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Research article

THE EXPLOSIVE STRENGTH OF GIRLS OF A YOUNGER SCHOOL AGE

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Abstract. *Physical education (PE) at a younger school age is very important. But in practice, this course is not carried out regularly or is not performed by PE teachers. The problem of the research was to determine whether the developmental gymnastics program had an effect on the development of explosive strength with younger school age girls. The sample of participants for the experimental group consisted of 59 girls and for the control group 45 girls aged 9 to 11. To determine the level of explosive strength three tests were used. Data processing was performed by the statistical program SPSS v. 20. For all the data, the parameters of descriptive statistics were calculated. To determine the differences between the groups, a t-test for independent samples was used with a calculation of significance of the size of the difference (Cohen's d). The research has shown the effects of the developmental gymnastics program on the development of explosive strength among girls aged 9 to 11. Differences in explosive strength were identified in favor of the experimental group in two out of the three variables. The results obtained accurately indicate that the participants included in the development gymnastics program have a significantly higher level of explosive strength than the participants who only attended PE classes.*

Key words: *Developmental gymnastics, physical education, explosive strength, young school age.*

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INTRODUCTION

The general problem is the realization of physical education (PE) in the younger school age, and especially the realization of gymnastic content within the class. It is assumed that the reason for this is the lack of space and gymnastic apparatus and equipment or insufficient professional competence of teachers (Badić, Živčić-Marković, Sporiš, Milanović, & Trajković, 2012).

It is of great importance to constantly improve the motor abilities related to gymnastics during the preschool years (Madić et al., 2018) due to the growth and development of the body, as well as corrective treatments for various deformities. At this age, this includes the development of the respiratory system, the cardiovascular system develops, bones become more and more stiff, more firm, and the physiological curves of the spinal column are corrected. PE classes in this period of physical growth and development are very important. But in practice this teaching is not carried out regularly or is not practiced by PE teachers (Đurašković, 2002).

The effects that each movement has on the human body are known in terms of stimulating its development and maintaining capabilities at a certain level. Exercises in artistic gymnastics are very diverse and some of them are more demanding in terms of different forms of power, some in terms of coordination, flexibility, balance, and some sublimate a few motor skills. For this reason, the application of exercises on the apparatus and floor indisputably affect the overall motor status of a person. Within artistic gymnastics, the widest auditorium experiences sport, conceptually defined as a competitive discipline, with polystructural content of the acyclic type and strictly defined rules as a convention applied in practice (Petković, Veličković, Petković, Hadži-Ilić, & Mekić, 2013).

Exercising on apparatus, as a wider concept of developmental gymnastics, is a motor activity rich with diversity of movements and positions. The richness of movement and position in exercise on apparatus allows those who use them to create a huge fund of motor knowledge that is a very good base and a predisposition for engaging in any sport (Madić & Popović, 2012).

There are a number of definitions of motor skills, so Findak (1999) and Prskalo (2004) similarly defined motor skills as latent motor structures that are responsible for an infinite number of manifest reactions that can be measured and described. Milanović (2009) defines motor skills as an ability that enables the realization of all kinds of movements. Malacko and Popović (2001) state that motor skills are latent, they cannot be directly measured, but indirectly, which means that only motor reactions, or manifestations of different measuring units, can be measured directly.

Many authors have tried to define strength in the most adequate and best way using different starting basics. Thus, Opavsky (1971) identifies strength with force and says that force is the ability to transform muscular strain in the composition of motor units into a kinetic or potential form of mechanical energy. In anthropomotorics, the term power is defined as a human trait, or its ability to overcome some external resistance or to resist it by means of muscular strains (Nićin, 2000).

Based on the character of muscular work, strength can be divided into:

- static, reflected in the ability to maintain maximum muscular contraction, of an isometric type, for a long time, without movement, and with the intention of preventing the disturbance of the assumed position; and
- dynamic, expressed in the form of explosive and repetitive strength (Herodek, 2006).

Rubin (2015) defines explosive power as the ability to activate the maximum number of muscle fibers in a unit of time. Explosive strength is one of the determinants of success in all activities that require the expression of maximum muscle force in as short a time unit as possible (Kreamer & Newton, 1994).

The subject of this research was explosive strength. Within the research problem, the answer to the basic question was given: are there differences in explosive strength among younger school age girls. The aim of the research was to determine the differences in explosive strength between the experimental and control group of girls of a younger school age. On the basis of the defined subject, problem and aim, tasks were set that are related to determining the differences in explosive strength of girls of a younger school age.

METHODS

An experimental model was used for research purposes. Appropriate procedures have been applied in accordance with the subject, aim and tasks of the research.

The sample of participants for the experimental group was intentional (Miljanović & Vojvodić, 2008). It consisted of 59 girls aged 9 to 11 from four cities, who as members of clubs were included in a developmental gymnastics program for at least three months. The average height of the participants was 141.13 cm, average mass was 33.88 kg and average BMI value was 16.84 (Table 1).

Table 1 Anthropometry and BMI

Experimental group	Height	Mass	BMI
Mean	141.13	33.88	16.84
Min	124.70	20.50	12.35
Max	159.00	51.70	25.75
Range	34.30	31.20	13.40

Legend: BMI – body mass index, Mean – mean value,
Min – minimum values, Max – maximum values.

A random stratified sample was formed for the control group (Miljanović & Vojvodić, 2008). It consisted of 45 girls from two third grade classes and two fourth grade classes from the primary school "Dušan Radović" in Niš, aged 9 to 11. The average height of the participants was 143.54 cm, average mass was 38.86 kg and average BMI value was 18.58 (Table 2).

Table 2 Anthropometry and BMI

Control group	Height	Mass	BMI
Mean	143.54	38.86	18.58
Min	127.50	21.90	12.88
Max	164.30	65.00	24.66
Range	36.80	43.10	11.78

Legend: BMI – body mass index, Mean – mean value,
Min – minimum values, Max – maximum values.

The participants of the control group regularly attended PE classes, which according to the curriculum for the 3rd and 4th grade include three classes within a week.

In addition of PE, the experimental group of participants were included in a program of developmental gymnastics three times a week for an hour. The developmental gymnastics program involves training of compulsories for the first category on vault, uneven bars, beam and floor (Veličković, Dejanović, & Drakučić, 2013).

Anthropometric characteristics of the sample were determined only for a better description, and were not taken for further analysis. They were measured in accordance with the recommendations of the International Biological Program-IBP (Weiner & Lourie, 1969). Height was measured with a measuring tape with an accuracy of 0.1 cm. Mass was estimated using a decimal scale with a precision of 0.1 kg. The Body Mass Index (BMI) was also not taken into account for statistical processing, but was calculated as body mass in kg/height in m², in order to provide insight into the state of nutrition of the participants.

Three tests were used to assess explosive strength:

Counter movement jump (CMJ): duration of the test: assessment of the duration of the test for one participant was about 2 minutes; number of testers: one examiner and one assistant; requisites: Optojump, the optical system for measurement; assignment: the participant stands upright, feet are hip width, and the arms are on the waist. From the starting position he quickly descends into squat with an angle of 90° at the knees. Without making a break, the participant performs a jump as high as possible without letting his hands off the waist and landing on both feet at the same time; evaluation: the explosive strength parameter obtained by Optojump, which is statistically processed, is the height of the jump in cm (Bosco Ergojump System, 2013).

Squat jump (SQJ): assessment of the duration of the test for one participant was about 2 minutes; one examiner and one assistant; requisites: Optojump, the optical system for measurement; assignment: From the starting position, the participant performs the jump as high as possible and lands on both feet simultaneously. The athlete stands calmly on the surface in an upright position, in stockings or barefoot, mass uniformly distributed on his whole feet. When ready, the athlete makes a squat at an angle of 90 ° between thigh and lower leg. After a few seconds in the initial position, at the mark of the tester or measuring device, the participant jumps as high as possible, and lands on both feet; evaluation: explosive strength parameter obtained by Optojump, which is statistically processed, is the height of the jump in cm (Bosco Ergojump System, 2013).

Throwing the medicine ball (TMB): assessment of the duration of the test for one participant is about 2 minutes; one examiner and one assistant; requisites; medicine ball (1 kg), centimeter tape, adhesive tape for marking the starting line; description of the place of performance: parallel with the wall of the hall at a distance of 50 cm from the floor, the starting line is marked indicating the place from which the throwing is performed. From the starting line, we mark each 100 cm on the floor with adhesive tape; assignment: the task of the participant is to place the medicine ball in front of his chest. Then he stands behind the starting line with his back turned towards the wall. When throwing of the medicine ball by stretching his arms forward, a small swing of the body is allowed. The examiner demonstrates the task; evaluation: the throwing length is measured on a centimeter tape with an accuracy of 1 dm; note: if a throw is performed incorrectly, repetition is allowed. As error in performance is considered to be overrun over the starting line during throwing and raising the foot from the floor (Gojković, 2009).

In all three tests three trials were measured and the mean value was taken for further statistical processing (Paunović, Veličković, Aleksić-Veljković, Kurtev, & Filipović, 2014).

The measurement of motor skills was conducted in a gymnastics halls in which participants train and which are intended for the implementation of this special program, with creating optimal conditions for performing measurements.

For the processing and analysis of raw data, the statistical data processing package SPSS v. 20 was used. For each applied variable, the basic parameters of descriptive statistics were calculated. The estimation of the distribution of the results and the estimation of the central and dispersion parameters was made in order to obtain data on whether the distribution of the results is normal or not. For this purpose, the following parameters were calculated: arithmetic mean (Mean), arithmetic mean calculated when ignored 5% of extreme cases from left and right (5% T Mean), standard deviation (S.D.), coefficient of variation (CV%), Range (R), minimum value (Min), maximum value (Max), coefficient of curvature (Skew), coefficient of roundness (Kurt), Kolmogorov-Smirnov zet (K-S Z), significance of Kolmogorov-Smirnov zet (Sig K-S Z).

For determining the differences between the groups, a t-test for independent samples was used, with a significance size difference calculation (Cohen's d).

RESULTS WITH DISCUSSION

Table 3 Descriptive parameters for the experimental group

Variables	Mean	SD	KV%	R	Min	Max	Skew	Kurt	K-S Z	Sig K-S Z
CMJ (cm)	19.83	3.61	18%	16.10	12.60	28.70	.36	.06	.83	.50
SQJ (cm)	19.27	3.76	20%	18.40	12.20	30.60	.65	.71	.63	.83
TMB (dm)	3.95	.91	23%	3.80	2.20	6.00	.00	-.79	.63	.82

When the Mean and 5% Mean values of the girls from the experimental group are compared (Table 3), it can be noted that the values are quite similar, which indicates that extreme values do not greatly affect the value of the arithmetic mean and there is no need for additional correction of extreme values. After examining the CV%-coefficient of variation (Papić, 2008) it can be seen that all three variables have relatively low variability. The significance of Kolmogorov-Smirnov Z (Sig K-S z) is in all cases is greater than 0.05, which indicates that the assumption of a significant deviation of observed distributions from normal distribution was not confirmed. Also, a confirmation that the observed distributions do not significantly deviate from the normal distribution are all the values of asymmetry (Skew) and roundness of distribution (Kurt) that do not extremely deviate from zero value.

Table 4 Descriptive parameters for the control group

Variables	Mean	SD	KV%	R	Min	Max	Skew	Kurt	K-S Z	Sig K-S Z
CMJ (cm)	16.67	2.77	17%	12.30	10.90	23.20	.27	-.25	.71	.70
SQJ (cm)	16.48	2.96	18%	12.90	11.60	24.50	.53	.11	.92	.37
TMB (dm)	3.70	.70	19%	3.00	2.50	5.50	.70	.16	.77	.60

As with the previous group of participants, values of Mean and 5% T Mean indicate that extreme values do not affect the value of the arithmetic mean and there is no need for additional correction of extreme values (Table 4). The coefficient of variation (CV%) indicates that all three variables have relatively low variability. The values of Kolmogorov-Smirnov Z (Sig K-S z) test indicate that there is no significant deviation from normal distribution, which is confirmed by the values of asymmetry (Skew) and distribution roundness (Kurt).

Table 5 t-test results

Variables	Mean E	Mean K	Mean Diff (E-K)	t	df	p	Cohen's d
CMJ (cm)	19.83	16.67	3.15	4.87	102.00	**.000****	0.96
SQJ (cm)	19.27	16.48	2.80	4.11	102.00	**.000****	0.81
TMB (dm)	3.95	3.70	.24	1.55	101.99	.127	0.31

Legend: Mean E – mean values of experimental group, Mean K – mean values of control group, Mean Diff (E-K) – the differences that are obtained when the arithmetic mean of experimental group is subtracted from the arithmetic mean of the control group, t – calculated t-test value, df – degrees of freedom, p – statistical significance of the t-test * < 0.05, ** < 0.01, Cohen's d – calculated Cohen's index of the size of differences.

In all three applied variables, the numerical difference between the arithmetic means in favor of better results of the experimental group are shown (Table 5). Reviewing the results of the t-test and its statistical significance, it is noted that the differences between arithmetic means are in addition to numerical difference also statistically significantly differ from the tests CMJ and SQJ at the level p= .000. With the test TMB there were no statistically significant differences (p= .127), and numerical differences are almost negligible.

Cohen proposed the following guidelines regarding the interpretation of the size of differences (Pallant, 2011): small-from 0.20, medium-from 0.50 and large-from 0.80. The review of the obtained coefficients on the size of the differences (Cohen's d) large differences in favor of better results of the experimental group can be noted for variables CMJ (0.96) and SQJ (0.81), while for the variable TMB, the strength of the difference is medium (0.31) in favor of the experimental group.

The obtained results indicate a higher quality of explosive strength of the experimental group in relation to the control group. These differences in the variables CMJ and SQJ are attributed to the program of developmental gymnastics, which obviously has a greater influence on explosive strength of the lower extremities than the current curriculum of PE. Thus obtained results are consistent with previous research (Gojković, 2009; Milenković, 2002, 2004), in which the authors examined differences in motor skills on a different sample of participants.

The reason why the differences are small and statistically insignificant for the variable TMB can be found in anthropometric characteristics of the participants. By reviewing Table 1 and 2, it can be noticed that the control group of participants has higher height, mass and BMI values than the participants from the experimental group. A few researchers (Rodić, 2012; Kondrič, Mišigoj-Duraković & Metikoš, 2002; Diane, Julie, & Louise, 2006), came to conclusion that body mass and height positively affect explosive strength of the upper extremities.

The results obtained in the current research can be compared with the results of the research of Madić et al. (2018), performed on a sample of 56 healthy preschool girls that were divided into two groups (developmental training group and a control group). Developmental gymnastic training process consisted of station and circuit work and obstacle courses (two times a week lasting for 60 min with intensity around 160-180bpm). The following test batteries of motor fitness tests were used: the 20m dash, Obstacle course backwards, Standing broad jump, Arm plate tapping, Seated straddle stretch, Bent arm hang, Sit ups. At the end of the training program, the experimental group showed significant ($p<0.05$) improvements in almost all the parameters analyzed (e.g., Obstacle course backwards; Standing broad jump; Arm plate tapping; Bent arm hang and Sit ups) compared with pretest values, with percentages of change and ES ranging from 13.3% to 48.2% and 0.64 (moderate) to 1.20 (large), respectively. There were no significant changes observed in the control group after the training intervention except for the standing broad jump and arm plate tapping ($p<0.05$).

CONCLUSION

The conducted research indicates that the teaching of PE itself is not sufficient for quality development of explosive strength. It should be further modified and adapted to give better results in the motor development of younger school age girls. The results accurately indicate that the participants included in the developmental gymnastics program have a significantly higher level of explosive strength than participants who attended only PE classes. One of the problems is that the teaching of PE at this age is performed by insufficiently trained persons. A possible solution is the introduction of extra-curricular activities that would not be carried out by teachers, but professors of PE.

This research should encourage a series of studies that would include a larger population, on a larger number of tests covering more motor spaces. It should also awaken parents' awareness to more seriously address the problem of physical (in-) activity of children, because with the development of technology, play has completely changed its character and caused the development of various deformities. We hope that by using these and similar programs, children will be separated from computers, tablets and phones and that they will have healthy growth and development. The best effect would be achieved by implementing the aforementioned programs into the curriculum and the PE program.

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EKSPLOZIVNA SNAGA DEVOJČICA MLAĐEG ŠKOLSKOG UZRASTA

Fizičko vaspitanje (FV) je u mlađem školskom uzrastu veoma važno. Ipak, u praksi, nastava FV se ne sprovodi redovno ili je ne sprovode nastavnici FV. Problem istraživanja bio je da se utvrdi da li program razvojne gimnastike ima uticaj na razvoj eksplozivne snage kod devojčica mlađeg školskog uzrasta. Uzorak ispitanica eksperimentalne grupe sačinjavalo je 59 devojčica, a kontrolne grupe 45 devojčica, uzrasta od 9 do 11 godina. U cilju utvrđivanja nivoa eksplozivne snage korišćena su tri testa. Obrada podataka izvršena je statističkim programom SPSS v. 20. Izračunati su parametri deskriptivne statistike. Da bi se utvrdile razlike između grupa, korišćen je t-test za nezavisne uzorke uz izračunavanje značaja veličine razlike (Cohen's d). Istraživanjem su utvrđeni efekti programa razvojne gimnastike na razvoj eksplozivne snage kod devojčica uzrasta od 9 do 11 godina. Razlike u eksplozivnoj snazi su identifikovane u korist eksperimentalne grupe u dve od tri varijable. Dobijeni rezultati jasno ukazuju da učesnici uključeni u razvojni program gimnastike imaju značajno viši nivo eksplozivne snage od učesnika koji su pohađali redovnu nastavu FV.

Ključne reči: *razvojna gimnastika, fizičko vaspitanje, eksplozivna snaga, mladi školski uzrast*