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Original research article

RELIABILITY OF COORDINATION TESTS APPLIED IN SELECTION PROCESS IN ARTISTIC GYMNASTICS

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Abstract. *The aim of this study was to perform a restandardization of coordination tests that are used in the selection process in artistic gymnastics and to verify their reliability. The research was carried out on a sample of 112 boys (7 years ± 6 months), first-grade elementary school students from Nis. The reliability evaluation included 19 situational-motor coordination tests, measured by instruments that were used in the selection of gymnasts in 8 countries (Russia, Bulgaria, Romania, Czech Republic, Slovakia, Slovenia, Greece and Serbia). We hypothesized that the composite coordination tests, which consist of a pilot trial and two measurements (two particles), are the most adequate for practical use, with acceptable reliability. All the tests are recommended for further use in practice, for selection in gymnastics and all sports in which coordination essentially determines success. The tests are recommended for measuring coordination skills of younger school age children.*

Key words: *coordination, skills, gymnastic training, young school age.*

INTRODUCTION

Coordination represents the qualitative part of psychomotor activity and is a complex and multidimensional phenomenon, in which several systems participate to assure optimal movement control and reaction to environmental variations (Vandorpe et al., 2012). Coordination skills play an essential role in achieving good results in sports, especially in closed skill disciplines (Miletic et al., 2004; Mijanović & Vojvodić, 2010). Researchers constantly find new tests to check the motor abilities of children of different gender and ages, examine their psychometric properties, and only then recommend them for use in practice (Grubbs, Russell & William, 1997; Wareham et all, 2002; Lolland, 2002; Treuth et al., 2003; Milton, Bull & Bauman, 2010).

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Coordination, flexibility and reactive strength are important determinants of successful performance in artistic gymnastics and may have practical implication in talent identification. A review of the literature showed that there is still a lack of knowledge when we consider motor coordination testing. In particular, studies should take into account the reliability of the tests which have the purpose of checking capabilities that affect the outcome of a particular sporting industry (Sleeper et al., 2006; Casey & Sleeper, 2010) and which are often checked in selection in sports (Proje, 1982; Madić & Protic, 1995; Sadura, Čaklec & Živčić-Lanc, 1991).

Difficulties in trying to define the concept of coordination, especially difficulties in attempting to determine its latent structure, usually result in disagreements in determining the area of motor skills (Hošek in 1976; Pavlovic, 2008). Coordination is not only determined by a single factor (Sekulic & Metikoš, 2007; Kostic et al., 2009), and it is necessary to use battery of tests in the evaluation of this ability (Botao & Chonggao, 1999).

Kochanowicz et al. (2009) investigated the evaluation criteria of selected motor coordination abilities, useful in the optimization of training in young female gymnast at the initial stage of sport training. The aim of the research was to select valid and reliable indicators helpful in the objective evaluation of motor coordination abilities in female gymnasts at the initial stage of training.

The problem is that the area of coordination in many cases tested measuring instruments, whose reliability had not been checked (Velickovic & Petkovic, 2005). The measuring instrument often takes one shot and a motor task (one-item tests). In the selection process for gymnastics, measuring coordination identified as many as 19 one-item tests (Velickovic, 1999). This method of motor testing gives little information about the measured motor skill and can lead to false conclusions. In the tests constructed this way it is impossible to reduce the measurement error (Thomas, Nelson & Silverman, 2005). Improvement of the reliability of existing tests can be obtained only if the restandardisation and reconstruction of composite types of measuring instruments is done. The simplest and most cost-effective procedure that allows the evaluation and reduction of the measurement error is the multiple repetition of certain motor tasks (Bala, 2001).

The problem of this study relates to the reliability of coordination tests used in the selection process in gymnastics and could be applied in all other polystructural sports and sports where coordination capabilities significantly affect the result. The aim of the research is to determine the optimal composite tests with high reliability and cost-effectiveness to implement in practice. Based on the objectives, a working hypothesis (H1) was set: a composite test consisting of a pilot trial and two measurements (two particles) will have acceptable reliability.

THE METHODS

The sample included in the study was a selective subsample of 112 males, aged 7 years (±6 months), candidates for further engagement in gymnastics.

The variable sample, which was used in this study were 19 situational-motor coordination tests, which have found their application in the selection of gymnastics in the region of 8 European countries: Russia, Bulgaria, Romania, Greece, Czech Republic, Slovakia, Slovenia and Serbia (Velickovic, 1999). With the name of the tests a brief description of the problem will be given:

The tests were intentionally designed to assess the accuracy of complex motor tasks: *1) Jumps with symmetrical movements of the extremities (JPSME)* – four jump from the initial position, to the straddled legs and open arms position and back. After four repetitions of the task, the participant immediately takes a new starting position – the straddle stance with arms resting next to the body and without pause, four jump from the initial position to the position with legs together and open arms. The result is a score from 1 to 10, according to the evaluation table (Velickovic, 1999). *2) Jumps in place with asymmetrical limb movements (JPAME)* – four jumps from the initial position to straddle leg position with the right arm in front of the body, and the left behind the body. After this task, without a break, the next task is to perform 4 jumps from the position with legs together and open arms to the position with the right leg in front. The result is a score from 1 to 10, in the evaluation table. *3) Exercise of movement with asymmetric arm movements (EMAAM)* - from the standing position (legs together) in one's own rhythm, the participant performs: (1-2) right leg step forward, left hand front raising, right hand raising; (3-4) step forward with left leg, right hand front raising, left hand up raising; (5-6) step backward right leg, left hand front raising, right hand up raising; (7-8) step backward left leg, right hand front raising, left hand up raising. The entire task is to be repeated once again, only in the opposite way. The result is the number of mistakes made. *4) A combination of asymmetrical hand movements and jumping in place (CAMJP)* – from the standing position (legs together) the participant performs: a) right hand sidewise raising, left arm bended to the chest; b) hands down resting next to the body; c) left hand sidewise raising, right hand in front of the chest; d) hands down resting next to the body; e) raise both arms and place them in front of the chest; f) hands sidewise raising; g) jump in place wide step position, hands down resting next to the body; h) jump in place until position legs together, hands front raising. The result is the number of mistakes made. *5) A combination of asymmetric movements of arms and legs in place (CAMAL)* – the task is, from a still stand, to perform the following: a) lean on the left leg, right leg back raising, right hand front raising, left hand back raising; b) right leg front raising, left hand front raising, right hand back raising; c) right leg back raising, make a circle with both arms back, up, forward; d) put the right leg and both hands in the initial position; e) lean on the right leg, left leg back raising, left hand front raising, right hand back raising; f) left leg front raising, right hand front raising, left hand back raising; g) left leg back raising, make a circle with both arms back, up, forward; h) put left leg and both arms in the initial position. The result is the number of mistakes made. *6) A combination of symmetric movement of the extremities in a seated position (CSMES)* – the task is, from the seated position, legs stretched, to perform: a) a leg raise; b) hand sidewise raising; c) legs apart and hands front raising; d) legs together and separate hands to the side; e) legs apart and hands raising; f) legs together and separate hand to the side; g) put the legs to the ground, h) put arms to the ground until seated in a support position. The result is the number of mistakes made. *7) Rolling and walking on the line with asymmetric hand movements (RWAHM)* – the task is, from the standing position, to do three side rolls on the mat, straight-line then stand on the beginning of the line without a pause, and do the following: a) left leg step forward, right hand on the head, left arm in hands to the side palm up, head turned to the left; b) step by right leg, left hand on the head, right arm in hands to the side palm up, head turned to the right. The exercise is to be repeated two times. At the end, maintain the position on one leg (Frontal standing scale) for a duration of 3 seconds. The result is the number of mistakes made in the part of the test after the side roll.

The measuring instruments for the assessment of the abilities of coordination in rhythm: *1) Rhythmical drumming with legs and arms (RDRLA)* – the task is performed in the corner of the room, the participant stands facing the corner. The goal is to do as many correct cycles in 20 seconds: a) hit the left wall with the left foot once above the horizontal line, drawn 10 cm above the ground; b) put the left leg on the ground and hit the right wall with the right palm once; c) put down the right hand and hit the left wall with the left palm twice; d) put the left arm down and once hit the right wall with the right foot (10cm above the ground). *2) Hitting the horizontal boards (HITHB)* – There are four marked boards on the table, size 25cm, placed in the following way $_{1}{}^{2}{}_{3}{}^{4}$ (similar to boards of the same color on the chessboard). The task is to do as many correct cycles in 30 seconds: a) left palm board 1; b) right palm board 2; c) left palm board 3; d) right palm board 4; e) right palm board 4; f) left palm board 3; g) right palm board 2; h) left palm board 1. This sequence of movements is performed in metronome rhythm, 120 beats a minute. *3) Non-rhythmical hand drumming (NRHDR)* – The participant sits on a chair, places his palms on the table (divided in two halves by means of a line), the left palm on the left half, and the right palm on the right part of the central line. The distance between the palms is shoulder width. The task is to do as many correct cycles in 20 seconds: a) hit the left half of the table twice with the left palm, leave it on the table; b) right palm, over the left hand (so, left of the left palm) hit the left half of the table twice; c) raise the left palm and touch the forehead; d) put the right palm on the right half of the table (initial position).

The assessment tests for the ability to accurately estimate hand movements in space: 1) Performing hand movements in the frontal plane, under the given angle (PHMFP) – The participant stands still, back turned and at a 0,5m distance from the control board (with drawn angles from 0^{O} – down to 180^{O} – up). One shoulder is in the line of control table center. The participant performs the following movements with arms stretched in the frontal surface: (1-2) hands to the side down at an angle of 45^{O}; (3-4) pause; (1-2) hands to the side at an angle of 90^{O}; (3-4) pause; (1-2) hands to the side up under an angle of 135^{O}; (3-4) pause; (1-2) hands up raising at an angle of 180^{O}; (3-4) pause. What is registered is the degree deviation from the given task, and the result is the total of all the deviations. *2) Performing hand movements in the sagittal plane at a given angle (PHMSP)* – The participant stands still, hip turned, at 0,5m from the control board, one shoulder in the same line with the center of the board. The participant performs movements with arms stretched in the sagittal plane, similar as in the previous task, without looking at the board. What is registered is the degree deviation from the given task, and the result is the total of all the deviations.

The assessment tests for the speed of complex motor tasks: *1) Rolling forward, backward and to the side (RFBS)* – the task is that the participant, in a straight-line path, performs the following: a) forward roll and turn the left hip (better side) in the direction of the movement; b) side roll and turn back to the direction of the movement; c) backward roll and turn the right hip in the direction of the movement; d) side roll and turn to face the direction of the movement; e) forward roll; f) high jump with a 360^{O} turn. The results are given in seconds. *2) Skill track (polygon skills), easier version (POSEV)* – the task is to, in the shortest time possible, complete the track length of the 16m jump (Legs together) over 4 medicine balls (the first is 1,3 m from the start, the others at a distance of 1m one from the other), do a forward roll (possibly side roll) on the first mat (5,8m from the start), go under the first horse (9.8 m from the start), overcome the second horse in an obstacle-free style (12m from the start) and go to the goal as quickly as possible. The result is given in seconds. *3) Skill track (polygon skills), harder version (POSHV)* – the task is to, in the shortest time possible, complete the track length 20m jump (Legs together) over 4 medicine balls (the first is 1m from the start, the others at a distance of 1m one from the other), go under the first horse (6 m from the start), do a forward roll on the mat (9m from the start), jump over a bench 40 cm high (13m from the start, placed transversally), overcome the second horse in an obstacle-free style (16m from the start) and go to the goal as quickly as possible. The result is given in seconds. *4) Backward polygon-track (BACKP)* – the task is to walk on all fours backward and go 10m by overcoming two obstacles by climbing (3m from the start, a transversally placed vaulting box 0,5m high), and the other going under (6m from the start, vaulting box frame). During the task, the participant cannot turn his head a single moment. The result is given in seconds.

The tests intentionally designed to assess agility: *1) Running 2x15m from a lying position (R2X15)* – the task is to in the shortest time possible, from push-up position, turn 180^{O}, run a distance of 15m, take a tennis ball and return, running through the start line. The result is given in seconds. *2) Envelope test (ENVET)* – in the shortest time possible, follow the ABCD route of a rectangle shape, dimensions 5x3m (AB and CD are the shorter sides). On the points ABCD (clockwise positioned) and in a diagonal section-center, there is a frame. The route is clockwise - A, B, CENTER, C, D, CENTER, A (the route looks like an envelope). The result is given in seconds. 3*) 10x lie, squat, jump (10LSJ)* – the task is to, in the shortest time possible, from a lying position 10 times go from a lying to a squatting position, then jump and return to the initial position. The result is given in seconds.

All of the tests were restandardized and reconstructed on a composite character, the measuring instruments, with the same composite motor tasks. Each composite consisted of a single test trial and three attempts that were measured (particles). The break between each attempt was 5 minutes (without the possibility of practicing).

Reliability evaluation included the testing of internal consistency and calculating Cronbach's Alpha (α) and Spearman-Brown (WB), the coefficient of the composite structure of the following tests:

α1 and SB1 - the composite of a pilot trial and two measurements;

α2 and SB2 - the composite of two test attempts and two measurements;

α3 and SB3 - the composite of a pilot trial and the three measurements.

The statistical analysis was performed using the statistical package SPSS 18.

RESULTS

The results, obtained during the analysis of the reliability of composite motor coordination tests are listed in Tables 1 to 5, depending on the dimensions of the evaluated coordination. In each table in column 1 we find the sequence number of the measuring instrument, column 2 gives the code name, in column 3 shows the numbers of the items, column 4 the data on arithmetic means of the items (MEAN), in column 5, 6 and 7 the values of Cronbach's coefficient (α) are shown, and in columns 8, 9 and 10 the Spearman-Brown coefficients.

Table 1 The reliability of the tests for the assessment of the correct realization of complex motor tasks

O. n.	Test	Item	MEAN	Crombach's Alpha			Spearman-Brown		
				α_1	α_2	α_3	SB_1	SB_2	SB_3
		1.	4,79						
1.	JPSME	2.	5,27	0,866	0,888	0,900	0,870	0,892	0,903
		3.	5,73						
		1.	4,98						
2.	JPAME	2.	5,75	0,959	0,972	0,974	0,960	0,972	0,975
		3.	6,36						
		1.	3,64						
3.	EMAAM	2.	3,31	0,899	0,925	0,934	0,892	0,925	0,944
		3.	2,96						
		1.	2,84						
4.	CAMJP	2.	2,64	0,842	0,918	0,906	0,842	0,918	0,921
		3.	2,28						
		1.	5,94						
5.	CAMAL	2.	5,87	0,911	0,947	0,945	0,913	0,947	0,950
		3.	5,70						
		1.	4,54						
6.	CSMES	2.	4,25	0,920	0,942	0,934	0,920	0,947	0,930
		3.	4,12						
		1.	5.52						
7.	RWAHM	2.	5.07	0,900	0,924	0,933	0,903	0,926	0,935
		3.	4.82						

In all the tests shown in Table 1, the result is the quality of the performance and accuracy of the implementation of the given practice unit, except that the test of JPSME and the JPAME quality was expressed in conditional units of measurement – by the number of points (higher value means a better result), and in tests EMAAM, RWAHM, CAMAL, CAMJP and CSMES by the number of errors (higher values mean worse results on the test).

Table 2 The reliability of the rhythm coordination tests

O. n.	Test	item	MEAN	Crombach's Alpha			Spearman-Brown		
				α_1	α_2	α_3	SB_1	SB_2	SB_3
		1.	2.66						
1.	RDRLA	2.	3.87	0,756	0,869	0,869	0,758	0,870	0,907
		3.	4.48						
		1.	0.88						
2.	HITHB	2.	1.58	0,765	0,886	0,854	0,788	0,894	0,891
		3.	2.16						
		1.	3.33						
3.	NRHDR	2.	4.62	0,700	0,826	0,821	0,703	0,828	0,860
		3.	5.20						

The test results RDRLA, NRHDR and HITHB (Table 2) represent the number of correctly executed cycles (composed of a series of movements) over time, except that in the first two tests the given cycles are implemented in an arbitrary rhythm, and in the third in the given metronome rhythm. The results in this group of tests were the number of regularly performed cycles in the given time, measured in seconds. Better results imply a larger number of correctly executed cycles.

Table 3 The reliability of the tests of the correct management of shoulder joint motion

O. n.	Test	item	MEAN	Crombach's Alpha			Spearman-Brown		
				α_1	α_2	α_3	SB_1	SB_2	SB_3
1.	PHMFP	1. 2. 3.	18.70 21.88 22.98	0,626	0,752	0,768	0,626	0,758	0,809
2.	PHMSP	1. 2. 3.	15.50 17.00 18.30	0,455	0,618	0,676	0,464	0,619	0,750
3.	PHMFP + PHMSP	1. 2. 3.	34.20 38.88 41.29	0,712	0,798	0,819	0,722	0,803	0,853

In the case of PHMFP and PHMSP tests (Table 3) the accuracy of the implementation of the previously given movement in the shoulder joint in the frontal and sagittal plane, with stretched hands, was measured. The result represents the degree of deviation from the set of angles (45°, 90°, 135°). The task is made more difficult by the fact that the participant performed it with his eyes closed. Higher values mean poorer performance on the test.

Table 4 The reliability of the tests for the measurement of complex motor tasks speed

O. n.	Test	item	MEAN	Crombach's Alpha			Spearman-Brown		
				α_1	α_2	α_3	SB_1	SB_2	SB_3
1.	RFBS	1. 2. 3.	14.23 12.93 12.48	0,776	0,790	0,814	0,788	0,790	0,795
2.	POSEV	1. 2. 3.	12.48 11.48 11.16	0,813	0,778	0,829	0,839	0,778	0,797
3.	POSHV	1. 2. 3.	14.69 13.83 13.47	0,874	0,866	0,895	0,878	0,868	0,883
4.	BACKP	1. 2. 3.	22.11 20.51 19.08	0,806	0,894	0,863	0,813	0,899	0,875

Table 5 The reliability of the agility tests

O. n.	Test	item	MEAN	Crombach's Alpha			Spearman-Brown		
				α_1	α_2	α_3	SB_1	SB_2	SB_3
1.	R2X15	1.	9.82	0,832	0,842	0,886	0,840	0,843	0,891
		2.	9.86						
		3.	9.77						
2.	ENVET	1.	10.82	0,784	0,757	0,812	0,786	0,759	0,785
		2.	10.40						
		3.	10.32						
3.	10LSJ	1.	35.03	0,843	0,890	0,892	0,850	0,890	0,896
		2.	34.18						
		3.	33.97						

In all the measuring instruments in Table 4 and 5 the result was a realization time of a motor task, registered in seconds. This means that the shorter the time of realization of the task meant a better result.

DISCUSSION

The values of the arithmetic means of all the analyzed tests, where higher values mean a better result, systematically grows, while on the tests, where lower values mean better results, they systematically decline. The aforementioned results indicate that in each successive measurement the results improve, so that the third measurement gave the best results. The systematic changes in the values of the arithmetic means, even though they are not widely expressed, indicate the existence of the process of learning in all the analyzed tests. The results in each successive attempt are in their small part a reflection of knowledge gained in the previous attempt. The educational function of the measurements was repeatedly ascertained by tests that include complex motor tasks (Botao & Chong-gao, 1999; Raczek, Grzegorz, & Waśkiewicz, 2001; Gurfinkel & Cordo, 2004). The problem is that the educational impact of these tests is minimal after a number of repetitions of the motor task (Sekulic & Metikoš, 2007). It is important to notice that the differences in means are reduced as the number of items increase. This indicator shows the tendencies of stabilization of the educational function of the test and hence the viability of the three items in the composite test.

By analyzing Cronbach's and Brown-Spearman's coefficient of reliability it can be said that the weakest reliability is achieved in one trial attempt and two attempts in which the result is registered (α1 and SB1). By this type of measurement a good ($0.9 > \alpha \geq 0.8$ - George & Mallery, 2003) and an excellent ($\alpha \geq 0.9$ - George & Mallery, (2003) reliability of the ability measurement tests of correct realization of complex movements was obtained (Table 1). For all the other mentioned tests, the measuring method caused mainly acceptable ($0.8 > \alpha \geq 0.7$ - George & Mallery, 2003) and good reliability. Only, the PHMFP and RDP (Table 3) gave questionable ($0.7 > \alpha \geq 0.6$ - George & Mallery, 2003) or unacceptable reliability ($0.5 > \alpha$ - George & Mallery, 2003).

More reliable measurement results are obtained if composites with two test trials and two measurements are applied, as well as when one attempt and the three measurements are performed. Both composites produce very similar result reliability. Excellent reliability was restrained at the tests of the accuracy of complex motor tasks (Table 1). The reliability of all the other measuring instruments ranges between the limits of acceptability and good reliability.

The coordination in rhythm tests and the tests used to assess precise control movements in the shoulder joint in place are not reliable if they are applied in the given way.

A special exception are the mentioned tests that evaluate the accuracy of the control movements in the shoulder joint. The means of the measured results of the PHMFP and PHMSP tests vary in a small range, with a nice uptrend in order to increase the errors in the implementation of the task. The data indicate that the outcome of the tests are influenced, probably, by stochastic processes, but not in terms of the educational impact of the previous measurement to the next, but in the sense of forgetting the task. The values of these coefficients are below the acceptable limits, indicating the need for the standardization of these tests.

Knowing that there is a strong similarity between measuring instruments (the difference is only in the plane of motion), standardization has been made to aggregate the results of each item for each test (the unit of measurement is the same - deviation from the set angles). This has produced a new testing and variable (PHMFP + RDP) with much greater reliability coefficients and the percentage of the explained variance. The values of the coefficients indicate that it is right to use this test, and if you take into account the two particles, having previously run one test attempt, all in order to economize measurements. Thus, the standardized test can find a further application in practice.

CONCLUSION

During the application of a test trial and two measurements, the obtained reliability ranges from acceptable values to excellent values, and the working hypothesis can be confirmed (H1): composite tests consisting of one trial attempt and two measurements (two particles) are the most economic for practical use and will be of acceptable reliability. The previous observation implies that the grant standardization of the PHMFP and PHMSP tests is correct, or that the results of these tests are distinguished as a single test - PHMFP and PHMSP.

Improved reliability can be achieved by adding another trial attempt or another measurement. These measuring instruments are used in the selection process in gymnastics and when there is a large sample to measure, the need for additional efforts does not exist there, because it gets little benefit (slightly better reliability) and loses a lot (the effectiveness of measurements). This conclusion is supported by the fact that very high reliabilities (0.95 or higher) are not necessarily desirable, as this indicates that the items may be entirely redundant (Streiner, 2003). The goal in designing a reliable instrument is for scores on similar items to be related (internally consistent), but for each to contribute some unique information as well.

All the tests can be applied in the selection in sports where coordination is an essential factor of success, and in measuring the coordination skills of young schoolchildren.

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POUZDANOST SITUACIONO-MOTORIČKIH TESTOVA KOORDINACIJE PRIMENJENIH U SELEKCIJI ZA SPORTSKU GIMNASTIKU

Cilj istraživanja bio je da se izvrši restandardizacija testova koordinacije koji se primenjuju u procesu selekcije za sportsku gimnastiku i proveri njihova pouzdanost. Istraživanje je izvršeno na uzorku od 112 osoba, muškog pola, uzrasta od 7 godina (± 6 meseci), polaznika prvih razreda osnovnih škola grada Niša. Procena pouzdanosti obuhvatila je 19 situaciono-motoričkih merenih instrumenata koordinacije koji su korišćeni u selekciji za sportsku gimnastiku u 8 zemalja (Rusija, Bugarska, Ruminija, Češka, Slovačka, Slovenija, Grčka i Srbija). Potvrđena je hipoteza da kompozitni testovi koordinacije sastavljeni od jednog probnog pokušaja i dva merenja (dve čestice), kao najekonimičniji za primenu u praksi, imaju prihvatljivu pouzdanost. Svi testovi se preporučuju za dalju upotrebu u praksi selekcije kako za sportsku gimnastiku tako i za sve sportove u kojima koordinacija bitno opredeljuje uspeh. Preporučuju se i za merenje koordinacionih sposobnosti kod sve dece mljađeg školskog uzrasta.

Ključne reči: *koordinacija, sposobnosti, gimnastički trening, mlađi školski uzrast.*