Study on the Development of the Trunk Stabilizing Muscle Strength in Young Groups of Juniors in Rhythmic Gymnastics

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Abstract: Higher standards of sports performance in rhythmic gymnastics require constant improvement of the practice in the field by enriching and adapting the training methodology, in line with the latest trends in the modern training process. Physical training is one of the determining factors in achieving sports performance in rhythmic gymnastics, having the role to support the technical training, by conferring effectiveness in all the competition trials. The study's goal is to better the physical training for the gymnasts aged 8-10 by including in the training nonspecific means, focused on the developing the strength of the trunk-stabilizing muscles. In our research, 28 gymnasts participated voluntarily, divided into two groups: experimental (14 subjects) and control (14 subjects). The pedagogical experiment took place between 06.09.2017 - 28.05.2018, during which we intervened in the preparation of the experimental group by applying non-specific means of developing the strength of the trunk stabilizing muscles. The control group followed the usual training program. Both groups of subjects (experimental and control) were tested in the initial and final experiment stage by means of two rhythmic gymnastics control trials that evaluated the strength of the abdominal and back muscles. The comparative results in the two groups at the final evaluation revealed statistically significant differences in the two control trials applied. According to this study, the results obtained demonstrate that the nonspecific means used for the physical trainings in the female athletes from the experimental group facilitated getting significantly improved values of the strength of the trunk-stabilizing muscles compared to the subjects in the control group. This emphasizes the effectiveness of the didactic strategy we approached through the methodological content used that favored the evolution of the female athletes' performances we investigated.

Keywords: *strength; rhythmic gymnastics; young juniors; physical training.*

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1. Introduction

The evolution of the motor performances in recent years places rhythmic gymnastics among the elite sports disciplines, which requires a hard, prolonged and constant physical training during all the sports career (Román, del Campo, Solana, & Martín, 2012).

In practice, technical preparation plays a key role in the training, but the optimal support for its correct acquisition is provided by the physical training. However, physical training is often neglected in comparison to the technical one, which is why we deemed it adequate to tackle this topic of research. Physical training occupies an important place in the training process, being an essential factor for performances progress.

Physical training in rhythmic gymnastics focuses on the multilateral development of the motor skills: reaction and displacement rate, rapid and expansion force; muscle strength localized to body areas, general resistance to effort; development of all the coordinating components; development of the articular and musculo-ligamental joints suppleness (Macovei, 2004). Physical training, as a factor in the training process, should not be neglected in the preparation of groups of children because it provides the substrate necessary for the correct acquisition of specific technical skills, there being allocated to it approximately 23-30% of the total amount of the training lesson. It has a complex sphere, which includes concerns on several planes.

The female gymnasts must follow in an initial phase, a multilateral physical training focused on the strengthening of health and the formation of a correct, harmonious, specifically female gymnastic appearance, in order to be later oriented towards the optimization of the biomotor and coordinative capacity specific to the rhythmic gymnastics.

For the competitive success and the identification of the rhythmic gymnastics potential talent, the main performance motor variables are flexibility, strength, coordination, rhythm, balance, agility and endurance (H. Douda, Toubekis, Avloniti, & Tokmakidis, 2008; Laffranchi, 2001).

Starting from the premise that strength is one of the main physical capacities that have been pinpointed as performance leading factors in rhythmic gymnastics (Di Cagno et al., 2009; H. Douda et al., 2008; Rutkauskaitė & Skarbalius, 2009, 2011), we considered it important to investigate the biomotor capacity – force, in the upper body. Analyzing the literature, in the field of rhythmic gymnastics, we concluded that most of the authors were limited to analyzing the strength of the lower body (Grigoriu, Pelin, Netolitzchi, & Pricop, 2015; Grigoriu, Pelin, Wesselly & Pricop, 2017; Dobrijević, Dabović, & Moskovljević, 2014; Stadnik, Ulbricht, Perin,

& Ripka, 2010; Di Cagno et al. 2009, Pricop, 2011, 2012) and approached very little of the development in the strength of the upper body.

In rhythmic gymnastics, the gymnasts must have powerful muscular groups, to achieve a good performance in the training and competition routine (Jastrjemskaia & Titov, 1999).

We believe that the body and body segments support force intervenes directly in different positions during the execution of the technical elements (jumping, pirouette, equilibrium elements, suppleness). Therefore, for the development of this special form of force manifestation, it is necessary to act on the muscles involved directly in executing the technical elements as well as the procedures. Developing the strength of the back and abdominal muscles at optimum level strengthens the trunk stabilizing muscles, which intervene in consolidating the body's balance in the lifting phase of the jumps, in the in the pirouettes speed stage, in the execution of the amplitude-suppleness elements, that determines over time a correct technical execution, with the appropriate range and intensity.

2. Material and methods

2.1. Research purpose

Our study aims at designing and applying a system of operational structures non-specific to rhythmic gymnastics, converted into training programs focused on the development of the trunk-stabilizing muscles, respectively the abdominal and back muscles, in 8-10-year-old female gymnasts.

2.2. Research Hypothesis

It is assumed that through the correct and timely application, during the training lessons of rhythmic gymnastics of some non-specific means, we can contribute to developing the strength of the trunk-stabilizing muscles of 8-10 years old female athletes.

2.3. Research Methods

At the base of this research there was the bibliographic documentation, as "documentation is an indispensable and the most important activity in the scientific research" being necessary to have a theoretical substantiation of the problematic studied (Epuran, 2005, p.131).

The research methods used were the following:

- direct observation method (Epuran, 2005, p.207), through which we followed the behavior of the female gymnasts in the training process;

- the systematic, organized, experimental type observation caused during the application of the methods and trials used;
- the experimental method. In this research we used the verification experiment, of the constative and improvement type, in order to confirm or reject the hypothesis proposed, by organizing, coordinating and conducting the experimental activity;
- the statistical-mathematical method, which we used in analyzing and interpreting the results of the experimental research. The dependent T-test was determined to highlight the differences in the tests following the application of the same independent variable on a single sample and the independent T-test was used to verify if the arithmetic mean of the two samples (the experimental and the control group) differed significantly;
- the graphical method, which allowed us to accurately assess the data, because it performs an intuitive and synthetic presentation of the research data;
- the evaluation and measurement method.

The evaluation of the strength of the trunk-stabilizing muscles was performed by means of two trials:

- the determination of the abdominal force development: vertical trunk liftings from the dorsally lying position, with the inferior limbs semi-bended with the feet soles on the ground supported by the examiner, the rope folded in four held by the ends, successive trunk elevations at 90 ° are executed;

-the determination of the development of the back muscles force: trunk extensions from the facially lying position, with the lower limbs stretched, the rope folded in four held by the ends, successive liftings of the trunk in extension to the maximum amplitude are executed

Both trials were performed for 30 seconds and the number of the correctly executed repeats was recorded.

2.4. Subjects and location

We employed in our experimental research a number of 28 female athletes from Blue Stars 2000 Bucharest Club, divided into two training groups: - the experimental group - consisting of 14 female gymnasts aged 8-10;- the control group - consisting of 14 female gymnasts aged 8-10.

At the beginning of the experiment, our subjects were informed about the test specific issues and, also, about the types of assessment utilized, expressing their agreement to participate voluntarily in the research.

The sample used consisted of healthy individuals who did not show lesions that could have worsened through the tests. The research respected the ethical and medical conditions regarding the participation, for our subjects.

2.5. Research organization

The experimental research took place over the course of nine months, between September 2017 and May 2018, thus:

- between September 6 and September 12, 2017 the initial test for both groups of subjects was organized;
- between September 13, 2017 - May 20, 2018, the training program, which included nonspecific means for developing the trunk-stabilizing muscle, was applied only to the experimental group;
- during the period 08.01.2018 - 16.01.2018 the experimental group's intermediate testing was carried out in order to verify the working techniques;
- between 20 and 28 May 2018 the final testing of the two groups the experimental and control groups took place.

After the results obtained by the female athletes in the initial testing, a training program with non-specific means was developed; we modified the trainings for the female gymnasts in the experimental group so as to increase the strength of the abdominal and back muscles.

The training program was conducted over 36 weeks in 180 training sessions of 90-120min./training, during which non-specific means of developing the stabilizing force of the trunk were used. The practical implementation of the didactic strategy elaborated was made according to the stages of training set in the annual training cycle, in accordance with the age and training level of the female athletes. By using the force exercises, the strengthening of the back muscles in the shortening of the muscle fibers regime and of the abdominal muscles under the conditions of the fiber elongation was followed. The means used in the experiment were made with different teaching materials (gym ball, medical balls) with the use of the own body as a load, but also with the use of small weights.

Concretely, the experimental group worked for 8-10 minutes/ training the development program for the trunk stabilizing strength developed by us, while the control group followed the usual training program.

2.6. Results

After the completion of each test, the results obtained were statistically and mathematically processed. For each parameter there were

recorded: the arithmetic mean ($\bar{X}$), standard deviation (σ), coefficient of variability (Cv -%); the "Student" test calculated "t" to determine the authenticity of the differences between the groups and the significance of the progress by comparison with the significance threshold for the number of cases (N = 13) according to Fisher's table. In our case N = 13, the critical value of t is $t \geq 2.16$ at the value of $p < 0.05$; the critical value of t is $t \geq 3.01$ at the value of $p < 0.01$, and at the value of $p < 0.001$, the critical value of t is $t \geq 4.22$. The graphical representation of the evolution of the arithmetic mean of the two groups (experimental and control), as well as the dynamics of the individual results obtained by the subjects of the research during the experiment were dealt with.

All these operations were necessary to identify the effects of the didactic strategy applied in the experiment and in particular to outline the conclusions of the research undertaken.

In tables no. 1,2,3, we present the dynamics for the results in the experimental group (EG) during the experiment after the three tests (initial, intermediate and final), by comparing the value of the parameters determined through the trials for assessing the trunk stabilizing muscles at the group level, following the statistical indicators determined and represented graphically in Figures 1-4:

Table 1. Comparison analysis for the results of the experimental group in assessing the trunk stabilizing muscles - initial test (T1) and intermediate test (T2)

TESTS	STATISTICAL AND MATHEMATICAL INDICATORS						
	$\bar{X} \pm \sigma$		Progress		Cv		t Test dep. t
	T1	T2	T1-T2	T1	T2		
abd. stren.	21,57rep./ $\pm 1,91$	22rep./ $\pm 1,85$	0,43rep.	8.88	8.41	1,47	>0,05
back stren.	30,71rep./ $\pm 4,29$	30,71rep./ $\pm 4,33$	0rep.	13.99	14.10	0,50	>0,05

Table 2. Comparing analysis regarding the results for the experimental group in the assessment of trunk stabilizing muscles - intermediate test (T2) and final test (T3)

TESTS	STATISTICAL AND MATHEMATICAL INDICATORS						
	$\bar{X} \pm \sigma$		Progress	Cv		t Test dep.	
	T2	T3	T2-T3	T2	T3	t	p
abd. stren.	22,0rep./ $\pm 1,85$	25,71rep./ $\pm 1,23$	3,71rep.	8.41	7.07	15,20	<0,001
back stren.	30,71rep./ $\pm 4,33$	34,0rep./ $\pm 4,10$	3,29rep.	14.1 0	12.0 5	8,55	<0,001

Table 3. Comparative analysis of the results obtained by the experimental group in assessing the trunk stabilizing muscles - initial test (T1) and final test (T3)

TESTS	STATISTICAL AND MATHEMATICAL INDICATORS						
	$\bar{X} \pm \sigma$		Progress	Cv		t Test dep.	
	T1	T3	T1-T3	T1	T3	t	p
abd. stren.	21,57rep./ $\pm 1,91$	25,71rep./ $\pm 1,23$	4,14rep.	8.88	7.07	13,27	<0,001
back stren.	30,71rep./ $\pm 4,33$	34,0rep./ $\pm 4,10$	3,29rep.	13,99	12.05	8,55	<0,001

In the abd. stren. trial (abdominal force) the arithmetic mean „ $\bar{X}$ ” at the initial test (T1) is of 21.57 rep. at the intermediate test (T2) it is of 22rep. and at the the final test (T3) of 25.71rep. (Figure 1).

The rate of progress between T1-T2 is of 0.43 rep., between T2-T3 it is of 3.71 rep., and between T1-T3 it is of 4.14 rep. The spread rate of the string values represented by the standard deviation "σ" has values at the initial test (T1) of 1.91, at the intermediate test (T2) of 1.85, and at the final test (T3) of 1.23.

The coefficient of variability "Cv" is of 8.88% for the initial testing (T1), of 8.41% for the intermediate test (T2) and of 7.07% for the final test (T3), therefore the dispersion being low at all three tests the homogeneity is high. The value in the "Student" test computed "t" for T1 - T2 is of 1.47, hence $1.47 < 2.16$ (at the value of $p < 0.05$ Fischer Tab), therefore we have no important differences in the means of the two tests.

The "t" value between T2-T3 is of 15.20, and between T1-T3 it is of 13.27, hence there is a significant difference in both tests for $p < 0.001$.

Figure 1. Dynamics of experimental group in Abd.stren. (T1,T2,T3)

Figure 2. Individual dynamics in Abd.stren. (T1,T2,T3)

In Figure 2, we note that all subjects progressed during the tests.

In the Back stren. trial (force of the back muscles) the arithmetic mean „ $\bar{X}$ ” in the initial test (T1) and the intermediate test (T2) is of 30.71 rep. and in the final test (T3) of 34.00 rep. (Figure 3).

The rate of progress between T2-T3 and T1-T3 is the same, respectively of 3.29 rep.

The spread rate of the string values represented by the standard deviation "σ" has the values at the initial test (T1) of 4.29, at the intermediate test (T2) of 4.33, and the final test (T3) of 4.10. The coefficient of variability "Cv" is 13,99% at the initial test (T1), of 14,10% at the intermediate test (T2) and of 12,05% at the final test (T3), hence the dispersion being average, the sample is relative homogeneously in all the three tests.

The value for the "Student" test calculated "t" between T1 - T2 is of 0.50, hence $0.50 < 2.16$ (at the value of $p < 0.05$ Fischer Tab), so we see no

differences of signification in the means of the two tests. The "t" value between T2-T3 is of 8.55 and between T1-T3 it is also of 8.55, therefore there is a significant difference in both tests for $p < 0.001$.

Figure 3. Dynamics of the experimental group in back stren. (T1,T2,T3)

In Figure 4 we illustrated suggestively the individual dynamics of the female gymnasts in this trial.

All the subjects were found to have progressed during the three tests.

Figure 4. Individual dynamics in back stren. (T1,T2,T3)

The results obtained by the control group at the two tests, the initial and final ones, are presented in Table 4 and they are represented in graphs in Figures 5-8.

Table 4. Comparison analysis for the control group results in the assessment for the trunk stabilizing muscles - initial test (IT) and final test (FT)

TESTS	STATISTICAL AND MATHEMATICAL INDICATORS						
	$\bar{X} \pm \sigma$		Progress	Cv		t Test dep. t	p
	IT	FT	IT-FT	IT	FT		
abd. stren.	21,5rep./ $\pm 1,80$	22,50rep./ $\pm 1,18$	1,00rep.	8.38	5.24	0,45	>0,05
back stren.	28,35rep./ $\pm 3,22$	29,57rep./ $\pm 3,17$	1,22rep.	11.35	10.74	7,84	<0,001

At the Abd stren. trial (abdominal force) the arithmetic mean „ $\bar{X}$ ” for the initial test (IT) is of 21.5 rep. and the value at the final test (FT) is of 22.5 rep. (Figure 5). The rate of progress between the two tests IT - FT is of 1.00. The spread degree of the string values represented by the standard deviation "σ" has the values at the initial test (IT) of 1.80 and at the final test (FT) of 1.18. The coefficient of variability "Cv" is of 8.38% at the initial test (IT) and of 5.24% at the final test (FT); the dispersion is low, the homogeneity is high. The "Student" test value computed "t" between the initial test (IT) and the final test (FT) is 0.45, hence $0.45 < 2.16$ (Fischer Tab) therefore we haven't got increased differences between the means in the two tests $p > 0.05$.

Figure 5. Dynamics of the control group in Abd Stren. (IT,TF)

Figure 6 shows that 90% of the subjects progressed from one test to another, although statistically there were no significant differences between the means of the two tests.

Figure 6. Individual dynamics in Abd. stren. (IT,FT)

In the Back stren. trial (the force of the back muscles) the value of the arithmetic mean „ $\bar{X}$ ” at the initial test (IT) is of 28.35 rep. and at the final test (FT) it is of 29.57 rep. (Figure 7). The spread degree of the string values represented by the standard deviation “ σ ” has at the initial test (IT) the value of 3.22 and at the final test (FT) of 3.17. The coefficient of variability “Cv” displays the percentage of 11.35% in the initial test (IT) and of 10.74% in the final test (FT); the dispersion is average and the sample is relatively uniform. The value for the “Student” test calculated „t” between the initial test (IT) and the final test (FT) is of 7.84, so $7.84 > 4.22$ (Fischer Tab); as a result the differences are significant between the means of the two tests, $p < 0.001$.

Figure 7. Dynamics of the control group in Back stren. (IT,FT)

In this trial we find (Figure 8) that apart from a subject, the rest progressed from one test to the other.

Figure 8.Individual dynamics in Back stren. (IT,FT)

The comparative analysis of the trunk stabilizing muscle strength indicators obtained from the end of the research measurements for the control and experimental group is shown in Table 5 and is graphically represented in Figure 9-10.

Table 5. Analysis of comparison in the results of the two groups (experimental and control) in assessing the trunk stabilizing muscles - final test

TESTS	STATISTICAL AND MATHEMATICAL INDICATORS						
	$\bar{X} \pm \sigma$		Progress		Cv		t Test indep. t
	E.G.	C.G.	EG-CG	E.G.	C.G.		
abd. stren.	21,57rep./ $\pm 1,23$	22,50rep./ $\pm 1,18$	3,21rep.	7.07	5.24	5,49	<0,001
back stren.	34,00rep./ $\pm 4,10$	29,57rep./ $\pm 3,17$	4,43rep.	12,05	10.74	3,15	<0,01

In the Abd stren. trial (abdominal force), the final results recorded by the experimental group ($\bar{X}=25,71\text{rep.}$) were superior to those of the control group ($\bar{X}=22,5\text{rep.}$), the rate of progression between the two groups being of 3.2 (Figure 9). The spread degree of the string values represented by the standard deviation " σ " is of 1.23 for the experimental group and of 1.18 for the control group. The coefficient of variability "Cv" for the final test has a value of 7.07% for the experimental group and of 5.24% for the control group, these aspects pointing to the fact that the two groups are homogeneous. The value in the "Student" test calculated "t" for the two groups is of 5.49, so $5.49 > 4.22$ (Fischer Tab), therefore the differences are significant between the means of the two groups, $p < 0.001$.

Figure 9. The representation of the means obtained by the experimental group (E.G.) as well as by the control group (C.G.) at the final test - Abd.stren.

In the Back stren. trial (the strength of the back muscles), the final results recorded by the experimental group ($\bar{X}=34,00\text{rep.}$) were better compared to those of the control group ($\bar{X}=29,57\text{rep.}$), the rate of progress between the two groups being of 4.43 rep. (Figure 10).

The spread degree of the string values represented by the standard deviation " σ " is of 4.10 for the experimental group and of 3.178 for the control group.

The coefficient of variability " C_v " in the final test has a value of 12.05% for the experimental group and a value of 10.74% for the control group, these aspects reflecting the high homogeneity of both groups.

The "Student" test value computed " t " between the two groups is of 3.15, so $3.15 > 3.01$ (Fischer Tab), therefore the differences are significant between the means of the two groups $p < 0.01$.

Figure 10. The means representation of the experimental group (E.G.) and of the control group (C.G.) in the final test - Back stren.

Based on the analysis of the data recorded at the end of the experiment we can appreciate that the program for the development of the

trunk stabilizing muscle strength, respectively the independent variable applied to the experimental group, proved to be effective, therefore the research hypothesis was confirmed.

3.3. Conclusions

The validation of the hypothesis underlying the experimental approach validates the fact that our nonspecific means we utilized in developing the abdominal and back muscles were useful in preparing the female gymnasts, with significant progressing in the experimental group as compared to our control group at all our parameters we assessed and tested.

The different program of trainings for the two groups (experimental and control) highlights the fact that the didactic strategy elaborated and applied to the experimental group led to significant increases in the strength of the abdominal and back muscles. The operational structures strictly quantified as a number of repetitions and rationally introduced in the training, contributed to the improvement of its methodology.

The nonspecific means included in new training programs that included an original succession of operational structures adapted to the level of training and age of the female athletes investigated may constitute a new approach in the development of the abdominal and back force in rhythmic gymnastics.

Considering that the means used to develop the force of the trunk-stabilizing muscles were well tolerated by the female athletes, without claiming any injury, we can assume that the data use resulting from our approach can facilitate the teaching activity optimization of the rhythmic gymnastics coaches.

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