COMPARISON OF CHANGES IN THE MUSCULAR POWER POTENTIAL OF ELBOW FLEXORS AFTER A SIX-WEEK EXPERIMENTAL PROCEDURE WITH TWO GROUPS OF SUBJECTS WORKING ACCORDING TO THE STANDARD LOAD METHOD AND THE GREATEST MUSCLE LOAD METHOD

Vladimir Vuksanovikj[1] Jovan Jovanovski[1], Agon Saiti[2]
[1]University St. Cirill and Methodius, Faculty of physical education, sport and health, Skopje, Macedonia
[2]High School Zef Lush Marku, Skopje, Macedonia

Abstract:

The six-week programme for improvement of the elbow flexor muscles strength was carried out on 14 subjects, divided into two experimental groups (E1 and E2) in order to assess the potential maximal strength changes. The first group worked according to the standard method of muscle contraction – entire amplitude in the elbow. The second experimental group worked according to the method of reduced angle of muscle contractions within an amplitude of maximal extension and 30^{o} to flexion in conditions when the muscle shows greatest muscle load. Each of the subjects exercised 3 times a week, performing 3 series on the Scott bench with one-arm weight as external load and one to three repetitions in each series. The programme, according to which the trainings were carried out, was performed with individual approach. In each series, the weight with which each of subjects exercised, changed (increased) in reference with the number of repetitions in single series, but with no more than 3 repetitions.

Individual changes in each of the groups were analysed, as well as the inter-group differences for all tests. Results have shown a statistically significant increase of the maximum strength of the elbow flexor muscles of 32,1% after 3 weeks of exercises and 46,8% after six weeks of exercises in E1, and 27.9% after the third, and 43.6% after the sixth week in E2 (tested with the 1RM test). The inter-group differences tested after the third, and after the sixth week, have shown no statistically significant differences, which means that although the subjects of both groups worked with different amplitudes of muscle contractions, they have still achieved statistically identical changes in the maximal strength component of the affected muscle groups.

This individual approach method, as well as the reduced amplitudes of exercise of the maximal strength of the flexor muscles, enables a fast and efficient change of this capacity and may have an application in the field of sports, recreation or rehabilitation.

Key Words: *muscular power, flexors of elbow, 6 weeks, individual programme, short amplitude, elbow*

Introduction

The maximal strength that humans can display in the individual movements presents the capability of the humans to employ all potentials they carry within, required for the purposes of overcoming certain external loads. The purpose of this research is the maximal strength component of the muscles in conditions of full and reduced amplitudes of contractions of elbow flexor muscles.

The main question to be answered through the research realisation was whether the strength programme envisaged in the experiment shall have an impact on the improvement of the maximal strength capabilities of the treated muscles of the subjects. This is supplemented with the analysis of the exercises with modified movements (partial amplitudes) seen in the training methods of bodybuilding (Sessions[1]; Alessi[2], Szczepanik[3].,Wilson[4], Sisco[5]). The basis while exercising with such type of muscle contractions

[1] Sessions K., "Partial Training for Massive Results", www.ezinearticles.com, 2005;
[2]Alessi D., "Escalate Partial Training", www.bodybuilding.com;

lies in the theory of physiological processes of the muscle contraction (sliding filament theory), located on the level of the "sarcomere" (Ronald,1993[6], Rassier, MacIntosh, Herzog[7]). This theory explains the essence of the muscle contraction. The actomyosin filaments overlap in a different manner during the muscle contraction and in case of different angle positions of the moved elbow while performing a movement. The overlapping of the myofibril components in the sarcomere and the return into the initial position is actually the manner in which the muscle fiber contraction is carried out (Guyton 1978)[8].

Material & methods

The group of 14 subjects, who were divided in 2 experimental groups (7 subjects per group), underwent an experimental procedure for transformation of the maximal muscular power of the elbow flexor muscles in a period of 6 weeks (Ramsay et all.,1990; Moss et al.,2004; Marx, et al. 1998[9]). The strength capacity of the flexor muscles was estimated through the one-repetition maximum test 1RM performed on a Scott bench (Image No 1)

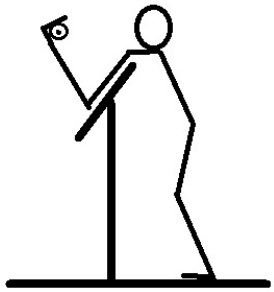

Image No 1

at the beginning, after the third week and at the end of the programme (sixth week). The main principles of the experimental procedure consisted of exercising of the subjects three times a week (Monday, Wednesday, Friday) in a period of six weeks. The exercises were performed by lifting certain weight, with one-armed weight, on a Scott bench for the elbow flexor muscles, with the non-dominant arm. The main load of the flexor muscles was 90% of the value of one-repetition maximum (1RM). Direct assessment was applied for the intensity of each training day so as to verify whether the subjects actually worked within this zone (90% of 1RM). This assessment was performed through the number of repetitions in single series. The number of repetitions in each series, throughout the experimental period was "one to no more than 3 repetitions" (Becker, 2003)[10]. The number of series for both muscle groups was limited to 3 series per single training (Fleck&Kraemer1996[11]). The break between series was limited to 3-5 minutes (Zaciorski, 1975[12]; Kukolj, 1996[13]). The subjects that would exceed this number of three repetitions would increase the external load of the weight in the next series so as to keep the principle of the number of repetitions throughout the programme (one to three repetitions) (Jovanovski 2013[14]). In that manner, continuous increase in steps was ensured for the muscle load which was always in the zone of 90% of 1RM. The groups were different in terms of the manner of performing the muscle contraction. The subjects of the E1 group performed muscle contractions with an entire amplitude in the elbow. E2 group worked according to the method of reduced amplitude when the muscle shows the greatest muscle

---

[3] Szczepanik E., "Partial Workout - Increasing your chin-up capacity",www.easychin.com;

[4] Wilson J., "Power Partials", ABC Bodybuilding Company, www.abcbodybuilding.com;

[5] Sisco Peter, "Strongest Range Partial", www.bodybuildingforyou.com;

[6] Ronald S. L., Kenneth R.D., "Matrix for muscle gain", Allen & Unwin Pty Ltd, Australia, 1993;

[7] Rassier D. E., MacIntosh B. R., and Herzog W., *Length force* ....:Vol. 86, Issue 5, 1445-1457, May 1999

[8] Guyton A.C., 1978, *Medicinska Fiziologija*, Medicinska knjiga, Beograd-Zagreb;

[9] Marx, J. O., at all, "The effect of periodization ...", *Medicine.., 30(5),* Supplement abstract 935,1998;

[10] Becker P.," Strength Training Programs", 2003,http://www.trulyhuge.com/strengthtrainingprograms.htm

[11] Fleck S.J., Kraemer W.J.,1996. Periodization beakthrough !. Advanced Research Press USA.

[12] Zaciorski V.M., 1975. *Fizicka svojstva sportiste*. Savez za fizi}ku kulturu Jugoslavije. Beograd.

[13] Kukolj M., 1996. *Opsta Antropomotorika*. Fakultet fizicke kultura-Beograd. Beograd.

[14] Јовановски Ј., 2013, Антропомоторика, Скопје

load (Zaciorski, 1975) (Верхошанский, 1977)[15] and the muscle contractions started from the maximal elbow extension up to the limit of 30º to flexion.
The subjects of both groups were tested at the beginning, after 3 weeks and the end of the sixth week of the experimental programme.

Results

Results should be presented precisely and should not contain material that is appropriate in the discussion. Units, quantities, and formulas should be expressed according to the International System (SI units). All measurements should be given in metric units.
Figures and Tables should be numbered as follows: Fig.1, Fig.2, … etc Table 1, Table 2, ….etc.

Table 1 Measures of the central and the dispersive statistical parameters for the maximum strength of the elbow flexors, estimated with the 1RMBI test for the first experimental group at the pilot, control and final testing

1RMBI	N	Mean	Median	Min	Max	S.d	Skew	Kurt	K-S	Shapiro-Wilk
initial	7	13.04	13.00	12.00	15.00	1.19	0.83	-0.69	d=.23572, p> .20	W=.84460, p<.1120
control	7	17.21	16.00	12.00	27.50	5.28	1.38	2.01	d=.19272, p> .20	W=.88983, p<.2846
final	7	19.14	20.00	15.00	25.00	3.98	0.32	-1.51	d=.21393, p> .20	W=.89253, p<.2996

Table 2 Percentage differences in the 1RMBI test for the group E1 at the pilot, control and final testing.

	% E1 group		
test	pil-con%	con-fin%	pil-fin%
1RMBI	32.1	11.2	46.8

Table 3 Analysis of the variance of values of the test for one-repetition maximum 1RMBI, for the three time periods (pilot, control, final)

Friedman ANOVA - E 1, INI-CON-FIN				
test	Chi Sqr.	N	df	p-level
1RMBI	**11.31**	**7**	**2**	**0.004**

Table 4 Wilcoxon (Post Hoc) test for the 1RMBI test

Wilcoxon Matched Pairs Test (phdv5ka.sta)				
1RMBI	N	T	Z	p-level
pilot / control	**7**	**0**	**2.20**	**0.028**
pilot / final	**7**	**0**	**2.37**	**0.018**
control / final	7	3	1.57	0.116

Table 5 Measures of the central and the dispersive statistical parameters for the maximum strength of the elbow flexors, estimated with the 1RMBI test for the second experimental group at the pilot, control and final testing

1RMBI	N	Mean	Median	Min	Max	S.d	Skew	Kurt	K-S	Shapiro-Wilk
пилот	7	13.18	13.00	12.00	15.00	1.31	0.83	-1.22	d=.26839, p> .20	W=.80049, p<.0413
контролно	7	16.86	17.50	13.00	20.00	2.12	-0.65	2.05	d=.23776, p> .20	W=.91870, p<.4769
финално	7	18.93	20.00	15.00	21.00	2.05	-1.38	1.60	d=.27082, p> .20	W=.85381, p<.1367

Table 6 Percentage differences in the 1RMBI test for the group E2 at the pilot, control and final testing.
group test

[15] Ю.Верхошанский 1977, *Основы специальнои силовои подготовки в спорте*

	% E2 group		
test	pil-con %	con-fin%	pil-fin%
1RMBI	27.9	12.3	43.6

Table 7 Analysis of the variance of values of the test for one-repetition maximum 1RMBI, for the three time periods (pilot, control, final)

Friedman ANOVA - E2, ini-con-fin				
test	Chi Sqr.	N	df	p-level
1RMBI	**12.29**	**7**	**2**	**0.002**

Table 8 Wilcoxon (Post Hoc) test for the 1RMBI test

Wilcoxon Matched Pairs Test (phdv5ka.sta)				
1RMBI	N	T	Z	p-level
pilot / control	**7**	**0**	**2.366**	**0.018**
pilot / final	**7**	**0**	**2.366**	**0.018**
control / final	7	4	1.690	0.091

Table 9 T-test for inter-group differences

T-test for independent samples					
	Mean E1	Mean E2	t-value	df	p
Initial	13.04	13.18	-0.21	12	0.83
control	17.21	16.86	0.17	12	0.87
final	19.14	18.93	0.13	12	0.90

Dicussion

At the pilot testing, the subjects of the first experimental group (E1) in the test for the maximal strength of the elbow flexors have an average achievement of 13,04 kilograms (Sd=1,19) Table No 1. In this group, the lowest lifted weight was 12 kg, and the biggest was 15 kg. At the control test (after 3 weeks) the average lifted weight (Hbar = H) is with value of H=17,21 kg (Sd=5,28) which is 32,1% (Table No 2) higher than the value noted at the pilot testing. At the final test (after 6 weeks of exercises since the programme commencement), the average lifted weight is H= 19,14 kg (Sd=3.98) which is a 46,8% higher value compared to the pilot test and 11,2% higher compared to the control test.

The analysis of the variance Table No 3 for the maximal strength of the elbow flexors for the E1 group has shown a statistically significant difference for the values of the three time periods at the level of p=0,004 (Chi Sqr.=11,31). The Post Hoc test (Table No 4) for the 1RMBI test is statistically significant (p=0,028) between the values obtained at the pilot and control testing, as well as between the pilot and the final testing (p=0.018). The maximal strength of the elbow flexors for the E1 group has no statistically significant increase in the second part of the experimental programme (from week 3 to week 6, p=0,116) although there is actual increase of the maximal strength of the subjects of 11,2% in terms of the average value of the lifted weight.

At the initial test (Table No 5) the subjects of the E2 group, while testing the maximal strength of the flexors (1RMBI) have lifted in average (as a group) H=13,18 kg (Sd=1,31 kg). After 3 weeks of exercises (Table No 6), the value for the average lifted weight value increased by 27,9% (H=16,86; Sd=2,12). This change is significant at the level of p= 0,018 (Post Hoc Test Table No 38). In the second part of the programme (3 to 6 week), although increase was noted of 12,3% of the medium value of the lifted weight for this group, this positive change is statistically not significant (p=0,091). However, by reviewing the entire period of the experimental procedure (after 6 weeks of exercises) at the relation pilot-final testing, there is positive change of the results for the medium value of the lifted weight while performing the elbow flexion (with reduced amplitudes, as performed by the E2 group) by 43,6% (Hbar= 18,93;

Sd=2,05) and this change is statistically significant p=0,018 (Table No 8).
The T-test for the inter-group differences (Table No 9, between the two groups (E1 and E2) has not shown a statistically significant difference between the obtained data.
.

Conclusions

The programming of the load intensity (in accordance with the realised programme) has enabled the occurrence of a relatively fast positive transformation of the maximal strength of the elbow flexors of the subjects performing entire amplitude of movements. A similar programme (Vuksanovikj, 2008[16]), has enabled the transformations of the maximal strength, but not with that intensity of the increase in strength (after the third week, 6,64%, after the sixth week 22,44%). Moss B. M.,(1996)[17] worked on the method of maximum repetitions and after 9 weeks of exercises has noted increase of the maximal muscle strength of the elbow flexors of 15,2%. Most probably, in this research, the increase of 32,1% after 3 weeks of exercises and 46,8% after 6 weeks of exercises for E1 and 27.9% after the third and 43.6% after the sixth week for E2, results from the individualised approach for weight modification which changes on a training-to-training basis (as explained in the programme). The continuous increase of the weight (in order to maintain the number of repetitions in a series of maximum 3 repetitions) at each training, has enabled the quality muscle stimulation, which has most probably mostly contributed to the increase of the strength capacities for the subjects of E1 group for a relatively short time and with quality positive transformation.
The realisation of the reduced amplitudes in the exercise programme of the second experimental group has made that the 6-week period has an impact on similar strength changes compared to the first experimental group, thus becoming an equivalent method of transformation of the maximum strength potential of the relevant muscles. The interpretation of that change can be supported by data from other similar studies pertaining to such training programmes with reduced operational amplitude (Vuksanović V, Jovanovski J 2010[18], Vuksanović V[19]). One can conclude from the analysis that the changes in this segment for the E1 and E2 experimental groups are not incidental, but that the same represent an effect of the realised strength experimental procedure.
As a result of the previously obtained results for the inter-group differences, it can be concluded that the subjects of both experimental groups do not differ during the experimental procedure, tested at all control points (initial, control, final). Although the subjects in each of the groups pursuant to the designed and realised programme have realised their own manner of performance of the load movements, the experimental procedure had an equal impact on the researched segments for the subjects of the three experimental groups.
This data shows that the manner in which the movements were performed in each of the groups (E1=entire amplitude; E2=amplitude in the zone when the muscle tissue is with maximum tension) was not crucial regarding the changes and achievements of the subjects in each researched segment in this paper. The most plausible key moment for the achieved results was the planned load system, designed in the exercise programmes. This load system represents an adaptation not only of the muscle but also of other functional levels (Jovanovski, 1988; Zatsiorsky&Kraemer, 2006) and the application and combination of various amplitudes of the elbow movements have shown not to be decisive for the muscle adaptation effects.

[16] Владимир Вуксановиќ, 2008., *Промени на максималниот силов.....* Магистерски труд, ФФК, Скопје
[17] Moss B. M., Refsnes P. E., at all., 1996. *Effects of maximal effort strength training*.....
[18] Vuksanovic V, Jovanovski J., P*romene maksimalne snage kod fleksora zgloba lakta posle šest nedeljnog vežbanja sa skraćenim amplitudama*, Crnogorska sportska akademija, Herceg-Novi, 2010;
[19] Vuksanovic V., *Promene maksimalnog potencijala snage na fleksore zgloba lakta posle šest nedeljnog programiranog vežbanja sa matriks metodom*, Crnogorska sportska akademija, Herceg-Novi, 2010;

References:

Alessi D., 2005. *Escalate Partial Training*, [online] www.bodybuilding.com;
Becker P.," Strength Training Programs", 2003,http://www.trulyhuge.com/strengthtrainingprograms.htm;
Вуксановиќ В, 2008., Промени на максималниот силов потенцијал на флексорите на зглобот на лакотот по шест неделно програмирано вежбање со стандардни и модифицирани репетитивни напрегања кај студентите од Факултетот за физичка култура во Скопје, *Магистерски труд, Факултет за физичка култура-Скопје, Скопје*;
Vuksanovic V, Jovanovski J., Promene maksimalne snage kod fleksora zgloba lakta posle šest nedeljnog vežbanja sa skraćenim amplitudama, *Crnogorska sportska akademija*, Herceg-Novi, 2010;
Vuksanovic V., Promene maksimalnog potencijala snage na fleksore zgloba lakta posle šest nedeljnog programiranog vežbanja sa matriks metodom, *Crnogorska sportska akademija*, Herceg-Novi, 2010;
Ю.Верхошанский 1977, *Основы специальнои силовои подготовки в спорте*;
Guyton A.C., 1978, Medicinska Fiziologija, *Medicinska knjiga*, Beograd-Zagreb;
Јовановски Ј., 2013, Антропомоторика, Скопје;
Миленковски Ј., Јовановски Ј., Стрезовски Г., Предикција на една максимална репетиција во практика.*Факултет за физичка култура*. Скопје;
Marx, J. O., et.al., 1998. The effect of periodization and volume of resistance training in women. *Medicine and Science in Sports and Exercise*. 30(5). Supplement abstract 935;
Moss B. M., Refsnes P. E., at all., 1996. Effects of maximal effort strength training with different loads on dynamic strength, cross-sectional area, load-power and load-velocity relationships., *Eur J Appl Physiol Occup Physiol.* 1997;75(3):193-9;
Rassier D. E., MacIntosh B. R., and Herzog W., Length dependence of active force production in skeletal muscle, *J \ Appl Physiol* 86:Vol. 86, Issue 5, 1445-1457, May 1999,
Ronald S. L., Kenneth R.D., 1993. Matrix for muscle gain. *Allen & Unwin Pty Ltd. Australia*;
Sessions K., 2005. Partial Training for Massive Results. [online] www.ezinearticles.com;
Sisco P., Strongest Range Partial. [online] www.bodybuildingforyou.com;
Szczepanik E., Partial Workout - Increasing your chin-up capacity. [online] www.easychin.com ;
Fleck S.J., Kraemer W.J.,1996. Periodization beakthrough !. *Advanced Research Press USA*;
Zatsiorsky V.M., Kraemer W.J., 2006. Science and practice of strength training-2and ed., *Human Kinetics*;
Zaciorski V.M., 1975. Fizicka svojstva sportiste. *Savez za fizicku kulturu Jugoslavije*. Beograd;
Wilson J., Power Partials. ABC Bodybuilding Company. [online] www.abcbodybuilding.com;

Corresponding Author
Vladimir Vuskanovikj,
Faculty of physical education, sport and health ,
Skopje
Macedonia
E-mail:vucko77@gmail.com