Ss. Cyril and Methodius University in Skopje

Faculty of Physical Education, Sport and Health

2ND INTERNATIONAL SCIENTIFIC CONFERENCE

RESEARCH IN PHYSICAL EDUCATION, SPORT AND HEALTH

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CONTENTS

CHANGES OF THE MAXIMUM STRENGTH POTENTIAL OF ELBOW FLEXORS IN 3 GROUPS OF SUBJECTS AFTER 3 WEEKS OF EXERCISES WITH MODIFIED MUSCLE CONTRACTIONS

UDC: 796.015.52.012.424-05

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Abstract:

The purpose of this study was to assess the changes in the maximal strength potential in elbow flexor muscles of the subjects, following a realised 6-week strength programme of exercises with standard and modified repetitive muscle loads.51 subjects were placed in 3 groups. The subjects have executed muscle power exercises on Scott bench for the elbow flexor muscles (m.biceps brashii; m.brachialis; m.brachioradialis) on the non-dominant arm, by using barbell weights, and movements with central support in the period of 3 weeks, with 3 sets and 5 minutes breaks in-between. The main task of each subject was to execute as many repetitions as possible until failure. The subjects in the groups have executed movements with reduced muscle contractions. The groups were differentiated in the manner (movement amplitude) of performing the non-dominant arm elbow flexion: E1-matrix method; E2 group – movement amplitude in the zone of half-flexion to maximal flexion of the elbow and vice-versa: E3 group – movement amplitude in the zone of maximal extension to half-flexion and vice-versa. Subjects were tested at the beginning and upon completion of the experiment in the tests: One maximal repetition on Scott bench (kg) (1RM), Maximal dynamometric strength in elbow under angle 90° [kg] (DMAX); Maximal repetition strength with load of 60% on Scott bench (RS60) and angle speed at elbow flexion Scott bench (1RM) rad/sec - (AGOLV). T- tests were used as statistics to track changes on level 0.05.There are significant changes in the E1 group for 1RM, of 6.64% ($p<0.01$) in the mean value. For E2, significant strength increase is noted by 4.15% ($p<0.005$), as well as for E3 by 5.67% ($p<0.01$). The dynamometrical measured static strength of the flexor muscles was not impacted by the experimental programme in a statistically important manner, although the reduction of this component is observed following the 3 weeks of exercise. For the E1 and E3 group, the angle speed test did not present any significant difference between the two tests; however, there is percentage increase of time in seconds (E1=20.94%; E3=67.49%). Whereas, for the E2 group, execution was also reduced by 45.36% against the initial value for 1RM; however with statistically significant change ($p<0.005$). Although the three groups have shown positive transformation of strength endurance in percentage terms, only the E2 group (half to maximal flexion) shows significant changes of 20.79% ($p<0.036$). Although the subjects did not execute full amplitude, there is still a positive transfer in the maximal strength of elbow flexors.Transformation methods of strength capacity were directed towards the maximal strength capacities; however, this type of exercises also impacts the endurance at manifesting muscle strength. The three weeks of exercises were sufficient for the occurrence of early transformation of the maximal strength of elbow flexor muscles.

***Key word**: muscular power, modified contractions, 1RM, dynamometric power, angular speed, training, 3 weeks*

Introduction

Each exercise process includes the process of transformation of certain type of muscle strength and, therefore, such planned transformation processes of the muscle strength are important and common for research purposes. Creation of the many types of procedures for strength transformation is based on the knowledge of the latent structure of muscle strength (D. Metikos, Gaic, 1985). In each sport discipline, the intervention in the transformation of muscle strength is specific and conditioned upon the functional role of muscles indicating the conditionally primary and secondary factors to which the manifested strength capacity has tendency. The muscle strength transformation methods (Zaciorski (1975); Jovanovski (1998); Nicin (2000); Stoiljkovic (2003)) often include exercises performing movements

with: repeated lifting of sub-maximal weight until failure; lifting of maximal weights; lifting of sub-maximal weights with maximal speed; electro-stimulation of muscles (Jovanovski, 1988); isometric training – for improvement of the static strength component (Kukolj, 1996), deviation method – single eccentric contractions (Zatsiorsky & Kraemer, 2006);

The maximal strength transformation process should be aimed towards overcoming the maximal external load. It often refers to overcoming loads which can be lifted once or twice, to be retained under an angle for one to two seconds (Jovanovski, 1989) or to work with overload (where speed is with negative indication). Within those frames, the load intensity would be above 90% of the maximum presented muscle strength Fleck & Kraemer (1996), Stoilkovik (2003), which means realisation of movement with low speed so as to present high strength, in accordance with the Hill's curve (Baechle & Earle, 2000). Regarding the maximal strength transformation, most authors recommend 1-3 repetitions in a single series (Kukolj, 1996; Zaciorski, 1975;). The 3 series of training represent an optimal number as regards the efficiency of exercises, Berger (1962), Fleck & Kraemer (1996). In order to produce load effect during the training session, breaks are recommended of more than 3 minutes between series (Fleck & Kraemer, 1996). In this manner, there is optimum time period for regeneration of all factors included in the muscle load (removal of muscle by-products, lactates and hydrogen cations of the muscles, supplementing of energy reserves, removal of fatigue of the central nervous system and repairing of the muscle tissue microtrauma). Recovery from the last training takes place in the period of 24-48 hours following the exercise unit (training) depending on the type of subjects (Fleck & Kraemer, 1996). In the first 4 to 6 weeks of training, greatest strength development can be observed, which results from the increased nerve activity, as positive stimulus (Philips,1956; Davies at all,1988, Hakkinen at all,1981).

This work uses modified (partial, incomplete) repetitive loads, and it refers to movements performed with reduced amplitudes. Movements with reduced amplitudes in a particular joint-muscle segment (Alessi, 20050) are often identified with exercises such as quarter or half squat or chest press exercises and similar. This "reduced" type of movements occurs as a variant (instinctive- comfortable) in the person performing the exercise in case of existing insufficiency for execution of the entire movement, mainly due to the imbalance of strength which is required for realisation of the entire movement amplitude (Ronald, 1993).

Materials and methods

The subject of this research was the maximal strength potential of the elbow flexor muscles on the non-dominant arm (m. biceps brachii, m. brahialis, m brachioradialis) in the subjects included in the programme.

The main objective of this research is to assess the changes of the maximal strength potential in elbow flexor muscles in the subjects, following the realised 6-week strength programme for exercises with standard and modified repetitive muscle loads.

The experimental procedure was realised on 51 subjects, male, age 18-20, non-athletes, without injuries to the locomotor system, and without undergoing a training process at least 2 months prior to the experiment commencement. Prior to the commencement of the experimental procedure, pilot test was executed on a group of 100 subjects who were tested in the maximal dynamic strength (1RM) and maximal dynamometrical strength (DMAX) tests, so as to select 51 subjects and create 3 groups of subjects. These groups were homogenised in accordance with the results in the 1RM test, thus managing to create groups without differences (in the maximal strength of elbow flexors). Groups were named as first (E1), second (E2) and third experimental group (E3), each with 17 subjects.

The difference between the groups was in the manner (movement amplitude) of execution of the flexion in the non-dominant arm elbow:

E1 group – Matrix muscle contractions:

The main load (number of repetitions for each individual subject) was divided by 3, and the produced result represented the envisaged number of repetitions in each series, for each of the three amplitudes (thirds) of movement in single series. Each of the subjects was informed that in the last third (amplitude) in each series, movements are executed until failure. Example:

Example: If the subject has executed 3 lifts of certain weight until failure (3:3=1), the realisation is as follows:

in the first third of the series (from maximal extension to half-flexed position of the elbow – angle of

90°), one repetition is executed.

in the second third of the series from half-flexion of elbow to maximal flexion, 1 repetition is executed, and

in the last third of the series execution of an entire amplitude (maximal extension to maximal flexion) of elbow, until failure.

E2 group – performed modified muscle load at which the movement amplitude was realised in the half-flexion zone up to maximal flexion of elbow, and vice-versa.

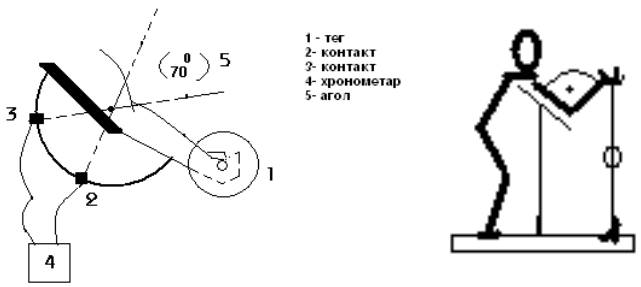
E3 group – performed modified muscle loads at which the movement amplitude was realised in the zone from maximal extension to half-flexion and vice-versa.

The work programme, regarding the load intensity and frequency, was identical for the three groups. It consisted of realisation of muscle power exercises on Scott bench for the elbow flexor muscles (m.biceps brashii; m.brachialis; m.brachioradialis) of the non-dominant arm, by using barbell weight and movements with central support. Each group, three times a week: Monday, Wednesday, Friday (Ramsay at all.,1990;, Moss at all.,2004; Marx, at all 1998) has realised its programme in the afternoon hours.

Until the experiment completion (3rd week), each subject of this group, at each training, has executed three series with such composition of movement amplitudes. There was 5 minutes break between series (Zaciorski,1975; Kukolj,1996;). The main load was 1RM tested at the pilot test. The main task of each subject was, in the E2 and E3 group, to execute as many repetitions as possible until failure. E1 group executed modification of the number of movements, in the second and third series, as a result of the number of repetitions achieved in the first series of each training.

Prior to the commencement of the experimental programme (initial test in following text) and following the 3rd week (control test), information were collected on the subjects' results of the three groups through the 4 tests assessing the following:

- One maximal repetition on Scott bench in attempt for elbow flexion, of the non-dominant arm expressed in kilograms [kg] (1RM)
- Maximal dynamometrical strength in attempt for elbow flexion of the non-dominant arm under angle of 90° expressed in kilograms [kg] (DMAX);
- Maximal repetition strength with load of 60% with weight lifting on Scott bench, expressed in number of repetitions until failure (RS60).
- Angle speed during lifting of maximal weight in one attempt for elbow flexion of the non-dominant arm on Scott bench (1RM) expressed in rad/sec - (AGOLV)



For the purposes of assessing the inter-group differences regarding the subjects' results in the applied tests between the initial, control test, a multivariate analysis of variance (MANOVA) was applied. The control of the programme effects for each individual group was executed through the t-test for each of the 4 tests.

Results

The results of the control test have indicated certain changes in values regarding the initial test. It was, to a certain extent, expected to note positive changes in the value of the 1RM test in all subjects. In the E1 group, significant positive change of 6.64% ($p<0.01$) can be observed in the mean value for the maximal strength of flexors. The situation is similar for E2, and significant strength increase is observed of 4.15% ($p<0.005$), as well as for E3 with increase of this value by 5.67% ($p<0.01$). In the domain of maximal strength, the subjects, although performing different per amplitude movements for the flexors, one can

still observe the existing parallel positive transformation of the three groups. Most probably, it refers to the successful dosage of the external load. Similar values for parallel development of the maximal strength of flexors were observed by Vuksanovic, V., & Jovanovski, J. (2010), Vuksanovikj, V., Jovanovski, J., & Acevski, A. (2015). The 1RM results, obtained for the matrix group (E1) are similar to the results presented by Redzepagikj, A. (2004). This can confirm that although full amplitude is not executed (except for E1, in one movement segment), such exercise has positive effect.

The dynamometrical measured static strength of the flexor muscles was not influenced by the experimental programme in statistically significant terms. We expect the exercises for maximal strength to have a positive effect on the static strength (Zaciorski, Verhoshanski, Gajikj, Kukolj, Peric) since the same are close in terms of structure of the muscle contraction (actomyosin function, energy engagement). The reduction of this component, after 3 weeks of exercises, is also observed for the E1 group.

Angle speed, tested at execution of 1RM, presents a good example for correction of achievements in 1RM (Jovanovski, PhD dissertation). We expected the speed to remain the same for different values of 1RM, at initial and control tests. The logic is as follows: subjects shall require the same amount of time to lift external weight at barbells, if the weight is within their capacities, for the purposes of presenting a single maximal contraction. That means that there should be no changes of the angle speed in the three groups at the end of the experimental procedure. For the E1 and E3 groups, although there are no significant differences between the two tests, there is still percentage increase of time in seconds (E1=20.94%; E3=67.49%) for execution of a single maximal repetition. Whereas, for the group E2, the execution is also reduced by 45.36% against the initial value for 1RM; however, with statistically significant change ($p<0.005$). Presented by Vuksanovic, V., Handjiski, Z., & Handjiska, E. (2014), (transformation of maximal muscle strength in elbow flexors); however, tested at isokinetic, the speed for execution of the maximal movement in flexion is reducing after 3-weeks training.

The results of the RS60 test should have presented whether the strength endurance, as strength potential of muscles showing endurance, shall be affected by the programme directed towards transformation of the maximum muscle component. Although the three groups have positive transformation of strength endurance in percentage terms, only group E2 (half to maximal flexion) has significant changes of 20.79% ($p<0.036$). One can observe positive transfer of the maximal strength as sub-component towards strength endurance (which is also strength sub-component) in the elbow flexors.

E1 group -matrix											
	initial test					final test					t-test
	Valid N	Mean	Min	Maxi	SD	Mean	Min	Maxi	SD	% ini/con	p-level
DMAX	17	28.94	20.00	50.00	7.35	27.82	16.00	46.00	6.74	-3.87	0.383
1RM	17	14.68	9.50	20.00	2.98	15.65	11.00	22.00	3.10	6.64	0.010
AGOLV	17	1.02	0.51	1.70	0.36	1.23	0.52	2.84	0.59	20.94	0.153
RS60	17	19.47	5.00	36.00	9.32	22.35	11.00	45.00	8.51	14.79	0.087

E2 group - half to maximal flexion											
	initial test					final test					t-test
	Valid N	Mean	Min	Maxi	SD	Mean	Min	Maxi	SD	% ini/con	p-level
DMAX	17	27.82	20.00	36.00	4.36	28.00	19.00	52.00	8.57	0.64	0.917
1RM	17	15.03	10.00	20.75	2.88	15.65	11.50	22.00	2.64	4.15	0.016
AGOLV	17	0.92	0.52	1.26	0.23	1.33	0.81	2.44	0.46	45.36	0.005
RS60	17	19.53	4.00	40.00	8.89	23.59	10.00	40.00	9.92	20.79	0.036

E3 group - maximal to half flexion											
	initial test					final test					t-test
	Valid N	Mean	Min	Maxi	SD	Mean	Min	Maxi	SD	% ini/con	p-level
DMAX	17	29.59	20.00	48.00	6.87	29.88	20.00	49.00	7.20	0.99	0.383
1RM	17	14.97	11.00	23,5	3.34	15.82	11.50	23.50	3.24	5.67	0.010
AGOLV	17	0.81	0,046	1,153	0.26	1.36	0.90	1.88	0.34	67.49	0.153
RS60	17	19.41	6.00	30.00	6.71	23.12	16.00	40.00	6.55	19.10	0.087

Summary of all Effects; design: INITIAL test				
Wilks'				
Lambda	Rao's R	df 1	df 2	p-level
0.881	0.739	8	90	0.657

MAIN EFFECT: INITIAL test				
	Mean sqr	Mean sqr	F(df1,2)	
	Effect	Error	2,48	p-level
DMAX	13.55	40.07	0.34	0.715
RM	0.60	9.44	0.06	0.938
AGOLV	0.18	0.08	2.16	0.126
RS60	0.06	70.30	0.00	0.999

Summary of all Effects; design: CONTROL test				
Wilks'				
Lambda	Rao's R	df 1	df 2	p-level
0.967	0.191	8	90	0.992
MAIN EFFECT: CONTROL test				
	Mean sqr	Mean sqr	F(df1,2)	
	Effect	Error	2,48	p-level
DMAX	22.14	56.92	0.39	0.680
RM	0.18	9.05	0.02	0.981
AGOLV	0.08	0.22	0.38	0.689
RS60	6.61	71.25	0.09	0.912

Conclusion

As presented by Redzepagikj, A. (2004) the 1RM results, produced for the matrix group (E1) behave similarly to the results presented in the work, which supports the conclusion that although full amplitude is not performed, one can still expect positive transfer in the maximal strength of elbow flexors.

Strength endurance is also affected by the exercises set in this experiment.

This segment has shown that although the strength capacity transformation methods have been directed towards the maximal strength capacities, this type of exercises still has an effect on the endurance in the manifestation of the muscle strength. This, most probably, refers to mechanisms to be included so as to enable the base to be upgraded also for maximal strength (MacIntosh B.R., Gardiner P.F., McComas A.J., 2006,).

The three weeks of exercises were sufficient for occurrence of early transformation of the maximal strength of elbow flexor muscles, thus confirming the recommendation of Zaciorski V.M., 1975 and Zatsiorsky V.M., Kraemer W.J., 2006 similar as Vuksanovikj, V., 2012

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