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Original research paper

EFFECTS OF THE ACROBATIC PROGRAM ON THE BODY COMPOSITION AND FLEXIBILITY OF ADOLESCENTS

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Abstract. *The aim of the research was to determine the effects of acrobatics programs (ground floor and skipping) on the body composition and flexibility of adolescents. The sample consisted of 50 male adolescents, seventh grade students of the elementary school "Bubanjski Heroji" in Niš, aged 14 years ± 6 months. The experimental group (n = 25) conducted 2 x 45 min per week experimental acrobatics program (ground floor and skipping) The control group (n = 25) continued with the program of regular physical education classes (handball and volleyball) 2 x 45 min per week. The results of the study showed positive changes in body composition: BMI, %MAT, %MIT and flexibility: PLNL, RANL, ISKP caused by the acrobatics program. Based on these results, it can be concluded that the experimental program of acrobatics lasting 16 weeks is an effective method that leads to a statistically significant improvement in body composition and flexibility of adolescents.*

Key words: *gymnastics, acrobatics, elementary school students, body composition, flexibility*

1. INTRODUCTION

Acrobatics is an anaerobic acyclic activity that consists of various movements and positions, exercises on the ground floor, exercises on devices that, in addition to jumping, also make sports gymnastics. In today's modern society, gymnastics, and especially acrobatics, exists in

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education, competitive sports, other sports, other areas of sports activities and physical activities, kinesitherapy programs, recreational forms of exercise (Broomfield, 2011).

The importance and role of body composition and flexibility in acrobatics is confirmed by studies (Taboada-Iglesias, Santana, & Gutiérrez-Sánchez, 2017; Kravchuk, Sanzharova, Golenkova, & Katrechko, 2020). Taboada-Iglesias et al. (2017) suggested that higher values of body height, minimum belly circumference, fat percentage and small biocrystal width are predictors of good results when acrobatic gymnasts work in pairs rather than in groups. Kravchuk et al. (2020) indicate a statistically significant positive effect of ground floor exercises on the development of flexibility of young gymnasts.

Acrobatics training is present in the teaching of physical education as well as in certain segments of training and phases of sports preparation of individual and collective sports. Numerous studies emphasize significance and role of body composition in gymnastics (Trexler, Smith-Ryan, Roelofs, & Hirsch, 2015; Granacher & Borde, 2017; Dobrosielski et al., 2019; Sterkowicz-Przybycień et al., 2019). Trexler et al. (2015) obtained results on a sample of young gymnasts that show that performance is not positively correlated with total body weight, adipose tissue and body fat assessment. The results of this study indicate that lean body mass can be a predictor of good results of professional gymnasts and recommend that weight loss gain should be given priority out of season. Granacher & Borde (2017) examined the effects of sports training and physical education on body composition, physical fitness and cognitive abilities of adolescents. The results of the study showed that athletes show a higher level of physical fitness with less relative body fat mass, more relative skeletal muscle mass and similar cognitive abilities compared to their non-athlete peers. Dobrosielski et al. (2019) indicate that the total percentage of body fat among gymnasts was 23.5%, and was lower compared to tennis, field hockey, lacrosse, athletics and softball. Similar results are confirmed by (Miletić et al., 2019) where the authors showed that experimental programs of gymnastics and acrobatics have a positive effect on the body composition of adolescents.

Performing numerous and varied movements in acrobatics contributes to better performance of dynamic and static movements and flexibility of the muscles of the whole body. In most girls and boys, the level of flexibility decreases with increasing number of years during childhood and adolescence. On average, girls have more flexibility than boys of all ages (Malina, Bouchard, & Bar-Or, 2004). Therefore, in addition to body composition, flexibility represents a very important component in acrobatics and gymnastics, and in addition it is most often associated with musculoskeletal injuries in gymnastics. Desai, Vance, Rosenwasser, & Ahmad (2019) emphasize that flexibility is an important factor in prevention common injury in acrobatics and gymnastics which include injuries to the spine and upper extremities, such as spondylolysis, shoulder instability, ulnar ligament injuries, capillary osteochondritis, and joint injuries. In general, the most common injuries in gymnastics are injuries of the lower extremity, ie. sprain of the ankle, followed by internal knee injuries, while in young gymnasts shoulder injuries are the most common (Hart, Meehan Bae, d'Hemecourt, & Stracciolini, 2018). One of the mechanisms of increasing flexibility in young gymnasts after the acrobatics program is the high prevalence of dynamic movements with large amplitudes that occur when performing technical elements within acrobatics and gymnastics. In any case, it has been confirmed that dynamic and static stretching, as well as long-term stretching, achieve good results in improving the flexibility of gymnasts (Santos, Lemos, Lebre, & Ávila Carvalho, 2015). In addition to flexibility, the authors of these studies point out that strength and agility are also important

in preventing injuries in acrobatics and gymnastics, and injuries are more common in professional gymnastics than recreational gymnastics. The role of flexibility in recreational gymnastics is especially emphasized after the age of forty due to the declining level of flexibility caused by the aging process. Therefore, it is very important to maintain or improve the level of flexibility, and the best results are achieved if adequate exercise programs are applied.

The aim of the research was to determine the effects of acrobatics programs (ground floor and skipping) on the body composition and flexibility of adolescents.

2. METHODS

2.1. Sample of participants

The sample consisted of 50 adolescents, students of the seventh grade of primary school "Bubanjski Heroji" in Niš, Serbia, aged 14 years ± 6 months, males who implemented a physical education program for the seventh grade of primary schools recommended by the Institute for Educational Improvement and education of the Republic of Serbia. The experimental group consisted of 25 participants, included in the experimental program of acrobatics (ground floor and jump). The control group consisted of 25 participants, included in the program of regular physical education classes (handball and volleyball).

2.2. The measuring instruments

The following variables were used to assess body composition: body height (ATVI), body mass (ATMA), body mass index (BMI), percentage of adipose tissue (%MAT), percentage of muscle tissue (%MIT). Body mass, body mass index, percentage of fat and muscle tissue was obtained using an electronic scale Omron BF511 Body Composition Monitor. Body height was measured with an anthropometer according to Martin.

The following variables were used to assess flexibility: lying on the back (PLNL), lying on the back (RANL), bending with a stick (ISKP). Measuring instruments for assessment flexibility are downloaded (Madić, Nikolić, & Stojiljković, 2015).

2.3. The experimental procedure

The experimental program was realized in the duration of 16 weeks. Physical education classes took place 2 x 45 minutes per week. The experimental group conducted an experimental acrobatics program (ground floor and jump) 2 x 45 min per week. The control group continued with the program of regular physical education classes (handball and volleyball) 2 x 45 minutes per week. The structure of the experimental and control group was divided into four parts: the introductory part of the class (5 min), the preparatory part of the class (15 min), the main part of the experimental group consisted of exercises on the ground and jump, volleyball and handball in the control group (20 min) and the final part of the class (5 min).

2.4. Statistical analysis

Multivariate covariance analysis (MANCOVA) and univariate covariance analysis (ANCOVA) were used to determine the effect of the experimental acrobatics program on adolescent body composition and flexibility, with the calculation of the magnitude of the

impact (Partial Eta Squared). Testing for differences was performed using the F-test. The significance level was set at $p < 0.05$. The data obtained were processed by the SPSS 19 statistical program (Statictical Package for Social Science, v19.0, SPSS Inc., Chicago, IL, USA).

3. RESULTS

Table 1 shows a multivariate analysis of the covariance of the applied variables for the assessment of body composition between the experimental and control groups at the final measurement, with the neutralization of the differences at the initial measurement. It can be stated that there is a statistically significant difference at the multivariate level between the subjects of the experimental and control groups, after the experimental program at the level of significance ($p = 0.03$).

Table 1 Multivariate analysis of covariance of experimental and control groups for body composition

Wilks' Lambda	F	df1	df2	p	Partial Eta Squared
.76	3.00	4.00	39.00	.03 *	0.24

Legend: Wilk's Lambda – Wilks lambda test, F – F approximation, df – degrees of freedom, p – statistical significance of differences * < 0.05, ** < 0.01, Partial Eta Squared – magnitude of impact (* = 0.01 (small impact), ** > 0.06 (moderate impact), *** > 0.14 (high impact)

Based on the partial eta squared (Partial Eta Squared = 0.24), a large influence of the experimental program on the differences between the groups in the final measurement can be stated. More specifically, this means that the difference between the groups, and thus the applied programs, explains as much as 24% of the variance in the results on the final measurement of body composition, ie 24% of the variance in the dependent variable is explained by the independent variable. Thus, it is evident that the experimental program of acrobatics at the multivariate level has significant effects on body composition.

Table 2 shows the univariate differences in the variables for the assessment of body composition between the subjects of the experimental and control groups at the final measurement with neutralization and partialization of the results at the initial measurement. Numerical differences between the mean values are mainly in favor of the better results of the experimental group.

Table 2 Univariate analysis of covariance of experimental and control groups for body composition

Variables	Adj. Mean E	Adj. Mean K	Adj. Mean diff. (EC)	F	p	Partial Eta Squared
ATMA	63.40	64.67	-1.26	1.27	.27	0.03 *
BMI	22.56	23.56	-1.00	4.79	.03 *	0.10 **
%MAT	20.08	23.59	-3.51	7.63	.01 **	0.15 ***
%MIT	37.97	35.90	2.08	9.79	.00 **	0.19 ***

Legend: Adj. Mean – corrected arithmetic mean (E – experimental group, K – control group), Adj. Mean diff. – differences between corrected arithmetic means, F – F test, p – significance level, statistical significance of differences ** < 0.01 * < 0.05, Partial Eta Squared – impact size (* = 0.01 (small impact), ** > 0.06 (moderate impact), *** > 0.14 (high impact)

Analysis of the results shows that statistically significant differences at the univariate level between the subjects of the experimental and control groups, at the level of significance ($p < 0.01$) are observed in the two variables %MIT (.00) and %MAT (.01). At the level ($p < 0.05$) it is observed with the variable BMI (.03), while the experimental program did not give statistically significant differences with the variable ATMA (.27), but a numerical difference was found in favor of the experimental group. In all variables in which a statistically significant difference was found, it was found that the experimental program contributed to large positive differences %MIT (0.19), %MAT (0.15), moderate positive differences BMI (0.10), as indicated by the values Partial Eta Squared. Only for the ATMA variable (0.03) is the difference small. Thus, it is evident that the experimental program of acrobatics at the univariate level has significant effects on the body composition.

Table 3 shows a multivariate analysis of the covariance of the applied variables to assess the flexibility between the experimental and control groups at the final measurement, with the neutralization of the differences at the initial measurement. It can be stated that there is a statistically significant difference at the multivariate level between the subjects of the experimental and control groups, after the experimental program at the level of significance ($p = 0.00$).

Table 3 Multivariate analysis of the covariance of the experimental and control groups for flexibility

Wilks' Lambda	F	df1	df2	p	Partial Eta Squared
.10	117.67	3.00	41.00	.00 **	0.90

Legend: Wilk's Lambda – Wilks lambda test, F – F approximation, df – degrees of freedom, p – statistical significance of differences * < 0.05, ** < 0.01, Partial Eta Squared – magnitude of impact (* = 0.01 (small impact), ** > 0.06 (moderate impact), *** > 0.14 (high impact).

Based on the Partial Eta Squared (0.90), a large influence of the experimental program on the differences between the groups in the final measurement can be stated. More specifically, this means that the difference between the groups, and thus the applied programs, explains as much as 90% of the variance in the results on the final measurement of flexibility, ie 90% of the variance in the dependent variable is explained by the independent variable. Thus, it is evident that the experimental acrobatics program at the multivariate level has significant effects on flexibility.

Table 4 shows the univariate differences in the variables for assessing flexibility between the subjects of the experimental and control groups at the final measurement with neutralization and partialization of the results at the initial measurement. Numerical differences between the mean values are in favor of the better results of the experimental group.

Table 4 Univariate covariance analysis of experimental and control groups for flexibility

Variables	Adj. Mean E	Adj. Mean K	Adj. Mean diff. (EC)	F	p	Partial Eta Squared
PLNL	96.25	82.04	14.21	90.38	.00 **	0.68 ***
RANL	133.67	103.58	30.08	205.54	.00 **	0.83 ***
ISKP	69.45	83.63	-14.19	106.37	.00 **	0.71 ***

Legend: Adj. Mean – corrected arithmetic mean (E – experimental group, K – control group), Adj. Mean diff. – differences between corrected arithmetic means, F – F test, p – significance level, statistical significance of differences ** < 0.01 * < 0.05, Partial Eta Squared – impact size (* = 0,01 (small impact), ** > 0.06 (moderate impact), *** > 0.14 (high impact).

The analysis of the results shows that statistically significant differences at the univariate level between the subjects of the experimental and control groups, at the level of significance ($p < 0.01$) are observed in all three variables PLNL (.00), RANL (.00) and ISKP (00). In all variables in which a statistically significant difference was found, it was stated that the experimental program contributed to large positive differences between RANL (0.83), ISKP (0.71) and PLNL (0.68), as indicated by the values of Partial Eta Squared. Thus, it is evident that the experimental acrobatics program at the univariate level has significant effects on flexibility.

4. DISCUSSION

The primary purpose of the study was to determine the effects of an experimental acrobatics program on the body composition and adolescent flexibility. The obtained results showed that the experimental group, which had an acrobatics program, achieved statistically significantly more progress than the control group, which had teaching units according to the curriculum of the primary school. This means that the experimental program of acrobatics lasting 16 weeks (2 times a week) had positive effects on improving the results between two tests of body composition and flexibility of adolescents. The results obtained in this way can be said to be expected. The reason for such a statement lies in the fact that the participants of the control group, in their classes, implemented a different plan and program, ie. they had a program of regular physical education activities (handball and volleyball teaching units), while the experimental group had an acrobatics program (ground floor and skipping).

The age characteristics of the subjects who underwent the experimental program represent an essential component. The sample of participants in this study consisted of adolescents, seventh grade elementary school students (14 years ± 6 months), whose age is suitable for the use of adequately planned acrobatics exercises. Maturity of the musculoskeletal system is an important component and greatly affects the fitness component (Bosco & Komi, 1981), and the reason for this is the continuous growth of the musculoskeletal system, as well as cartilage on the epiphyseal bone plates in that period (Ruprai, Tajpuriya, & Mishra, 2015). Gymnastics and acrobatics programs are also recommended for younger school-age students, because the skeletal system is in the phase of growth and hardening. This means that the bones are susceptible to external influences, because more intense ossification begins after the ninth year, but not evenly all parts of the body. Muscle mass of this age period increases significantly, especially the mass of larger muscle groups (Smajić et al., 2017). Therefore, experimental programs in gymnastics and acrobatics are fully recommended for elementary school students. On the other hand, Yurchuk-Zuliar, Tulyakova, & Kunshin (2018) indicate that acrobatics and gymnastics trainings cause delays in physical and sexual development in 10-year-old girls. Also, the authors point to a positive effect on anthropometric variables, body fat, body mass, body mass index and thickness of skin folds. Silva, Silva, & Paiva (2018) showed that acrobatic gymnasts have low levels of body fat, short sleep (less than eight hours) as well as inadequate intake of micro and macro elements in the diet. The authors point to the negative effects of overweight and obesity in adolescents. Also, the authors emphasize that proper dietary intake is an important resource for short-term and long-term health and performance of acrobatic gymnasts.

Each lesson in the applied experimental program in the conducted study consisted of a part in which exercises were performed with the aim of warming up the subject's body and raising

the body temperature., ie preparation of muscles, tendons and ligaments, for the realization of tasks in the main part of the class. The results of the study confirmed that there was a statistically significant improvement in body composition and flexibility in favor of the experimental group, as well as the fact that no injuries were observed during the entire experimental program, indicates proper planning and dosing of loads. This is a very important fact, because the age of 11 to 15 is crucial for the occurrence of injuries in acrobatics in adolescents (Purnell, Shirley, Nicholson, & Adams, 2010). The authors of this study showed that 50.7% of participants suffered an injury related to acrobatic gymnastics in the past 12 months of training, with 28.8% of participants receiving a chronic injury during the study. The highest percentage of acute and chronic injuries is in acrobatic gymnasts aged 14, and the most commonly injured anatomical locations are the knee, ankle and wrist. The obtained results can be explained by the fact that in adolescents, due to the appearance of increased growth and development during puberty, vulnerability to injuries can be created if the scope of training is above a certain threshold. However, thanks to biomechanical analyzes, it is possible to follow the sports technique of acrobatic gymnasts, their impact on the performance achieved in the competition, which has a positive effect on reducing the occurrence of injuries in acrobatics (Kyzim, Humeniuk, & Batieieva, 2018).

Bjelica (2020) recommended that training for the development of body composition, flexibility and motor fitness be applied twice a week. This avoids muscle fatigue that affects the quality of work. According to this recommendation, the experimental program in this study was conducted twice a week with an interval of 48 hours between trainings. Recommendation with with an interval of 48 hours between classes in adolescents has been confirmed in other studies in acrobatics (Ionescu, 2016; Mićović, Fulurija, & Ćeremidžić, 2018).

The recommendation for the duration of the experimental program of gymnastics and acrobatics with positive effects on the body composition, flexibility and motor fitness is 16 weeks (Rudd, 2016; Paunović, 2018; Miletić et al., 2019), or 12 weeks and more (Akin, 2013; Mićović et al., 2018). The experimental program of acrobatics in this study lasted 16 weeks, after which the results confirmed the positive impact on fitness components and the recommendations of previous research. However, there are studies that indicate that a shorter experimental acrobatics program may have effects on adolescent motor fitness. Das & Sarkar (2020) in a study aimed at determining the effects of acrobatics on adolescent motor fitness, obtained results showed positive effects of an acrobatics program lasting six weeks. Therefore, further studies are needed to fully clarify the impact of acrobatics programs on the fitness component of adolescents. Also, it would be interesting to examine the effects of acrobatics programs on the fitness component of adolescent girls, which is a recommendation to future researchers on this topic.

5. Conclusion

The results of the study showed positive changes in body composition and flexibility caused by the acrobatics program. Based on these results, it can be concluded that the experimental program of acrobatics lasting 16 weeks is an effective method that leads to a statistically significant improvement in body composition and flexibility of adolescents. Such knowledge can serve as a basis for the development of a supplement to the work program that would be applied in the teaching of physical education, as well as for the supplementation of validated

batteries of tests to assess the physical growth and development of primary school students. Also, trainers and experts in the field of gymnastics need exercises that will contribute to the improvement of body composition and flexibility as soon as possible, as one of the determinants of the success of gymnastics, with a reduced risk of injury.

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EFEKTI PROGRAMA AKROBATIKE NA TELESNU KOMPOZICIJU I FLEKSIBILNOST ADOLESCENATA

Cilj istraživanja bio je da se utvrde efekti programa akrobatike (parter i preskok) na telesnu kompoziciju i fleksibilnost adolescenata. Uzorak ispitanika činilo je 50 adolescenata muškog pola , učenika sedmog razreda osnovne škole "Bubanjski heroji" u Nišu, starosti 14 godina ± 6 meseci. Eksperimentalna grupa (n = 25) je sprovodila 2 x 45 min nedeljno eksperimentalni program akrobatike (parter i preskok) Kontrolna grupa (n = 25) je nastavila sa programom redovne nastave fizičkog vaspitanja (rukomet i odbojka) 2 x 45min nedeljno. Rezultati studije pokazali su pozitivne promene u telesnoj kompoziciji: ITM, %MAT, %MIT i fleksibilnosti: PLNL, RANL, ISKP izazvane programom akrobatike. Na osnovu ovakvih rezultata može se zaključiti da je eksperimentalni program akrobatike u trajanju od 16 nedelja efektivan metod koji dovodi do statistički značajnog poboljšanja telesne kompozicije i fleksibilnosti adolescenata.

Ključne reči: *gimnastika, akrobatika, učenici osnovne škole, telesni sastav, gipkost*