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Original research article

THE IMPORTANCE OF MOTOR COORDINATION ABILITIES FOR PERFORMANCE IN RHYTHMIC GYMNASTICS

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Abstract. *Rhythmic gymnastics (RG) is a difficult and complex sport which requires increased space-time coordination between body movements and apparatus handling, thus making specific motor coordination a vital part of technical preparation in RG with an important role in creating the preconditions necessary for allowing the gymnast to learn many RG techniques. The purpose of the research was to test and/or determine the possibility of predicting success in RG performance on the basis of gymnasts' coordination skills. One hundred and twenty-seven national- and international-level rhythmic gymnasts (age: 11.93±3.09 years, body height: 147.65±14.6 cm, body mass: 37.67±11.7 kg, BMI: 16.78±2.26 kg/m^2, training experience: 5.85±2.81 years), distributed in five age categories (22 beginners, aged 7-9 years; 39 intermediate, aged 9-12 years; 26 advanced, aged 12-14 years; 25 juniors, aged 14-16 years; 15 seniors, aged 16 years and older), volunteered to participate in the study. Their baseline characteristics (age, body height, body mass, BMI, years of training experience, Success) were established, as well as their specific coordination skills (B-ROL, R-TCJ, H-SKP and C-JUG). By means of a Multiple regression analysis the specific coordination skills' statistically significant influence on Success was established only in the group of advanced and intermediate gymnasts ($p<0.018$ and $p<0.000$, respectively), with an explanation of 42%, i.e. 50% of success in RG. Also, the Regression analysis emphasized the significant independent contributions, to the prediction of the dependent variable, of three independent variables: ball rolling (intermediate gymnasts: $p=0.03$), hoop skipping (intermediate gymnasts: $p=0.03$ and sample in total: $p=0.02$) and clubs juggling (intermediate gymnasts: $p=0.03$ and sample in total: $p=0.02$), with positive relationship among these independent variables and dependent variable. This study has confirmed the importance of coordination skills for success in RG, but only for younger age categories.*

Key words: *rhythmic gymnasts, age categories, specific coordination, regression.*

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INTRODUCTION

The ability of performing complex movements, solving complex motor tasks, performing speed of acquired motor programs, and speed of the adoption of new motor programs (Miletić, 2005), known as motor coordination, is one of the substantial determinants of motor functioning and of the development of the body as a whole. Coordination as an aspect of physical fitness is a complex entity which allows a person to use the neuromuscular and kinesthetic senses of body parts to perform exercises successfully and accurately. Certainly, among all aspects of physical fitness, coordination plays a very specific role, as it is connected with other areas of fitness. Motor coordination is no doubt the most important ability in terms of the overall performance and motor behavior of human beings. It is practically implemented in every movement structure, from the simplest to the most complex forms of motion (Purenović-Ivanović, 2014). We can further differentiate coordination abilities as being either general or specific. General coordination abilities are those involved in any motor task, and specific coordination abilities (or *specific coordination*) are those relating to sport-specific motor tasks.

Rhythmic gymnastics (RG) is a blend of gymnastics, dance and apparatus handling, a combination of impressive motor structures that are characterized by beauty, elegance and harmony of movement, with the constant striving to achieve perfectly coordinated, coherently connected and precisely executed motions and movements (Ivančević, 1976). This sport has undergone immense development in the last few decades, owing to the ever increasing technical skills required through the revision of the Code of Points. These rules stress the importance of high-difficulty activities, and high difficulties require suitable physical fitness. Due to this, RG is a sport which requires the complexity of skills, and develops a variety of motor abilities (whole-body coordination, dynamic balance and static balance, sense of kinesthesia, whole-body movement time, and hand-eye coordination) and perceptual abilities (whole-body reaction time, anticipation of coincidence, and depth perception) (Kiourmourtzoglou, Derri, Mertzanidou, & Tzetzis, 1997; Pavlova & Alexandrova, 2001; according to Pavlova, 2011). Specific coordination is a vital part of technical preparation in RG, and those abilities play an important role in creating the preconditions necessary to allow the gymnast to learn many RG techniques (Jastrjambskaia & Titov, 1998). Indeed, precise muscular efforts as well as space and time parameters of movements are especially important in RG.

Many previous studies confirmed the powerful influence of coordination on successful performance in RG (Furjan, 1990; Hume, Hopkins, Robinson, Robinson, & Hollings, 1993; Kioumourtzoglou et al., 1997), and the greatest influence was determined for rhythmic coordination, whole-body coordination, and arm and leg coordination (Sanader, 2005). Indeed, rhythmic gymnasts (RGs) are given the unique opportunity to display the highest degree of all of these different coordination abilities in unforeseen complex situations. Still, there are some studies (Giannitsopoulou, Zisi, & Kioumourtzoglou, 2003; Zisi, Giannitsopoulou, Vassiliadou, Pollatou, & Kioumourtzoglou, 2009) that claim that this importance of coordination skills for RG performance was primarily found in studies conducted before the changes of Code of Points in RG, which, according to them, probably resulted in shifting the importance of coordination to older age categories. Due to the potentially exceptional importance of motor coordination skills for the performance, as for the processes of orientation, selection and monitoring in the field of RG, this issue is given special attention. Therefore, this research aims to examine the predictive value of motor coordination in RG by testing these sport-specific coordination skills' influence on success (competitive score) of RGs of different age categories.

METHODS

Participants

One hundred and twenty-seven RGs, divided into five age categories (22 beginners, aged 7-9 years; 39 intermediate, aged 9-12 years; 26 advanced, aged 12-14 years; 25 juniors, aged 14-16 years; 15 seniors, aged 16 years and older), volunteered to participate in this cross-sectional study. All of the participants are individual competitors at national and/or international level in an "A" and "B" program (see Table 1).

Table 1 Distribution of study participants according to age category, program and country of competition

Age categories	6th "Montenegro Cup 2013" (Budva, Montenegro)	2014 National Championships (Belgrade, Serbia)	Total
Beginners	6A + 3B	0A + 13B	6A + 16B = 22
Intermediate	5A + 14B	4A + 16B	9A + 30B = 39
Advanced	2A + 7B	5A + 12B	7A + 19B = 26
Juniors	1A + 5B	12A + 7B	13A + 12B = 25
Seniors	/	7A + 8B	7A + 8B = 15
Total	14A + 29B = 43	28A + 56B = 84	42A + 85B = 127

Legend: A- "A" program, B- "B" program.

Ethical considerations

The study protocol was approved by the Ethics Committee of the Faculty of Sport and Physical Education, University of Niš, Serbia (No. 04-610). Written requests were promptly sent to the Expert Committee of the Gymnastics Federation of Montenegro, so as to the Gymnastics Federation of Serbia, and, after being informed about the study, its scientific value and multiple benefits, approvals were given for the testing to be conducted during the 6th "Montenegro Cup" in 2013 (Budva, Montenegro), and during the 2014 National Championships (Belgrade, Serbia). All testing was performed in accordance with the ethical standards of the Helsinki Declaration (WMA, 2002).

Measures and procedures

The first testing was conducted at the end of June 2013 in Budva (Montenegro), when 43 international-level gymnasts were tested. During the 2014 National Championships held in Belgrade (Serbia) on October 25th and 26th, the second testing was performed and it included 84 Serbian gymnasts.

Data on their age and years of training experience were collected by interviewing the participants. The Martin anthropometer was used to obtain the RGs' body height (in cm), while body mass (in kg) and body mass index (BMI, in kg/m^2) were assessed with a tetrapolar bioelectrical impedance device, Omron BF511 (Kyoto, Japan). For the estimation of RG-specific coordination skills the tests proposed by Jastrjambskaia et al. (1998) were used: ball rolling over the arms (B-ROL, in the number of consecutive successful attempts), throwing, catching and jumping through a rope (R-TCJ, in the number of consecutive successful attempts), skipping through a hoop (H-SKP, in the number of consecutive successful attempts during 15 sec) and club juggling (C-JUG, in the number of consecutive successful attempts during 10 sec). The criterion, i.e.

dependent variable, was the participants' competitive/performance score (Success), which can range from 0.0 to 20.0, according to the Code of Points (FIG, 2013).

Statistical analysis

The data were analyzed using the Statistical Package for the Social Sciences, version 21.0 (IBM SPSS 21.0, SPSS Inc, Chicago, USA). Descriptive statistics [average value (Mean), Standard Deviation (SD), Range] were summarized for all variables. The multiple regression analysis (R- multiple correlation coefficient, R^2- coefficient of determination, F- F-test, p- significance of multiple regression) was performed with the aim of determining the amount of variance in RG-specific coordination skills' influence on the success rate in RG performance, and for the purpose of determining the independent contributions of each independent variable to the prediction of the dependent variable, i.e. Success, regression analysis was performed (r- Pearson correlation coefficient, b- regression coefficient, p- statistical significance). The level of significance was set at $p<0.05$.

RESULTS

The baseline characteristics of the sample in total, and subsamples (age categories) are presented in Table 2. The descriptive statistics data of the subsamples' measured specific coordination skills are presented in Table 3 and in Figure 1 of the sample in total.

Based on the BMI cut-off points for girls of different ages (CDC, 2000), it can be stated that most of the RGs (n=117, or 92.13%) are of normal nutritional status, and few of them are underweighted (7.87%, i.e. six from the intermediate group, three from the advanced group, and one junior RGs; in the group of beginners and senior groups there are no underweighted RGs).

According to the cut-off points of coordination rating scale (Jastrjambskaia et al., 1998, 140) the situation is as follows (see Tables 4.1 – 4.4): in the first test (B-ROL) most of the gymnasts (63 out of 127, i.e. 49.61%) had an excellent score, 11.81% performed it well, 7.87% had fair scores, 10.24% had poor results, and 20.47% did not manage to do it at all (three from the advantage group, 10 intermediate RGs, and 13 beginners). The second test (R-TCJ) was a slightly difficult task: only 11.02% had an excellent score, 15.75% performed it well, 19.69% had fair scores, 26.77% had poor results and the same percent of gymnasts were unsuccessful (four from the advanced group, 15 intermediate RGs and 15 beginners). Unlike the R-TCJ, the third test (H-SKP) was an easy task: 83.47% scored excellent, 7.87% performed it well, 5.51% had fair scores and 3.15% had poor results. For the fourth test (C-JUG) the majority of the participants (42.52%) had an excellent score, 23.62% performed it well, 12.59% had fair scores, 11.81% scored poorly, and 9.45% did not manage to do it at all (one from the advantage group, seven intermediate RGs and four beginners).

Table 2 Baseline characteristics of the study participants

Age categories	Variables	Age (yrs)	Body height (cm)	Body mass (kg)	BMI (kg/m^2)	Training experience (yrs)	Success (score)
Beginners	Mean±SD	8.04±0.75[c]	128.39±5.73[c]	25.28±2.85	15.31±1.03	2.53±1.44[b]	7.18±1.15
(n=22)	Range	6.67 – 9.08	120.1 – 139.3	20.8 – 30.8	13.6 – 18.7	0.5 – 6.0	4.55 – 8.75
Intermediate	Mean±SD	10.09±0.81[abd]	139.78±5.95	29.92±4.27	15.24±1.26	4.84±1.9[bcd]	7.92±1.47
(n=39)	Range	8.71 – 12.02	125.1 – 151.4	22.6 – 40.2	12.7 – 18.9	1.0 – 8.0	4.4 – 10.38
Advanced	Mean±SD	12.25±0.89	151.31±8.72	38.99±8.01	16.83±1.94[b]	5.73±1.95	7.86±1.58
(n=26)	Range	10.57 – 13.8	136.0 – 164.4	25.5 – 53.2	13.8 – 21.4	0.5 – 9.0	4.3 – 10.45
Juniors	Mean±SD	14.53±0.74[d]	162.94±7.05	48.61±6.16	18.23±1.4	8.0±1.56[d]	9.34±1.54
(n=25)	Range	13.3 – 15.82	146.1 – 176.7	31.0 – 62.7	14.5 – 20.4	4.0 – 10.0	6.06 – 11.38
Seniors	Mean±SD	17.53±1.37	164.56±6.83	55.51±4.91	20.48±1.16	9.23±2.47	9.29±1.91
(n=15)	Range	16.16 – 20.34	150.0 – 178.2	47.4 – 67.0	19.0 – 23.3	5.0 – 14.0	5.53 – 11.83
Total	Mean±SD	11.93±3.09	147.65±14.56	37.67±11.7	16.78±2.26	5.85±2.81	8.22±1.69
(n=127)	Range	6.67 – 20.34	120.1 – 178.2	20.8 – 67.0	12.74 – 23.3	0.5 – 14.0	4.3 – 11.83

Legend: n- number of study participants, Mean- average value,
SD- Standard Deviation, yrs- years, BMI- Body Mass Index.
[abcd] Statistically significant correlations with RG-specific coordination skills ($p<0.05$):
[a] with B-ROL, [b] with R-TCJ, [c] with H-SKP, [d] with C-JUG.

The multiple regression analysis revealed the existence of the significant influence of the RGs' specific coordination skills on the dependent variable (Success) when considering the sample in total [$R=0.61$, $R^2=0.38$, $F(4,121)=18.279$, $p<0.0000$] and for the following subsamples: advanced RGs [$R=0.65$, $R^2=0.42$, $F(4,21)=3.8084$, $p<0.01763$] and intermediate RGs [$R=0.71$, $R^2=0.50$, $F(4,33)=8.3084$, $p<0.00009$] (see Figure 2). At the univariate level, the regression analysis revealed the significant independent contribution of hoop skipping and club juggling to the prediction of Success for the sample in total ($p=0.02$) and in the intermediate group ($p=0.02$ and $p=0.03$, respectively), as well as of hoop skipping and ball rolling in the intermediate group ($p=0.03$), with a positive relationship among these independent variables and dependent variable ($b=0.048$ for H-SKP and $b=0.091$ for C-JUG for the sample in total; $b=0.051$ for B-ROL and $b=0.092$ for H-SKP in intermediate RGs).

Table 3 Specific coordination skills in RGs of different age categories

Variables		Beginners (n=22)	Intermediate (n=39)	Advanced (n=26)	Juniors (n=25)	Seniors (n=15)	Total (n=127)
B-ROL	Mean±SD	1.41±4.23	8.21±13.2*	19.12±21.82	35.04±20.44	49.13±20.98	19.38±22.97
	Range	0.0 – 20.0	0.0 – 58.0	0.0 – 77.0	7.0 – 70.0	14.0 – 80.0	0.0 – 80.0
R-TCJ	Mean±SD	0.46±0.8	1.95±2.37	3.31±2.95	4.24±2.44	8.0±3.55	3.13±3.29
	Range	0.0 – 3.0	0.0 – 10.0	0.0 – 11.0	1.0 – 9.0	2.0 – 15.0	0.0 – 15.0
H-SKP	Mean±SD	22.55±8.54	29.18±6.28*	30.5±5.17	30.72±5.31	31.27±6.03	29.85±6.91†
	Range	5.0 – 35.0	11.0 – 38.0	16.0 – 36.0	17.0 – 39.0	12.0 – 39.0	5.0 – 39.0
C-JUG	Mean±SD	2.64±2.75	5.21±3.81	8.04±4.16	10.96±2.97	11.27±2.52	7.19±4.61‡
	Range	0.0 – 13.0	0.0 – 14.0	0.0 – 15.0	3.0 – 16.0	4.0 – 14.0	0.0 – 16.0

Legend: n- number of study participants, **Mean**- average value, **SD**- Standard Deviation,
B-ROL- ball rolling over the arms, **R-TCJ**- throwing, catching and jumping through a rope,
H-SKP- skipping through a hoop, **C-JUG**- club juggling.
Note: All measures are in times, i.e. number of consecutive successful attempts.
***†‡** Statistically significant influence on Success ($p<0.05$): * $p=0.03$, † $p=0.02$, ‡ $p=0.017$.

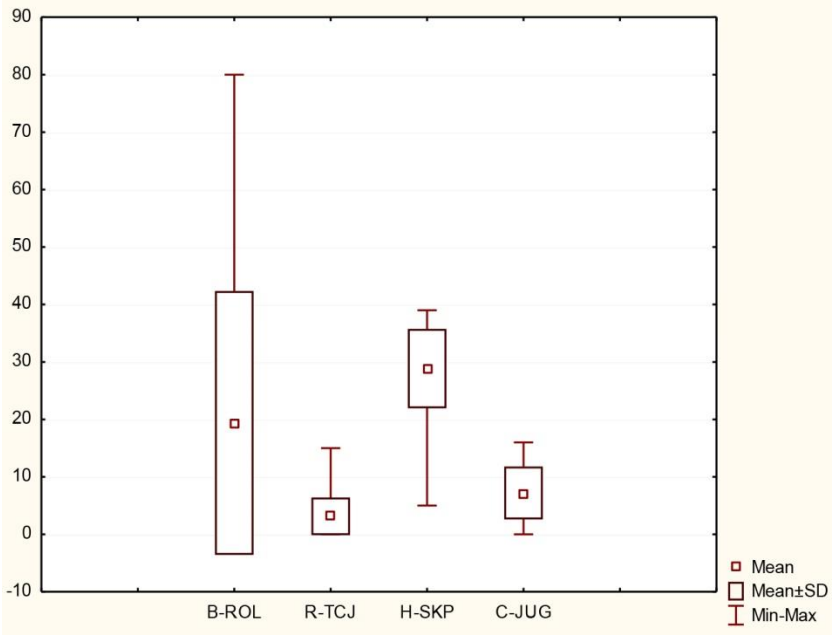

Fig. 1 Box Plot of the RGs' specific coordination skills (n=127)

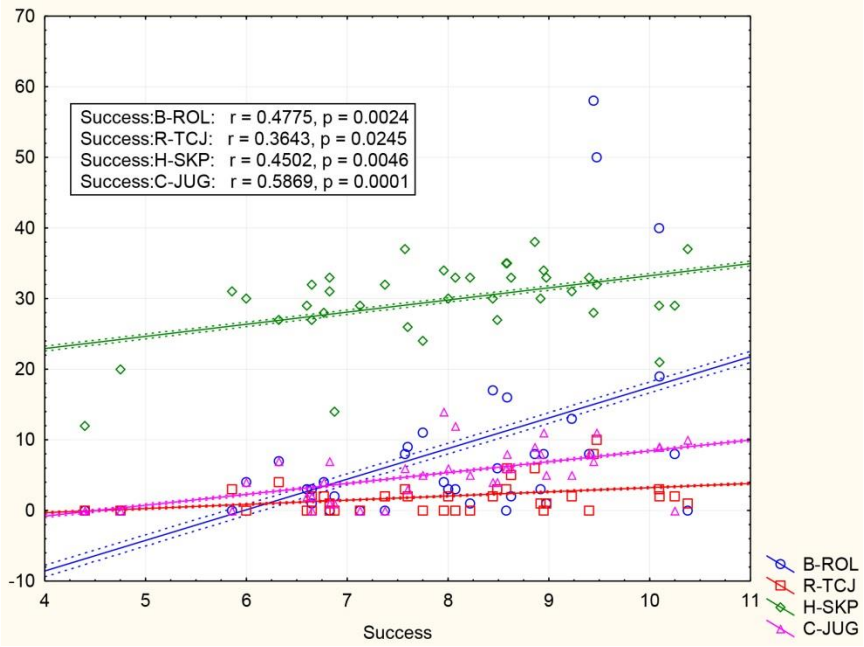

Fig. 2 Scatterplot of RG-specific coordination skills against success in the group of intermediate RGs (n=39)

DISCUSSION

Rhythmic gymnastics is a difficult and complex sport which requires increased space-time and hand-eye coordination between body movements and apparatus handling (Tsopani, Dallas, Tasika, & Tinto, 2012; Radisavljević & Moskovljević, 2011; according to Moskovljević, Radisavljević, & Dabović, 2013) and performance is influenced by the quantity as well as by the quality (Liviotti & Hökelmann, 2012; Hökelmann, Liviotti, & Breitkreutz, 2013). The quantitative aspect and the quality of execution depends directly on the level of coordination, technical mastery and physical performance of the gymnast (Mkaouer, Amara, & Tabka, 2012). For monitoring the coordination skills in RG, specific tests are suggested (Moskovljević & Orlić, 2012) even though many of the conducted studies were based on general coordination tests. Precision in the learning process evaluated by specific tests predicts talent outcomes better than coordination ability assessed with standardized and validated tests, because RG bases gymnastic preparation on the repetition of technical elements until perfect execution is attained (di Cagno et al., 2014). However, until this day only one battery of RG-specific coordination tests is known (Jastrjembskaia et al., 1998), and it is comprehensive and extensive, but it has its flaws and concerns. For the purpose of this research, four tests were chosen, those relating to manual dexterity.

Rhythmic gymnastics is a sport with a particular training process (very young athletes, early specialization, big training volume, many hours of intensive training per week, lots of repetition, high level of technical elements performed) (Bobo-Arce & Méndez-Rial, 2013), and it is characterized by an abundance of motor information acquired in the early years of life, between five and eight years of age (Miletić, Katić, & Maleš, 2004). This is the period of life when the first stage of a RG learning program is implemented and it implies the development of spatial awareness without an apparatus, and in the next stage the apparatus are added (Palmer, 2003), in a previously determined hierarchy. Because most children have had prior experiences with balls and ropes, it is best to begin with these apparatus and then move on to introduce the hoop, ribbon and clubs. As for the apparatus, beginners are firstly introduced to ball and rope handling, but only with fundamental elements for each of these apparatus, and at a later age the difficulty is increased by linking skills together and by increasing the speed at which the skills are performed. At the intermediate level, the RGs are introduced to hoop skills, but still retaining the ball and rope skills. Advanced RGs, besides upgrading their ball, rope and hoop skills, are introduced to club and ribbon manipulation. Juniors and seniors have the task of improving and refining the acquired skills further.

Ball rolling over the arms is one of the fundamental ball skills and it has to be performed with fluidity and without ball bouncing. At the very beginning, the novices learn to do it in facilitated conditions (the arms are not spread widely) and with an age-appropriate sized ball (junior ball measures 14 to 17 cm in diameter) which, on the other hand, makes it more difficult to perform (a senior ball has a greater diameter and thus a larger surface). The test B-ROL has a basic requirement to be done with the arms spread widely, and it is not a surprise that 59.09% of beginners did not manage to perform it, 31.82% scored poorly, and only one (4.55%) had a fair score. With the increment of the RGs age, the percentage of better scores increases (Table 4.1), which confirms the very important role of experience.

The throwing, catching and jumping through a rope (R-TCJ) is an intricate test which represents a combination of three fundamental elements of rope skills: rotation, the throw and catch, and jump. That kind of rope skill combination is inherent to the older age categories, and explains a lot of the obtained results in the group of beginners: 68.18% did not perform it at all, 27.27% had poor scores, and only one (4.55%) scored fairly. The intermediate RGs, as well as the advanced, cannot boast with their scores either (Table 4.2), but the situation is better with the increase of the gymnasts' age.

Skipping through a hoop is a basic hoop element, which, if done continuously in a given time frame, besides developing the ability to perform movements quickly and with precision, can be used for the development of cardiovascular fitness. The test H-SKP has a time limitation of 15 seconds, and it very much depends of the gymnasts' limb length, explosive and repetitive strength of the lower limbs, and overall endurance. Due to this, the majority of the obtained scores are excellent, across every age category and even in the youngest one (Table 4.3).

Table 4.1 The comparison of rating scale and obtained results of B-ROL across all age categories

Variable	B-ROL									
Rating scale	Excellent 9 and more		Good 5 – 8		Fair 3 – 4		Poor 1 – 2		Unsuccessful 0	
Age categories	N	f	N	f	N	f	N	f	N	f
Beginners (n=22)	1	4.55	-	-	1	4.55	7	31.82	13	59.09
Intermediate (n=39)	9	23.08	7	17.95	8	20.51	5	12.82	10	25.64
Advanced (n=26)	15	57.69	6	23.08	1	3.85	1	3.85	3	11.54
Juniors (n=25)	23	92.00	2	8.00	-	-	-	-	-	-
Seniors (n=15)	15	100.00	-	-	-	-	-	-	-	-
Total (n=127)	63	49.61	15	11.81	10	7.87	13	10.24	26	20.47

Legend: B-ROL – ball rolling over the arms, N – number of consecutive successful attempts, f – frequency in %.

Table 4.2 The comparison of rating scale and obtained results of R-TCJ across all age categories

Variable	R-TCJ									
Rating scale	Excellent 9 and more		Good 5 – 8		Fair 3 – 4		Poor 1 – 2		Unsuccessful 0	
Age categories	N	f	N	f	N	f	N	f	N	f
Beginners (n=22)	-	-	-	-	1	4.55	6	27.27	15	68.18
Intermediate (n=39)	1	2.56	4	10.26	6	15.39	13	33.33	15	38.46
Advanced (n=26)	2	7.69	5	19.23	7	26.92	8	30.77	4	15.39
Juniors (n=25)	2	8.00	8	32.00	9	36.00	6	24.00	-	-
Seniors (n=15)	9	60.00	3	20.00	2	13.33	1	6.67	-	-
Total (n=127)	14	11.02	20	15.75	25	19.69	34	26.77	34	26.77

Legend: R-TCJ – throwing, catching and jumping through a rope, N – number of consecutive successful attempts, f – frequency in %.

Table 4.3 The comparison of rating scale and obtained results of H-SKP across all age categories

Variable	H-SKP									
Rating scale	Excellent 25 and more		Good 18 – 24		Fair 11 – 17		Poor 1 – 10		Unsuccessful 0	
Age categories	N	f	N	f	N	f	N	f	N	f
Beginners (n=22)	13	59.09	4	18.18	1	4.55	4	18.18	-	-
Intermediate (n=39)	33	84.62	3	7.69	3	7.69	-	-	-	-
Advanced (n=26)	23	88.46	2	7.69	1	3.85	-	-	-	-
Juniors (n=25)	23	92.00	1	4.00	1	4.00	-	-	-	-
Seniors (n=15)	14	93.33	-	-	1	6.67	-	-	-	-
Total (n=127)	106	83.47	10	7.87	7	5.51	4	3.15	-	-

Legend: H-SKP – skipping through a hoop, N – number of consecutive successful attempts, f – frequency in %.

Table 4.4 The comparison of rating scale and obtained results of C-JUG across all age categories

Variable	C-JUG									
Rating scale	Excellent 9 and more		Good 5 – 8		Fair 3 – 4		Poor 1 – 2		Unsuccessful 0	
Age categories	N	f	N	f	N	f	N	f	N	f
Beginners (n=22)	1	4.55	1	4.55	7	31.82	9	40.91	4	18.18
Intermediate (n=39)	8	20.51	14	35.89	6	15.39	4	10.26	7	17.95
Advanced (n=26)	10	38.46	12	46.15	1	3.85	2	7.69	1	3.85
Juniors (n=25)	21	84.00	3	12.00	1	4.00	-	-	-	-
Seniors (n=15)	14	93.33	-	-	1	6.67	-	-	-	-
Total (n=127)	54	42.52	30	23.62	16	12.59	15	11.81	12	9.45

Legend: C-JUG – club juggling, N – number of consecutive successful attempts, f – frequency in %.

Clubs are a RG apparatus to which gymnasts are introduced at older age categories (advanced RGs). Club juggling is a skill which gymnasts adopt after mastering the fundamental elements: circles, mills and simple one-hand club throwing and catching. Even though this skill is inherent to older age categories, the younger age categories scored surprisingly well on this test (Table 4.4). The authors may have an explanation: young gymnasts might have been previously "provoked" by older gymnasts, which led to an explorative phase of this, to them, new apparatus, independently in a self-directed manner. Simply, gymnasts are often eager to try all of the apparatus (Palmer, 2003), especially an unfamiliar one, and, by offering open-ended challenges, RG is a sport that makes you explore constantly and thus expand your knowledge, skills and experiences. Overall, due to the apparatus hierarchy in the learning process, it is not a surprise that in younger age categories excellent and good scores are a rarity or absent.

CONCLUSION

Having in mind that important abilities needed to succeed in some tasks vary with the athletes' ages (Fleishman, 1972; according to Kioumourtzoglou et al., 1997), and the results derived from one specific age group cannot be generalized across all age groups or skill levels, we can make a conclusion that applies only to those specified age categories.

The obtained results, i.e. the lack of statistically significant influence of coordination on Success in the group of junior and senior RGs, clearly indicates the less important role of specific coordination in the performance of older age category RGs. This does not diminish the importance of coordination abilities, yet it rather simply suggests the presence of more important factors which discriminate the successful from less successful gymnasts. The statistically significant influence of specific coordination abilities on Success was established only in the group of advanced and intermediate gymnasts, with an explanation of 42%, i.e. 50% of success in RG. Also, this research emphasized the significant independent contributions to the prediction of the dependent variable of three independent variables: ball rolling, hoop skipping and club juggling in the group of intermediate gymnasts, with a positive relationship among these independent variables and the dependent one. This study has confirmed the importance of coordination skills for success in RG, but only for younger age categories. This is not a surprise considering that RG is a sport characterized by an abundance of motor information, and the information acquired in the early years of life, between five and eight years of age, significantly contribute to success in this sport.

STUDY LIMITATIONS

During the testing, we have noticed several limitations of the applied specific coordination test battery. Namely, in the description of the proposed test battery, the authors failed to provide us with a few very important facts. First of all, the information on what age those tests were applied is lacking, which caused two major problems. If it is intended for all ages, they should inform us about apparatus size (it should be age-appropriate, or the same, senior size, for all of the RGs regardless of age). Also, if it is not applicable to all ages, then the rating scale proposed by the authors cannot be used for result interpretation for every age category, but can only relate to the intended age. However, having in mind that there is an apparatus hierarchy in the learning process of RG, and in this test battery every apparatus (except the ribbon) is involved, it led us believe that this test battery applies to all ages.

Besides, this unidimensional approach lacks a broader perspective needed to explain overall performance in RG, which is multifactorial.

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ZNAČAJ MOTORIČKE KOORDINACIJE ZA USPEH U RITMIČKOJ GIMNASTICI

Ritmička gimnastika (RG) je kompleksan i složen sport koji zahteva povećanu prostorno-vremensku koordinaciju između kretanja tela i rukovanja rekvizitima, što čini specifičnu motoričku koordinaciju vitalnim delom tehničke pripreme u RG, sa važnom ulogom u stvaranju neophodnih preduslova gimnastičarki za učenje mnogih RG tehnika. Svrha istraživanja je ispitivanje i/ili utvrđivanje mogućnosti predviđanja uspeha u RG na osnovu koordinacionih sposobnosti gimnastičarki. Sto dvadeset sedam gimnastičarki nacionalnog i međunarodnog nivoa (uzrast: 11.93±3.09 godina, telesna visina: 147.65±14.6 cm, telesna masa: 37.67±11.7 kg, BMI: 16.78±2.26 kg/m^2, sportsko iskustvo: 5.85±2.81 godina), raspoređenih u pet uzrasnih kategorija (22 mlađe pionirke, uzrasta 7-9 godina; 39 pionirki, uzrasta 9-12 godina; 26 kadetkinja, uzrasta 12-14 godina; 25 juniorki, uzrasta 14-16 godina; 15 seniorki, uzrasta 16 godina i više), dobrovoljno je učestvovalo u ovom istraživanju. Utvrđene su njihove osnovne karakteristike (uzrast, telesna visina, telesna masa, BMI, godine sportskog iskustva, Uspeh), kao i specifične koordinacione sposobnosti (B-ROL, R-TCJ, H-SKP i C-JUG). Primenom multivarijantne regresione analize utvrđen je statistički značajan uticaj specifičnih koordinacionih sposobnosti na Uspeh samo kod kadetkinja i pionirki ($p<0.018$ i $p<0.000$, redom), sa 42%, odn. 50% objašnjenja uspeha u RG. Takođe, regresiona analiza je istakla značajne pojedinačne doprinose predviđanju zavisne varijable, od strane triju nezavisnih varijabli: kotrljanje lopte preko ruku (pionirke: $p=0.03$), skokovi u obruč (pionirke: $p=0.03$ i total uzorak: $p=0.02$) i "žongliranje" čunjevima (pionirke: $p=0.03$ i total uzorak: $p=0.02$), sa pozitivnom relacijom između ovih nezavisnih varijabli i zavisne varijable. Ovo istraživanje je potvrdilo značaj koordinacionih sposobnosti za uspeh u RG, ali samo kod mlađih takmičarskih kategorija.

Ključne reči: *ritmičke gimnastičarke, uzrasne kategorije, specifična koordinacija, regresija.*