

CONSTRUCTION OF A SPECIFIC TEST FOR ESTIMATING COORDINATION IN RHYTHMIC GYMNASTICS

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Abstract

Rhythmic gymnastics is a combination of sport and art in which the ability of coordination plays a very important role. Since there are not enough specific tests that would assess coordination, both in the selection of children for potential rhythmic gymnasts, as well as in monitoring the training process, the main purpose of this paper is to construct a coordination assessment test that will be applied specifically to rhythmic gymnastics. The sample consisted of 93 students of the 3rd year of integrated undergraduate and graduate study at the Faculty of Kinesiology, University of Zagreb (average age 21 ± 1 year). In addition to the newly constructed test "Echappe" with the rope (MKEV), three other tests were used: ground maneuverability (MAGONT), the jumping hoop forward (MKOOPO), and the back polygon (MREPOL). Microsoft Excel 365 was used to facilitate data preparation and visualization, while IBM SPSS Statistics 26 was used for statistical analysis, with arithmetic mean and standard deviation as descriptive indicators, Shapiro-Wilks test to determine distribution normality, Kruskal-Wallis test with Bonferroni correction for validation, and Fleiss Kappa for reliability determination, which was further determined by Spearman's Rank correlation. The results showed that there is no evidence that "Echappe" with the rope measures the coordination required for success in rhythmic gymnastics, and that further research is needed with redefined criteria that will contribute to the improvement of metric characteristics of the test.

Keywords: Motor intelligence, Newly constructed test, Metric characteristics, Rhythmic gymnastics, Coordination, "Echappe".

INTRODUCTION

Under the great influence of ballet and modern dance, rhythmic gymnastics is a connection of sport and art. Performing an exercise with music, as individual or group practitioners, the rhythmic gymnasts amaze the audience with their astonishing skills by performing extremely difficult elements with a small hand apparatus: a hoop, a ball, clubs, a ribbon and a rope. Flexibility and music interpretation are important components of rhythmic gymnastics. Coordination is considered a

qualitative motor ability. Motor skills influence the efficiency of human movement. Various studies have shown that motor skills cannot be widely defined by just one, universal feature. To analyze the ability of humans to move, it is necessary to divide movements into several quantitative (strength, speed, endurance, mobility) and qualitative (coordination, balance, agility, precision) motor skills. (Cvenić, 2007). Coordination is, according to Metikoš and Hošek (1972),

the ability to control movements of the whole or part of the body. It manifests as efficient and precise execution of complex motor tasks, i.e., a quick solution of motor problems. For that reason, this ability is also called "motor intelligence". The term "coordination" refers to the precise and coordinated movement of the whole body, coordination of complex movements of the upper and lower extremities, as well as rapid motor learning, and rhythmic performance of motor tasks. Furthermore, there are several action factors of coordination. These are: speed coordination (ability to efficiently and correctly execute complex motor tasks), rhythmic coordination (ability to perform more or less complex structures of movement in a given or free rhythm), fast learning of motor tasks (fast and efficient adoption of complex motor tasks), timeliness or timing (ability to assess the spatio-temporal relations of a movement and timely response in complex motor tasks), and spatio-temporal orientation (ability to accurately distinguish spatial distances and to assess and perform a given pace of movement) (Milanović, 2013). As rhythmic gymnastics is a difficult and complex sport that requires spatio-temporal coordination of body movements and apparatus manipulation, specific motor coordination is a vital part of technical preparation with a very important role and a prerequisite for learning many rhythmic techniques. However, what distinguishes a gymnast is the amount of risk that she takes by throwing a small hand apparatus a few meters in the air, often losing sight of it, while performing jumps, pirouettes or semi-acrobatic elements, and catching it (Federation Internationale de Gymnastique, 2020). This gives us an idea how important coordination is in the equation of a rhythmic gymnastics performance. This hypothesis, although only for younger age categories, is confirmed by the research study of Purenović - Ivanović T., Popović R.,

Stanković D. and Bubanj S. (2016) that tested 127 rhythmic gymnasts on the national and international level to determine if it was possible to predict success of rhythmic-gymnasts on the basis of their coordination skills. The same is confirmed by research of Mullagildine A. (2017), whose purpose was to determine the influence of sensorimotor coordination on the technical readiness in the performance of elements with clubs in rhythmic gymnasts aged 8-9 years. After testing and analysing 11 elements, it was concluded that the performance of basic technical elements with clubs is influenced by the following: ability to analyze the spatial-temporal characteristics of movement; differentiate one's own muscle proprioceptive sensitivity, ability to predict the next move. In a scientific paper by Furjan, G. (1990), the relationships between situational and coordination tests, and evaluation of exercises without apparatus and exercises with a hoop were determined, and the results showed that all tests had satisfactory measurable characteristics. Research by Kolarec M., Horvatin - Fučkar M. and Radaš J. (2013) focused on the connection between motor skills and performance of technical elements with a ball, and the coordination test MBKS3L (slalom with three balls) proved to be statistically significant. In their study "Coordination training of athletes who specialize in gymnastics", Tereshchenko IA, Otsupok AP, Krupneve SV et al. (2015) aimed to experimentally determine the effectiveness of a coordination training program designed for athletes who specialize in sports gymnastics. First-year students participated in the research (21 participant: 14 girls and 7 boys, aged 17-18). The obtained results showed that the realization of the program of exercises for the improvement of static-dynamic and static-kinetic stability increased the sensory-motor coordination of students. These results concluded that a new direction for certain exercises is recommended: to practice, develop and

improve static-dynamic and static-kinetic balance of the body. Coordination training of athletes specializing in gymnastics should be one of the priorities in the system of physical education and health as well as the sport itself. The problem with research is that there are not enough specific measurement instruments to evaluate coordination in rhythmic gymnastics. As coordination in the specific equation is a top priority, it is important that coaches have as large a battery of tests as possible, especially for measuring coordination in children. Another problem is that coaches often use tests that they think that measure/assess what they need (in this case coordination) without any evidence that the specific tests really measure this. The main goal of this paper is to construct a specific coordination test that will be useful to rhythmic gymnastics trainers. In this way, the test could not only facilitate assessment of coordination skills in the selection of children for potential rhythmic gymnasts in the future, it would also assess opportunities for their progress in rhythmic gymnastics and serve as a source of insight into the training process of coordination abilities.

METHODS

The sample of subjects consisted of 93 male students of the 3rd year of integrated undergraduate and graduate university studies of the Faculty of Kinesiology, University of Zagreb (average age 21 ± 1 years). The condition for participating in the study was not attending courses in rhythmic gymnastics, and student's health, i.e., no injuries that could affect the performance of the task itself or risk worsening any student's health condition. Before conducting the study, the respondents were informed about the goals and potential risks, signed informed consent for voluntary participation in the experiment (approved by the Ethics Committee of the Faculty of Kinesiology, University of Zagreb) and were asked if

they had any injuries that prevented them from participating.

Testing was carried out in the wrestling hall; a third of the large hall of the Faculty of Kinesiology, University of Zagreb, was used. Due to the current epidemiological situation with the coronavirus, an application was submitted for the use of the faculty premises before the start of testing, which was approved, and all tests were carried out in accordance with the adopted epidemiological measures at the given moment. In addition to the main measurer, testing was carried out with two assistant measurers. Three students entered the hall at a time, and invited in the next three students after completion, thus completing the measurements of each group. In addition to the newly constructed coordination test "Echappe" with the rope, three other, already verified coordination tests, were measured: jumps over the hoop forward (MKOOPO), polygon backwards (MREPOL) and agility on the ground (MAGONT).

Jumps over the hoop forward (MKOOPO)

Coordination test "Jumps over the hoop forward" was taken from the scientific paper "Construction and validation of coordination test BOSKO" by Jagić, M. and Polančec, J. (2008). Metric characteristics that were established for this test are: sensitivity, reliability and validity.

For the test to be performed correctly, an appropriate hoop size and a stopwatch are required.

Testing is carried out in an indoor area measuring 1x1 meter. In the starting position, the respondent stands and holds the hoop with both hands in front of him. At the sign "now", the subject begins to skip the hoop first with his right, then with his left foot, and tries to do as many correct jumps as possible in 20 seconds. The person conducting the test stands near the subject and counts the correctly performed skips. The task is completed when 20

seconds pass and the examiner says "stop". The examiner performs one demonstration and gives oral instructions, while there are no trial attempts or practice before the performance. For the purposes of the data analysis of this test, the arithmetic mean is calculated.

Polygon backwards (MREPOL)

For the purpose of conducting this test, the following was used: a stopwatch, an upholstered base and a Swedish crate frame, as well as a self-adhesive tape to mark the ground space.

The task is performed in an indoor or outdoor area, with a minimum dimensions of 12x3 m. First, the starting mark (straight line) of 1 meter (start mark) is marked, and in parallel with it, the finishing line (goal mark) is marked 10 meters further. 3 meters from the initial horizontal marking of the "start", the upholstered base of the Swedish crate is placed, vertically on the direction. The place where the crate should be is marked by self-adhesive tape. Six meters from the initial mark, the largest box of the crate is placed across the track so that it touches the ground with its longer side, while the location of the obstacle is also marked. (Metikoš, Hofman, Prot, Pintar, & Oreb, 1989.) The subject takes the starting position with his back to the direction of movement and his palms and feet on the ground (knees are bent and separated from the ground, with feet immediately in front of the starting line). On the signal "now", the subject walks backwards 10 meters on all fours, trying to successfully overcome each obstacle. The first obstacle is overcome by climbing, and the second by crawling. During the execution of the task, it is not allowed to turn one's head and look in the direction of movement. The task is repeated 3 times; between repetitions, the subjects has a short break. The task is completed when the subject crosses the goal mark with both hands. During the performance of the task, the person in charge of measuring the time moves alongside the subject, holding a

stopwatch in his hand and controlling the performance of the task. The elapsed time is measured and recorded in tenths of a second from the sign "now" to crossing both hands over the goal mark. In the case that the subject knocks down an obstacle, he must continue, and the crate frame is put back in its position by the examiner for the next respondent. After the examiner has demonstrated and described the task, the subjects start with the execution without a trial attempt.

Agility on the ground (MAGONT)

The props needed to carry out the test include: a stopwatch, four mats and the upper part of the judo kimono, which is duly rolled up and tied with a belt.

The subject performs the task in an indoor or outdoor space that measures at least 8x4 meters. The mats are placed in the form of the letter "L", in such a way that three mats are placed longitudinally, one after another, while the fourth is placed vertically, next to the third mat. On the edge of the fourth mat, there is the folded kimono. (Metikoš, Hofman, Prot, Pintar, & Oreb, 1989.) The subject lies on the abdomen, fully extended arms and legs, perpendicular to the first mat. At the sign "now", the subject begins to roll over the first three mats. When the subject reaches the fourth mat with his whole body, he goes on all fours and moves backwards (four-legged) over the fourth mat to the kimono. He straddles the kimono with his knees without the help of his hands, and then, holding the kimono between his knees, returns by rolling over the fourth mat back to the third. Here the subject makes a 90° turn, so that it is with his back to the first mat, and continues the back roll to the end of the first mat while keeping the kimono between his knees. The task is completed when the subject crosses the edge of the last mat with any part of his body. In the case of the kimono falling down from between the knees, the subject must again collect it with his legs, without any help of his hands and continue the

task. During the execution, the examiner walks along the subject and controls the correct execution of the task. The task is demonstrated once, accompanied with oral instructions, and repeated four times, with breaks between repetitions. In the data analysis, the arithmetic mean of all four repetition results is used. There are no trial attempts or practice before the first attempt.

Newly constructed test "Echappe" with the rope (MKEV)

The doctoral dissertation "Evaluation and analysis of the development of motor skills in rhythmic gymnastics" by Bozanic A. (2011) mentions the test of coordination with the rope "Ejecting one end of the rope (VB)," which has been modified for the purposes of this testing and called "Echappe" with the rope.

For the proper performance, ropes of different lengths are needed so that each subject performs the task in the same conditions. The rope is of good length when the subject with both legs fits in the middle of the rope holding knots in his hands and the knots are reaching to the armpits of the subject.

The subject stands and holds a rope in each arm in front of the body so that each rope knot is in one hand, and the rope makes the shape of the letter "U". At the sign "now", the subject executes a large circular movement with his arms to the back: one hand leads behind the back towards the opposite side, while the other remains in the handout, diagonally left or right (depending on which hand the subject performs the movement). At the moment of the arrival of the arm behind the back to the side of the opposite flank, the arm bends and releases the knot, while the arm in the handout makes a circular motion to bring the rope knot back towards the subject. After the subject has caught the knot, he jumps over the rope with a "feline" jump (like a high skip, from foot to foot) and completes the task. The task is performed three times and is evaluated

with grades from 0 to 5. The subjects' performances are monitored and evaluated by three experts in rhythmic gymnastics (former rhythmic gymnasts from the Croatian national team, two of whom are also international judges). With oral instructions, the examiner demonstrates the task three times: face to the subjects, back to the subjects, and sideways from the subject. No trial attempt or exercise is allowed before the first attempt.

Evaluation criteria

Grade 5 - Cleanly executed "Echappe" with a clean catch and a quick skip without a stop. "Cleanly executed "Echappe" and a catch" is meant to be the correct trajectory of the rope through the air without hitting the floor when pulling the rope back and a catch of the knot before jumping over

Grade 4 - Cleanly executed "Echappe" with a clean catch and skip after a short break

Grade 3 - Executed "Echappe" with a catch and skip with or without a pause

Grade 2 - Executed "Echappe" with a catch, but without successfully jumping the rope

Grade 1 - Executed "Echappe", the rope is not caught

Grade 0 - There is no "Echappe" or any visible stage of the task - the respondent did not perform a circle with his hands, the knot immediately hits the floor, etc.

Microsoft Excel 365 was used to enter, prepare, and visualize the data, while IBM SPSS Statistics 26 was used for statistical analyses.

The arithmetic mean and standard deviation were also calculated. The Shapiro-Wilks test was used to determine the normality of distribution, on the basis of which it was decided whether to use parametric or nonparametric tests in the further processing of the results. (Shapiro & Wilk, 1965)

The validity of- "Echappe" with the rope was checked with the Kruskal-Wallis

test with Bonferroni correction to determine statistically significant differences between grades (groups) and results in other coordination estimation tests. Subjects who have better grades in this test should also have statistically significantly ($p < 0.05$) better results in other tests that assess coordination (Corder & Foreman, 2009) (Bonferroni, 1936).

Test reliability – "Echappe" with the rope was checked with Fleiss' Kapp for ordinal data. The correlation between

individual measurements with Spearman's Rank correlation was further established. (Fleiss, 1971) (Daniel, 1990)

RESULTS

Descriptive statistics and data distribution

Table 1 shows descriptive indicators of the entire sample, while Table 2 shows descriptive indicators by test scores – "Echappe" with the rope.

Table 1

Descriptive indicators of sample.

	Arithmetic mean $\pm$ Standard deviation (n = 93)
Age (years)	21 $\pm$ 1
Jumps over hoop forward (n/20 sec)	21 $\pm$ 5
Polygon backwards (sec)	7.84 $\pm$ 1.21
Agility on the ground (sec)	13.06 $\pm$ 1.67

Table 2

Descriptive indicators by test scores – "Echappe" with the rope.

	Test "Echappe" with the rope				Shapiro-Wilks p value
	Grade 0 (n = 12)	Grade 1 (n = 11)	Grade 2 (n = 40)	Grade 3 (n = 30)	
Age (years)	21 $\pm$ 1	21 $\pm$ 2	21 $\pm$ 1	21 $\pm$ 1	
Jumps over the hoop forward (n/20 sec)	20 $\pm$ 4	22 $\pm$ 5	19 $\pm$ 5	22 $\pm$ 5	0.013
Polygon backwards (sec)	7.79 $\pm$ 1.14	8.21 $\pm$ 1.63	7.83 $\pm$ 1.05	7.73 $\pm$ 1.30	0.127
Agility on the ground (sec)	13.94 $\pm$ 1.93	12.68 $\pm$ 2.01	13.10 $\pm$ 1.40	12.797 $\pm$ 1.73	0.020

Table 3

Comparison of the results of different tests by assessments of the test subjects - "Echappe" with the rope.

	Test "Echappe" with the rope				Kruskal-Wallis p value
	Grade 0 (n = 12)	Grade 1 (n = 11)	Grade 2 (n = 40)	Grade 3 (n = 30)	
Age (years)	21±1	21±2	21±1	21±1	
Jumps over the hoop forward (n/20 sec)	20±4	22±5	19±5	22±5	0.046
Polygon backwards (sec)	7.79±1.14	8.21±1.63	7.83±1.05	7.73±1.30	0.601
Agility on the ground (sec)	13.94±1.93	12.68±2.01	13.10±1.40	12.797±1.73	0.248

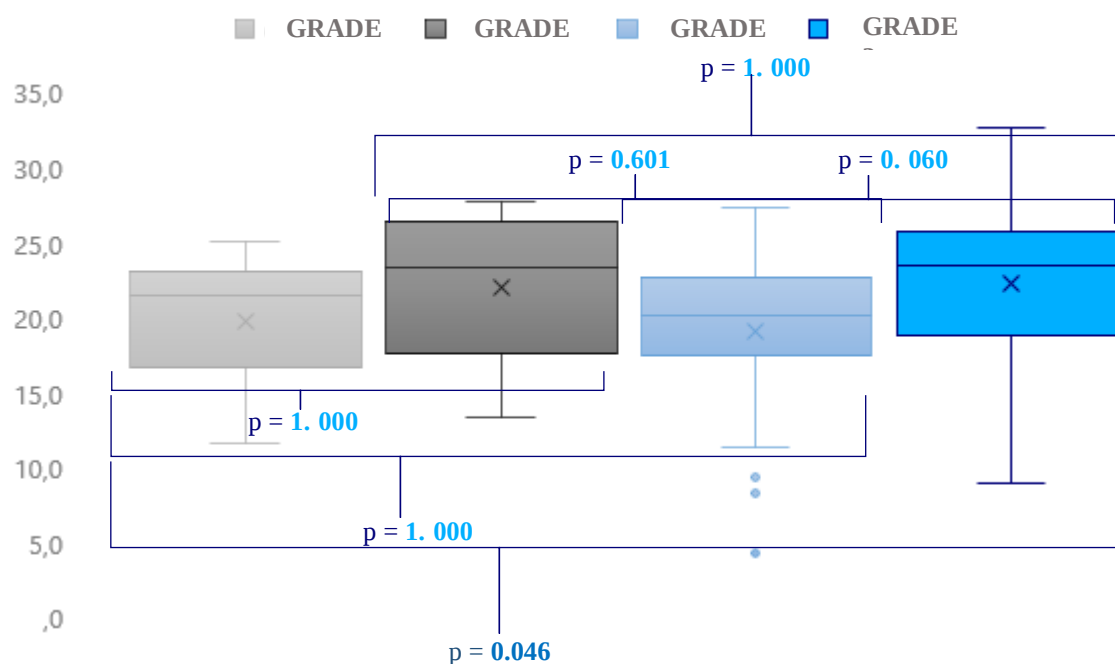


Figure 1. Comparison of test results – jumps over the hoop forward according to the test subjects' ratings - "Echappe" with the rope.

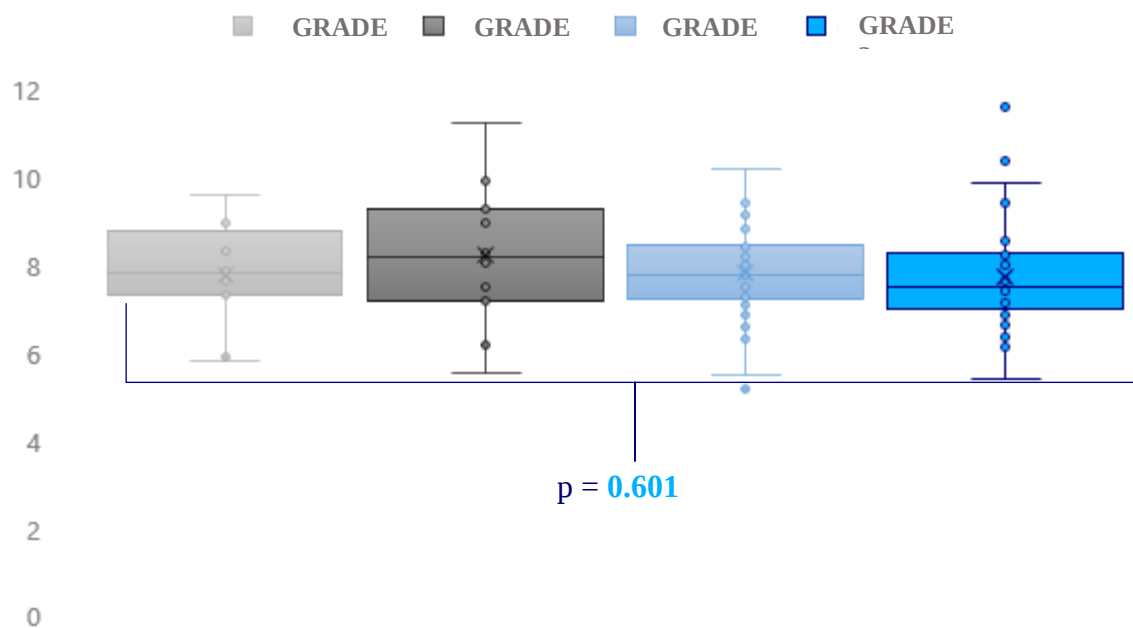


Figure 2. Comparison of test results - polygon backwards according to the assessments of the subjects in the test - "Echappe" with the rope

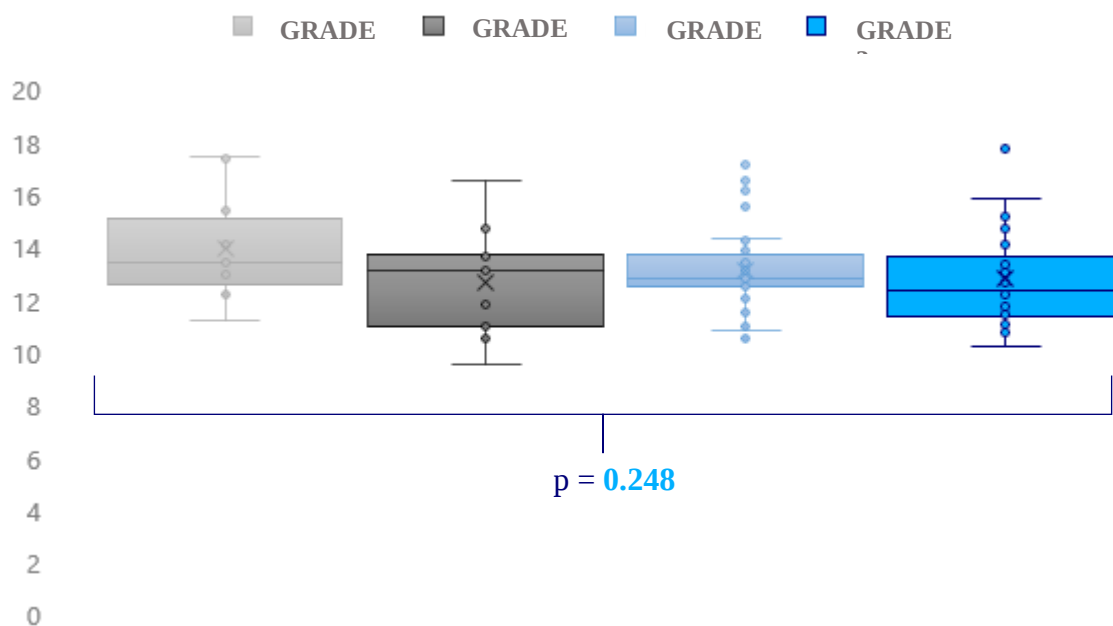


Figure 3. Comparison of test results - agility on the ground by test subjects' ratings - "Echappe" with the rope

Table 4

Connectivity and reliability of individual test measurements - "Echappe" with the rope.

Spearman correlation	Test – "Escape" with the rope			Reliability	
	1st measurement	2nd measurement	3rd measurement	Fleiss Kappa	p value
				0.120	<
Measurement1	1.000	0.341	0.335		0.001
Measurement2	0.341	1.000	0.255		
Measurement3	0.335	0.255	1.000		

Arithmetic mean and standard deviation are descriptive indicators used to describe the sample of respondents. The Shapiro-Wilks test was used to determine the normality of the distribution (Shapiro & Wilk, 1965), on the basis of which it was decided whether to use parametric or nonparametric tests in the further processing of the results.

The distribution of most variables deviates statistically significantly from the normal distribution (Table 2, p value > 0.05); therefore, nonparametric variants of the tests are used in further analyses.

There is no evidence that the test measures the coordination necessary for success in rhythmic gymnastics (Table 3, Figure 1, Figure 2, Figure 3).

Although there seems to be a statistically significant difference in the scores in the test results a detailed comparison of all groups shows that it does not really exist (Figure 1)

There is a statistically significant correlation between individual measurements ($p < 0.001$), but the power of the correlation between measurements is too weak (Fleiss Kappa = 0.120) to consider this test reliable (Table 4). The expected value of the Fleiss Kappa should be above 0.810 to consider the test reliable. (Landis & Koch, 1977)

DISCUSSION

The results of this study indicate that there is no evidence that the "Echappe" test with the rope measures the coordination

required to succeed in rhythmic gymnastics. A comparison of the results for all four tests show that there is seemingly a statistically significant difference, but when comparing each group with each other in more detail, it turns out that there is no statistically significant difference between them. Furthermore, when it comes to test reliability, a statistically significant correlation exists ($p < 0.001$), but it is still too weak to consider this test reliable enough. According to Landis and Koch in 1977, in order to consider a test reliable, the Fleiss Kappa should have a value above 0.810, while in this test it is only 0.120. We can also see that subjects who have better grades in the "Echappe" test with the rope do not necessarily perform better in the remaining three tests, namely jumps over the hoop forward, polygon backwards and agility on the ground, as presented in Table 3, and in Figures 1, 2 and 3. Likewise, subjects who have lower grades in the "Echappe" test with the rope do not necessarily perform worse on the above tests (Table 3, Figures 1, 2 and 3). The obtained results indicate the complexity in constructing specific tests for assessment of coordination. The question arises as to why this is the case and what can be changed in order to improve the metric characteristics of the test so that it can be used to evaluate coordination in the future. One of the reasons that certainly affects the reliability of the newly constructed test is the subjectivity of the assessment. In fact, even when conducting the test on students it was already evident that the criteria were

not defined clearly enough, and their performances were often on the borderline between two grades that were then decided by the measurers on the basis of their subjective estimation of good or poor performance. This shows us that there is still much room for redefinition and a clearer set of criteria to make the assessment as objective as possible, and ultimately more reliable. Coordination is also quite complex and undefined, composed of several components, and the question is whether it can be defined as just one ability that can be measured. For this reason, it is also called "motor intelligence". If different studies from different authors are examined, each of them will have its own definition of coordination, which does not mean that they are wrong but confirms its complexity. The author of this paper believes that it would be desirable to have an even larger battery of tests created for assessment of coordination. Each such test should evaluate one of the coordination components and thus ensure a better and more reliable assessment and certainty that it really measures the component that we want to evaluate. Each test should have its own criteria based on the capability of a particular component, and once all tests are conducted and the results obtained, new criteria can be devised for the entire battery together. The results of the tests carried out could then be added together and from the common criteria for the entire battery the final assessment of coordination with all its components could be made. Such a holistic approach which looks at all components both separately and together could be much more effective than using just one test for such a complex ability.

Furthermore, it is possible that the newly constructed test was too difficult for the student population on which it was conducted. After all, it is a specific test that requires a certain level of skill to handle the rope, and it could lead to different results on another population. For this reason, the purpose of the Purenović –

Ivanovic T., Popović R., Stanković D. and Bubanj S. (2016) research study was to test and/or determine whether it was possible to predict success of a rhythmic gymnastics performance on the basis of the coordination abilities of rhythmic gymnasts. 127 national and international rhythmic gymnasts were included in this study. In multiple regression analyses of specific coordination skills, a statistically significant influence on success was found only in the group of cadets and younger cadets ($p < 0.018$ and $p < 0.000$), with an explanation of 42% and 50% of success in RG. The regression analysis also highlighted the contribution of three independent variables (rolling the ball – younger cadets: $p = 0.03$; hoop skipping – younger cadets: $p = 0.03$ and the whole sample: $p = 0.02$, and manipulating clubs – younger cadets: $p = 0.03$ and the whole sample: $p = 0.02$) in predicting the dependent variable, with a positive link between these independent and dependent variables. This research study confirmed the importance of coordination skills for success in RG, but only for younger age categories. The scientific paper by Furjan, G. (1990) defines three main objectives: determining the relationship between situational tests and coordination tests and year from an exercise without apparatus; determining the relationship between situational tests and coordination tests and year from an exercise with the hoop, and determining the relationship between situational and coordination tests. The research was conducted with participants in the first, second and third year of schools of rhythmic – sports gymnastics, with the first stage being beginner and the third the most advanced. After conducting analyses based on the observed measurement characteristics of the selected tests for this study, it can be concluded that all tests (RSETKV, RSEKSV, RSEBLP, RSESPR, MFRURC, MFRURB, MFRMOS, MKRBUB, MSLDN, MVLRL, MZON, MOZ, MPIS) have satisfactory measurable characteristics. Additionally,

they are appropriate for the subjects on whom the test was performed, except for the MKRBUB test, which is not the best test to assess rhythmic abilities.

The primary objective of the Kolarec M., Horvatin – Fučkar M. and Radaš J. (2013) study was to determine whether there was a correlation between motor skills and success in performance of technical elements in the ball exercise in rhythmic gymnastics. The study was conducted on 52 second-year students of the Faculty of Kinesiology, University of Zagreb. From the group of predictor variables, only the MBKS3L coordination assessment test (three-ball slalom) showed statistical significance in predicting success in performing selected elements.

CONCLUSION

The results of this study suggest that the newly constructed "Echappe" test with the rope is not good for estimating the specific coordination needed to succeed in rhythmic gymnastics. After processing the data and comparing the tests with each other, it can be concluded that there are no statistically significant differences between them, which means that the metric characteristics of the test (validity and reliability) are not good. The obtained results point to the fact that to improve the metric characteristics of the test, a redefinition of the criteria is required, with further research, a potential construction of a larger battery of tests that will have a better defined approach for each component of coordination as an ability, and applying the test to the rhythmic sample. In addition, there is a need for a clearer definition of criteria which will make performance assessment when testing as objective as possible.

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