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Original research article

THE EFFECTS OF PHYSICAL EXERCISE WITH RESISTANCE ON THE EXPLOSIVE STRENGTH OF STUDENTS

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Abstract. *Resistance training is very complex, and cannot be conducted without professional guidelines. The optimum characteristics of a resistance training program involve certain principles and norms which should comply with programmed strength exercises. The main aim of the currentresearch was to quantify the level of explosive strength and to determine the differences in explosive strength of the upper and lower extremities in male students of the Biomedical Science Department at the State University of Novi Pazar. The sample of participants consisted of 63 male students of Biomedical Science Department at the State University of Novi Pazar, freshmen, sophomores and juniors. The participantswere of males, 20±1 years (Mean±St.Dev), and divided into an experimental group (EG, N=39), that participated in an exercise resistance program for a duration of eight weeks, and a control group (CG, N=24), that had no specially organised physical activities. The experimental exercise program lasted for 8 weeks, with 16 exercise sessions and was practised by the EG. Each session had 14 different exercises involving resistance. The resistance itself was from 50 to 70% 1RM. For the evaluation of explosive strength, the bench press tests and squat tests were used. The parameters used to evaluate explosive strength included: Power, Peak Power, Force and Velocity. The statistical analysie included the basic descriptive parameters and analysis of variance (method MANOVA and method ANOVA). Statistically significant changes in explosive strength of the lower extremities were determined for the experimental group (p=0.018). No difference in explosive strength of the upper extremities, was determined either forthe EG, or the CG.*

Key words: *effects, exercise program with resistance, explosive strength, students*

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INTRODUCTION

Physical exercise is a planned and expedient activity whose primary goal is to improve the health and physical shape of the participants (Ostojić et al., 2009), and to activate the adaptive process that will produce certain positive changes in the human body (Živanović, 2000). According to Bjelica (2006), the main goal of exercise is to upgrade explosive strength to the highest level possible by maintaining movement technique at the highest level.

Resistance training is very complex, and cannot be conducted without professional guidelines. The optimum characteristics of a resistance training program involve certain principles and norms which should comply with programmed strength exercise. The need for a methodological approach to strength development was confirmed in scientific studies grounded in exercise principles, such as rotation of excentric and concentric muscular action, exercising intensity, volume, pauses between workout sets, etc.

Physical exercise with resistance is popular, but is incorrectly known as power training. It includes exercising with the use of equipment, weights, expanders or exercising which relies on body mass, with the goal of developing muscle strength, power and endurance (Ignjatović, Stanković, Radovanović, Marković, and Cvećka, 2009). Exercising with resistance is a form of physical activity that is used to upgrade motor abilities and the ability to overcome resistance. The exercise has to be designed so it could reflect the goals that were set, to define if the goal is endurance or hypertrophy, to envelop the choice of exercise, exercise schedule, the amount of rest between exercise sessions, the number of repetitions within exercise sessions and the intensity of each exercise (Kraemer &Ratamess, 2004).

Van Praagh & Dore (2002) generally define strength as a neuro-muscle system ability to produce the highest possible strength at the time needed, while explosive strength is defined as the ability to invest maximum possible energy into one movement in the shortest period of time. It is one of the determinants of success in each activity that requires expression of muscular strength in the shortest time unit (Kraemer & Newton, 1994). Also, Fleishman defines explosive strength as the ability to invest maximum energy in one and only explosive movement (in Kurelićet., 1975). Explosive strength interacts with power and velocity. With explosive mastery of greater external resistance, the force component has a higher impact than velocity component (Milanović, 2009).

The development of explosive strength has to begin in early childhood, between the ages of 5-7. Maximum development is achieved by the age of 20-22, while it starts do decrease after the age of 30, while after age of 35 the decrease reaches up to 60% (Malacko & Radjo, 2004).

Resistance training has been extremely popular in last 20 years, especially used as a method of increasing athletes' performance, muscular strength, velocity, balance and coordination. Earlier, traditionally, physical exercise with resistance was practiced mostly by bodybuilders. However, today it has become popular among adolescents, healthy gown-ups, elderly people and clinical population (Kraemer & Ratamess, 2004).

The main aim of the current research was to quantify the level of explosive strength and to determine the differences in explosive strength of the upper and lower extremities among the male students of the Biomedical Science Department at the State University of Novi Pazar.

METHODS

Participants

The sample of participants consisted of 63 male students of the Department of Biomedical Sciences at the State University of Novi Pazar, freshmen, sophomores and juniors. The participants were all males, 20±1 years (Mean±St.Dev), and divided into an experimental group (N=39), that participated in an exercise resistance program for a duration of eight weeks, and a control group (N=24), that had no specially organised physical activities.

Measuring instruments

For the evaluation of upper and lower extremities, the explosive strength bench-press test and squat test were used. The parameters used for the evaluation were Power (in W), Peak Power (in W), Force (in N) and Velocity (in cm/s), obtained by the usage of a Myotest accelerometer (Sion, Switzerland). Its validity and reliability were experimentally confirmed (Jidovtseff, 2008; Bubanj et al., 2010; Bubanj et al., 2015).

Data processing

In the data processing, basic descriptive statistics were used that establish the measures of central tendency (mean) and of variability (standard deviation, range, maximum and minimum scores). In order to determine the differences in arithmetic means between the initial and final measuring, both in the experimental and control group of students, the Univariate Analysis of Variance (ANOVA method) and Multivariate Analysis of Variance (MANOVA method) were used.

Experimental procedure

The experimental program lasted for two months (eight weeks). The participants of experimental group exercised twice a week, for a total of16separateworkout sessions. During the program realization, attention was placed on the extent and intensity of the exercise, that gradually increased. 1RM was determined at the beginning of the experimental program. At the beginning of the exercise session, there was no change in the extent or intensity of the workout (50% of 1RM), while there was an increase, up to 70% of 1RM during program, following the recommendations of Stojiljković (2005) who stated that the intensity of the resistance rate for healthy persons should be from 50% up to 80-85% of 1RM (in Pantelić, 2008). Sixteen workout sessions consisted of 14 different exercises related to six different groups of muscles: arms and shoulder joint, chests, back, stomach and legs (Delavier, 2006). Each exercise had its own structure and was conducted under a qualified persons' supervision. The sessions lasted from 45 min to a maximum of 65 minutes, and were divided into three phases: warm-up, conditioning and cool down.

In sessions 1-4, each of the14 exercises was performed once (one session). The number of repetitions within the sessions was 10 to 14 times, with a resistance 50% of 1RM, and 1 min of rest between the exercises. The next four sessions (from 5 to 8) were performed twice, with 50% of 1RM in the first series, and 60% of 1RM in the second series (six exercises), with 1 min rest between the exercises and 5 min rest between the sessions. The number of repetitions was 10 to 12 times.

Sessions 9-12 were performed twice, and the number of repetitions was 8 to 12 times. In the first series the resistance was 50% of 1RM, while in the second series (seven exercises) the resistance was 65% of 1RM, with a rest time as in the previous four sessions (from 5 to 8).

In the last four exercise sessions (from 13 to 16), the number of repetitions was from 8 to 10 times, with 50% of 1RM in first series (14 exercises), 60% of 1RM in the second series (three exercises) and 70% of 1RM in the third series (three exercises).

RESULTS

Table 1 Descriptive parameters of the physical characteristics at the initial and final measuring of the participants of the experimental and control group

Measuring		Variables	Range	Min	Max	Mean	SD
EG	Initial/ Final	Body Height (cm)	36,00/ 36,00	164,07/ 164,00	200,00/ 200,00	180,43/ 180/32	7,36/ 8,16
		Body Mass (kg)	69,00/ 75,30	57,00/ 48,70	126,00/ 124,00	78,84/ 77,50	13,47/ 14,62
CG	Initial/ Final	Body Height (cm)	29,00/ 29,00	168,00/ 168,00	197,00/ 197,00	182,23/ 182,71	7,64/ 7,75
		Body Mass (kg)	44,00/ 44,00	66,00/ 67,00	110,00/ 111,00	81,73/ 82,00	10,49/ 10,12

Table 2 Descriptive parameters of the explosive strength of the upper extremities at the initial and final measuring of the participants of the experimental and control group

Measuring		Variables	Range	Min	Max	Mean	SD
EG	Initial/ Final	Power (W)	784,00/ 842,00	246,00/ 248,00	1030,00/ 1090,00	576,47/ 646,36	167,55/ 172,60
		Peak Power (W)	738/ 773	302/ 367	1040/ 1140	613,35/ 684,10	164,48/ 170,10
		Force (N)	204/ 192	182/ 209	386/ 401	285,51/ 297,03	47,36/ 45,45
		Velocity (cm/s)	165,00/ 192,00	182,00/ 199,00	347,00/ 391,00	277,46/ 295,67	39,22/ 39,02
CG	Initial/ Final	Power (W)	610,00/ 549,00	351,00/ 372,00	961,00/ 921,00	607,73/ 612,67	162,60/ 150,67
		Peak Power (W)	618/ 614	382/ 386	1000/ 1000	653,27/ 654,00	164,49/ 156,97
		Force (N)	165/ 150	222/ 228	387/ 378	292,00/ 294,29	45,98/ 44,46
		Velocity (cm/s)	135,00/ 104,00	208,00/ 228,00	343,00/ 332,00	285,12/ 285,08	33,97/ 28,44

Table 3 Descriptive parameters of the explosive strength of the lower extremities at the initial and final measuring of the participants of the experimental and control group

Measuring		Variables	Range	Min	Max	Mean	SD
EG	Initial/ Final	Power (W)	2590/ 3600	1520/ 2010	4110/ 5610	2825,02/ 3255,87	612,82/ 851,98
		Peak Power (W)	2830/ 3830	1910/ 2070	4740/ 5900	3048,18/ 3534,95	616,12/ 902,91
		Force (N)	1820/ 1490	1360/ 1310	3180/ 2800	1892,55/ 1948,18	373,65/ 353,48
		Velocity (cm/s)	145,00/ 202,00	127,00/ 135,00	272,00/ 337,00	204,73/ 227,39	30,22/ 40,45
CG	Initial/ Final	Power (W)	3390/ 3560	1460/ 1280	4850/ 4840	3206,15/ 3206,25	751,39/ 756,20
		Peak Power (W)	3490/ 3760	1780/ 1440	5270/ 5200	3511,15/ 3512,96	770,66/ 735,38
		Force (N)	1390/ 1681	1340/ 1270	2730/ 2951	2001,15/ 1986,29	289,38/ 372,43
		Velocity (cm/s)	142,00/ 147,00	138,00/ 127,00	280,00/ 274,00	217,35/ 215,71	32,57/ 33,67

After eight weeks of the experimental program and the statistical data processing of the initial and final measuring of the explosive strength of the upper extremities, there were no statistically significant differences in the experimental group at the established level of $p<0,05$. In the experimental group, by applying method MANOVA, that relevance was $p=0,146$, and in the control group $p=0,986$. The same goes for the control group, i.e., no statistically significant difference was determined.

However, the program effects on the experimental group, i.e., statistically significant differences were determined for the explosive strength of the lower extremities ($p=.018$). The value of Wilks' lambda was 0,88, while the F approximation for 4 and 89 degrees of freedom was 3,15. No statistically significant difference was determined for the control group ($p=0,99$).

Table 4 Results of the ANOVA for the explosive strength of the lower extremities between the initial and final measuring for the experimental group

Variables	F	p
Power (W)	8,142	**,005**
Peak Power (W)	9,663	**,003**
Force (N)	,529	,469
Velocity (cm/s)	9,668	**,002**

Table 5 Results of MANOVA for the explosive strength of the lower extremities between the initial and final measuring for the experimental group

Wilks' lambda	F	Hypothesis df	Error df	Sig.
,876	3,154	4,000	89,000	,018

DISCUSSION

According to Hong, Hong, & Shin (2014), strength improvement is directly depended and closely linked to exercise. Fleck & Kraemer (1997) deducted in their research that a properly designed program with resistance, after a certain amount of time improves muscular ability (in Ignjatović, 2011).

The resistance used in actual research ranged between 50% and 70% of 1RM, which probably contributed to the lack of statistically significant changes in certain test areas. Moss, Refsnes, Abildgaard, Nicolaysen, & Jensen (1997) obtained similar results in the research conducted on sample of 30 students with the purpose of showing how different levels of exterior resistance have an impact on explosive strength. On the other hand Tomas et al. (2007) determined that lower values of 1RM can be used as a starting point in order to train maximal mechanical power output capabilities of the upper extremities.

The statistically significant growth in the explosive strength of the lower extremities in the experimental group is in accordance with the findings of Fulton, 1992; Young et al., 1993; Beneka et al., 2005; Alcaraz, et al., 2011; Schilling, Murphy, Bonney, & Thich, 2013; Dorgo, Kin., & Rice (2009). However, it can be attributed to the relatively low initial values at the initial measuring, considering the fact that the participants themselves indicated, that while working previously with the external load, they neglected leg exercises, focusing at the same time on the strength of the upper extremities.

Numerous studies conducted so far that aimed at monitoring the changes in the explosive strength of the upper extremities, by the means of resistance training, emphasized the significant changes in this dimension (Young &Bilby,1993; Kraemer, Mazzetti, Nindl, Botshalk, Lolek, et al., 2001; Arslan, 2005; Caserotti, Aagaard, Larsen, Puggaard, 2008; Aarskog, Wisnes, Wilhelmsen, Skogen, & Bjordal, 2012).

Concerning actual study results, the starting point for the explosive strength of the upper extremities of the respondents was relatively higher, which could partially explain the lack of a statistically significant increase in strength, unlike the participants with a lower starting point, as was the casein the study conducted by Fulton (1992), where the achieved growth in the strength of the upper extremities was 25%. The same explanation goes for the study conducted by Sáez de Villarreal, Requena, Izquiredo & Gonzalez-Badillo (2013), where the respondents achieved progressof20% in the explosive strength of the upper extremities after eight weeks of exercise, due to a lower starting point before the program application.

Finally, the experimental program applied in this study was not expected to significantly affect the change in body mass, which is in line with the results of a similar study conducted by Alcaraz, Perez-Gomez, Chavarrias & Blazevich (2011) or by Willis, Slentz, Bateman, Shields, Piner et al. (2012), who concluded that the reduction in body mass is more influenced by aerobic exercise than by resistance training.

CONCLUSION

The research results have provided more accurate and comprehensive information about adaptive responses and their variations with the student population, compared to previously conducted research. The results of this study indicate that work-out intensity of an appropriate training program need to be increased in order for improvement in explosive strength results to be achieved. The obtained results will largely be used for more efficient planning and programming of the program of resistance training of the male students of the Department of Biomedical Sciences at the State University of Novi Pazar.

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EFEKTI VEŽBANJA SA OPTEREĆENJEM NA EKSPLOZIVNU SNAGU STUDENATA

Trening sa opterećenjem je veoma složen i ne može biti sproveden bez pomoći stručnjaka. Optimalne karakteristike vežbanja sa opterećenjem uključuju određene principe i norme. Glavni cilj aktuelnog istraživanja bio je da se kvantifikuje nivo eksplozivne snage i utvrde razlike u eksplozivnoj snazi gornjih i donjih ekstremiteta studenata Departmana za biomedicinske nauke Državnog Univerziteta u Novom Pazaru. Uzorak ispitanika sastojao se od 63 studenata, muškog pola,, 20±1 godina (Mean±St.Dev), podeljenih u eksperimentalnu grupu (EG, N=39), koja je sprovodila program vežbanja sa opterećenjem tokom osam nedelja i 16 sesija, i kontrolnu grupu (CG, N=24), koja nije imala posebno organizovanu fizičku aktivnost. Svaka sesija sadržala je 14 različitih vežbi sa optetrećenjem. Opterećenje je bilo u rasponu od 50 do 70% 1RM (jednoponavljajućeg maksimuma).U proceni eksplozivne snage korišćeni su testovi potisak sa klupe i čučanj. Parametri za procenu eksplozivne snage bili su: Power, Peak Power, Force i Velocity. Statistička analiza podrazumevala je osnovne deskriptivne parametre i analizu varijanse (metode ANOVA i MANOVA). Statistički značajne promene u eksplozivnoj snazi donjih ekstremiteta utvrđene su u EG (p=0.018). Nisu utvrđene statistički značajne razlike ni u EG, niti u CG.

Ključne reči: *uticaj, program vežbanja sa opterećenjem, eksplozivna snaga, studenti*