are the following ones:

Reliability

In order to determine the reliability of the tool, a study of its internal consistency, temporal stability and inter-observer concordance was conducted. The internal consistency was achieved through the measurement of Cronbach's Alpha coefficient using for it the SPSS statistical program getting 0.827 as a result in the 7 analyzed tasks, showing quite acceptable values for internal consistency since they are higher than the 0.7 required for this type of studies.

Temporal stability is the concordance obtained between the results of the test when the same sample is assessed by the same assessor in two different situations (test-retest reliability). A 70% correlation shows an acceptable reliability and, in our case, the temporal stability of this tool was applied on a sample of 178 pupils who did the test on the same day in two following weeks. The data were analyzed with the Excel/Office 2007 software showing a result of 0.99 as the correlation coefficient of the 7 variables and the two captures.

The inter-observer concordance was deduced from the analysis of the agreement level obtained when the same sample was assessed in the same conditions by three different assessors. The findings were also analyzed with the Excel/Office 2007 software. As a result, the correlation coefficient for the 7 variables and the two captures was 0.95.

Validity

As regards the internal validity of the tool, it was checked through its apparent validity by using the experts' intuitive perception. 10 expert teachers and 3 Physical Education graduates collaborated in the study, all of whom had a teaching experience of more than 5 years, which allowed us to know their opinion on whether the test was regarded as valid by the teaching staff who would apply it later. Also, the rational and content validity of the test was checked by asking the same group of experts to mark on a list the abilities and skills that they considered to be assessed by each task in order to ensure whether they were representative for what was intended to be assessed. The vast majority had a favorable opinion about it.

The response validity was later determined through interviews with the pupils who did the pilot experiment in order to check their opinion on the comprehension, development and results obtained during the performance of the test. The results of the interviews show a high level of comprehension and the lack of doubts on the test.

For the external or criterion validity, we did not find any validated test for the measurement of motor coordination in Primary Education that we might use as "Gold Standard Test". There were tests available for the measurement of motor coordination in Secondary Education, but when we tried to apply them to Primary pupils, we realized that most of the tasks were impossible to carry out due to their complexity for most of them. So those tests were dismissed. Some validated tests are also available for the measurement of motor coordination in the field of psychology, but most of the component tasks are very simple and are totally unrelated to genuine Physical Education abilities. Consequently, neither were they useful for the current validation.

We attempted to link the results of our "3JS" test with Ulrich's "TGMD-2" test (2000) applying it to 600 pupils who had previously done our test, but, despite the results obtained being similar, neither was its use as "Gold Standard Test" considered appropriate due to its duration and proved scarcely effective use in Primary Education. There are numerous and various reasons why the TGMD-2 test was not taken as reference for the validation of our test, but they can be condensed in the fact that the tasks used are too simple and unspecific. Additionally, it is validated for 3 to 10-year olds whereas our test is for Primary pupils aged between 6 and 12 years. Therefore, although this test was applied to most of our sample, we do not consider it a gold standard test to measure coordination in the current validation.

As a result of this and since it is a qualitative type of instrument, we thought it was appropriate to determine the validity of our test through the same technique of consultation with experts used for the internal validity of the content previously mentioned checking that the selected tasks are unanimously considered suitable for the goal we pretend to assess.

CONCLUSIONS

After the performance of the different tasks for the validation of this test, we reached the conclusion that it is a an incredibly valid and useful tool in practice in order to assess the development of coordination in the field of Physical Education in Primary Education for the following reasons:

- The 3JS test is a reliable and valid tool for the measurement of the development of motor coordination in pupils aged between 6 and 12 years.

- It is a tool that, thanks to its simple tasks, can be applied throughout Primary Education, which will allow us to check the evolution of coordination improvement all through the educational period.
- The suggested tasks, though with very limited difficulty, are very specific in their use within the field of Physical Education. This caters for a greater motivation for their performance and provides the pupils with a more accurate knowledge of their own results.
- The number of tasks is quite reduced, which allows a fast and safe application. At the end of the test, the results are directly obtained without having to apply formulae or recodify the items.
- The test can be performed with all the pupils of a class during one single session, which makes it a very useful tool for the teachers.
- The assessment criteria of the tasks performance are very clear and specific to Physical Education.
- The record template is very easy to use and does not require much preparation for its application, so it can be used by teachers with little experience regarding its use.
- This test does not require much preparation before its performance. Very little material equipment is needed, all of which is specific to Physical Education and common in all Primary schools.

To sum up, we are convinced that this tool may become a reference within the next decades as far as teaching assessment tools are concerned since they are very frequently used in Physical Education in Primary schools.

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