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(Original scientific paper)

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Abstract

The aim of this research are anthropometrical measurement of the forearm and upper arm of the respondents included in the research and their possible changes as result of training whose purpose is to transform the maximal muscle strength. Material and methods: A prospective study was realized on a group of 7 respondents, which included experimental program for transformation of the maximal strength of the elbow flexors and extensors. The training program was intended for transformation of the maximal muscle strength for the muscles flexors (exercise of Scots bench) and the muscles extensors (triceps push down). The experimental training was conducted in a period of six weeks, three times in week, within 1-3 repetitions, till failure. The following seven anthropometrical measurements were measured: forearm skin-fold and subcutaneous fat, upper arm skin-fold and subcutaneous fat, forearm circumference relaxed, upper arm circumference relaxed, forearm circumference contracted, upper arm circumference contracted, upper arm circumference in contacted extensor in height of m. triceps brachii. The respondents were tested at the beginning, after 3 weeks, and in the end of the sixth week of the experimental program. The following parameters were calculated using Friedman ANOVA. Results: After 3 weeks of exercise following the program, significant changes were observed in the measures of: upper arm skin-fold and subcutaneous fat -28, 9%, forearm circumference relaxed 4,3%, upper arm circumference relaxed 2,7%, forearm circumference contacted 5,6% and upper arm circumference contracted 7%. After the six weeks of exercising, the following changes of the measurements were noticed: upper arm skin-fold and subcutaneous fat -15,3%, forearm circumference relaxed 7,5%, upper arm circumference relaxed 5,1%, forearm circumference relaxed -2,5% and upper arm circumference contracted 2,5%. In the second half of the experimental program the following changes in the measurements were observed: upper arm skin-fold and subcutaneous fat of 19,2%, forearm circumference relaxed 3%, forearm circumference contracted -7,7%, upper arm circumference contracted -4,3%, and m. triceps brachii height circumference of the upper arm contracted -5,5%. Conclusion: The type of the workout that was given to the respondents was in high intensity. Regarding this kind of program, the following changes of the anthropometrical measurements are not corresponding with the previous research results (Ozmun et al., 1994; Ramsay et al., 1990 and Fleck&Kraemer, 1996). Lifting weight with maximal external load causes certain physiological processes, (CNS mechanisms are not crucial), so, the tissues respond with adaptation and changes of the anthropometric measurements. The turbulence of anthropometric measurements, during the 6 weeks of the experimental program, indicates the need of detail analysis for body composition of the body parts that are included in the exercising programs.

Key words: anthropometry, 1 RM, strength, elbow, experimental training

Introduction

The relations between the strength and anthropometric indicators are evident and objective (Vuksanovikj et al., 2013). Although the purpose of the experimental training program is to transform the maximum strength capacity, most of the authors point to the increase of the indicators of one maximal repetition independent of the anthropometrical indicators for circumference and the fat tissue (Fleck S.J., Kraemer W.J.,1996), which means that there are not significant changes in the field of anthropometry. These dilemmas for the relation of the strength capacity and the anthropometric indicators depend on the types of the training programs which are given, and which are directly related with the manner of dosing the training (intensity of external load, amount of work, weekly repetition, regime of loading, way of performing movements etc.).

This research is analyzing the anthropometric changes in the respondents who are on a six week experimental strength program aiming to increase their maximal strength. Maximal strength can be defined as the strength which a person can exhibit in individual movements and is ability of a person to recruit all the potentials he/she has to overcome an external load. (Jovanovski, 1988)

The assessment of the maximal strength capacity of the muscles is most often performed with a motoric test in which the person has to overcome external load of one repetition maximum - 1 RM (Milenovski et al.,). In practice, the dosage of the external load is most commonly done using the indicators of the maximal strength of the individual. (Zatsiorsky&Kraemer, 2006).

Work program

The research is conducted on 7 respondents, students at the Faculty of Physical Education in Skopje. The assignment of the respondents was to exercise a program which had the purpose to increase the maximal muscle strength of the flexors and extensors of the elbow joint of their non-dominant hand. The duration of the experimental procedure was 6 weeks (Ramsay et al.,1990; Moss et al.,2004; Marx, et al 1998). The respondents were exercising by performing muscle contractions on Scots bench with one-handed dumbbell, 3 times a week, 3 series per training (Fleck&Kraemer1996). The intensity of the overload was given in percentage and it was 90% of the indicator of the test of one repetition maximum 1PM. The exercising program was with individual approach for all the respondents, and consequently the intensity of the load was variable from "set to set" in the course of one workout. (Jovanovski 2013). The imperative for each respondent was to lift heavy enough dumbbell for the flexors and to push the weight (down) with the "triceps" machine for the muscles extensors, not more than 3 repetitions in one set (Becker,2003). In that manner a cascade increase of the muscle load was achieved and every time the load was within the limits of 90% of 1RM. The rest between the sets was limited between 3 to 5 minutes (Zaciorski,1975; Kukolj,1996).

The respondents were tested at the beginning of the study, after 3 weeks, and at the end of the sixth week of the experimental program. Each respondent encompassed by the experimental procedure was measured the skin- fold with subcutaneous fat as well as the circumferences of the forearm and upper arm of the non-dominant hand tested as per Kurelic, N et al., 1975.

- Forearm skin-fold and subcutaneous fat - ADPOD [mm];
- Upper arm skin-fold and subcutaneous fat - ADNAD [mm];
- Forearm circumference relaxed- AORPOD [mm];
- Upper arm circumference relaxed- AORNAD [mm];
- Forearm circumference contracted- AOKPOD [mm]; (Toteva M., Slnchev, 1990);
- Upper arm circumference contracted- AOKBI [mm] (Papo-Petrovski, V., 1997)
- Upper arm circumference with contracted extensor in height of m. triceps brachii- AOKTRI [mm] (The circumference of the upper arm contracted extensor, in height of the m. triceps brachii (the hand tightly clenched into a fist).The measuring tape is put around the forearm in a height of the largest circumference.

Results and Discussion

The experimental test proved influence on the anthropometric status and on the measurements which were performed on the respondents. In relaxed muscle of the tested arm significant changes were observed on the circumference of the forearm (AORPOD) on the level of $p=0,002$. At the initial testing the average value on this test was $X=24,97$. At the control and final testing this value increased for 4,3% and 3% (7,5% after 6 weeks of exercising). The post-hoc tests are also significant in all three relations, which shows that

positive changes occurred (statistically significant) on the average circumference of the forearm after the third and sixth week of exercising. Also, it should be noted that there is a positive transformation of the maximal muscle strength of 32,1% after the 3rd week of exercising and 46,8% after the 6th week of the exercising. (Vuksanovikj V, Jovanovski J, Saiti A, 2014)

Table No. 1 Measurements of the central and dispersive statistical parameters of the anthropometrical measurements for the initial, control and the final testing

ADPOD	N	Mean	Median	Min	Max	S.d	Skew	Kurt	K-S	Shapiro-Wilk
initial	7	8.91	9.70	4.50	12.10	2.96	-0.49	-1.34	d=.17625, p> .20	W=.91841, p<.4746
control	7	6.93	7.20	3.80	9.30	1.76	-0.75	1.04	d=.25314, p> .20	W=.94539, p<.7039
final	7	6.11	5.90	3.90	8.20	1.61	0.09	-1.49	d=.16385, p> .20	W=.94292, p<.6821
ADNAD	N	Mean	Median	Min	Max	S.d	Skew	Kurt	K-S	Shapiro-Wilk
initial	7	14.66	14.80	8.20	21.30	4.30	-0.09	0.11	d=.21827, p> .20	W=.96441, p<.8622
control	7	10.41	10.50	5.30	15.10	2.85	-0.31	2.82	d=.29941, p> .20	W=.86921, p<.1888
final	7	12.41	13.60	6.40	16.90	3.80	-0.52	-1.04	d=.19406, p> .20	W=.93402, p<.6040
AORPOD	N	Mean	Median	Min	Max	S.d	Skew	Kurt	K-S	Shapiro-Wilk
initial	7	24.97	25.30	22.80	26.70	1.48	-0.44	-1.08	d=.16820, p> .20	W=.92009, p<.4878
control	7	26.06	26.70	23.70	27.70	1.50	-0.95	-0.69	d=.30469, p> .20	W=.83871, p<.0984
final	7	26.84	27.40	23.60	28.30	1.69	-1.43	1.55	d=.27475, p> .20	W=.84286, p<.1078
AORNAD	N	Mean	Median	Min	Max	S.d	Skew	Kurt	K-S	Shapiro-Wilk
initial	7	29.23	29.50	26.40	31.50	1.62	-0.52	0.91	d=.16193, p> .20	W=.97072, p<.9061
control	7	30.01	29.90	27.50	33.10	1.72	0.60	1.67	d=.24079, p> .20	W=.94146, p<.6692
final	7	30.71	31.30	26.70	32.80	1.92	-1.80	4.17	d=.27339, p> .20	W=.80829, p<.0495
AOKPOD	N	Mean	Median	Min	Max	S.d	Skew	Kurt	K-S	Shapiro-Wilk
initial	7	26.56	27.00	24.00	28.10	1.60	-0.90	-0.77	d=.24984, p> .20	W=.86536, p<.1744
control	7	28.04	28.20	25.70	30.40	1.65	-0.21	-0.63	d=.20390, p> .20	W=.95288, p<.7691
final	7	25.89	26.40	23.30	27.70	1.66	-0.84	-0.84	d=.24175, p> .20	W=.88377, p<.2530
AOKBI	N	Mean	Median	Min	Max	S.d	Skew	Kurt	K-S	Shapiro-Wilk
initial	7	30.74	30.60	28.40	32.90	1.57	0.08	-0.59	d=.15445, p> .20	W=.95844, p<.8156
control	7	32.90	32.70	30.00	34.80	1.66	-0.65	0.35	d=.17179, p> .20	W=.93746, p<.6340
final	7	31.50	31.40	28.20	34.30	1.95	-0.34	0.70	d=.17900, p> .20	W=.97904, p<.9528
AOKTRI	N	Mean	Median	Min	Max	S.d	Skew	Kurt	K-S	Shapiro-Wilk
initial	7	29.90	29.30	27.40	33.10	2.02	0.75	-0.49	d=.29277, p> .20	W=.89589, p<.3192
control	7	30.99	30.60	29.00	33.00	1.38	0.06	-0.87	d=.18149, p> .20	W=.96705, p<.8814
final	7	29.29	29.10	27.50	31.80	1.28	1.13	3.32	d=.29066, p> .20	W=.85439, p<.1384

Table No.2 Percentage differences in the anthropometric measurements between the initial, control and final testing

test	all measures		
	ini-con %	con-fin%	ini-fin%
ADPOD	-22.3	-11.8	-31.4
ADNAD	-28.9	19.2	-15.3
AORPOD	4.3	3.0	7.5
AORNAD	2.7	2.3	5.1
AOKPOD	5.6	-7.7	-2.5
AOKBI	7.0	-4.3	2.5
AOKTRI	3.6	-5.5	-2.1

The upper arm circumferences in relax condition (AORNAD) of the respondents had changed in positive direction which is statistically significant on the level of p=0.0004. After the third week, the result for average value X=29,23 (Sd=1.62 table no.1) was increased for 2,7%. After the sixth week of exercise this result is increased for 5,1%. The post-hoc tests were statistically significant for both changes. There were no significant changes from the third week until the end of the program. Also, knowing that the point where the variable AORNAD is measured is in the height were the muscle of the frontal side of the upper arm

are mostly used, can lead to conclusion that the following changes of this variable are based on the changes of the frontal side of the upper arm muscles.

While measuring the contracted muscles on the frontal and dorsal side of the upper arm, significant changes in level of $p=0,02$ (AOKBI initially: $X=30,74$; $Sd=1,57$) and $p=0,028$ (AOKTRI initially: $X=29,9$; $Sd=2,02$) are observed. During contraction of the upper arm in flexion a significant positive change of 7% is noticed in the first part of the program. In the second part of the program (3-6 week) this number is beginning to decrease for 4,3% (significant for level $p=0,018$, post-hoc test). After six weeks of exercise, the change of 2,5% compared to the initial state in respondents, speaks that the program has a significant influence ($p=0,028$) on increasing the volume of the muscles on the front side of the upper arm. The muscles on the dorsal side of the upper arm (during a contraction) decreased in circumference for 5,5% on the spot of measurement, which occurred in the second part of the program ($p=0,018$).

Significant changes are also observed in the muscles of the forearm. The forearm circumference in relaxed condition (AORPOD) is significantly increased, at a level of $p=0,02$. This positive changes are in the three points of time (initial-control=4.3%; control-final=3%; initial-final=7,5%). In the state of contraction, the change of the circumference of the forearm (AOKPOD) is statistically significant (at level of $p=0,1$, in positive direction for 5,6% after the third week of exercise). However, in the second part of the program, the circumference of the forearm in contracted condition is decreased for 7,7%.

The skin-folds measured in the respondents also showed that the program had influence on their decrease. In the fold of the forearm (ADPOD), although there is a reduction expressed in percentages from the mean values, still these results are not significantly different. However, in the fold of upper arm (ADNAD), there is a statistically significant difference at level of $p=0,02$. Post-hoc testing showed about 22,3% decrease in the third week, 11,8% decrease from third until the sixth week, and 31,4% decrease (after six weeks exercise compared to the initial condition) which is statistically significant.

Discussion

As a result of treatment on two deferent muscle groups of the non-dominant hand, at the very beginning of the research, a need of anthropometrical following of the eventual changes at both muscle groups was evident. The anthropometrical measurement of the volume of the forearm is a measurement of which most of the obtained result is due to involving the muscles of the front side of the upper arm i.e. the flexors. Because of that, the interpretation of measurement AORNAD and AOKBI are mainly related to the changes of the muscles of the front side of the elbow. For testing the anthropometrical changes on the muscles on the dorsal side of the elbow a spot which was in height of the muscle triceps brachii was used. Anatomically, this muscle is placed in the above parts of the upper arm related to the muscles of the front side. Therefore, this muscle was included through this anthropometrical testing. So, the anthropometrical measurement AOKTRI (which is testing the volume of the upper arm in height of contracted triceps brachii) is measurement which arose from this research, (there cannot be found anthropometrical measure which can divide the assessment of the possible changes of the frontal and dorsal side of the upper arm muscle) and it is used for analyzing the possible changes in the muscles on dorsal side of the upper arm, for the needs of this research.

The changes in the forearm circumference (in first 3 weeks) may be due to the systematic activation of the strength capacity of the forearm muscles which during the exercise provide strong contraction isometric conditions, since the hand either holds the dumbbell or is fixed on the bar while pulling the triceps machine, although in the second part (3-6 week) a decrease of the circumference is noticed. Decreasing of the the skin-folds is probably achieved as a result from the systematic muscle contractions on which the respondents were exposed during the experimental procedure, which occurs as a result from using the local adipose tissue in addition of the exercise. The pending question on the segment in the muscle (sarcooplasmic or myofibril segment) in which these changes occurred, cannot be answered in this research, since there were no relevant instruments used to determine the type of change. According to the results, in the respondents, the frontal part of the arm gained in muscle mass, while the muscles of the dorsal part of the arm decreased in muscle mass.

Conclusion

The researches from similar character, that had analyzed realization of the strength program of the elbow muscles, were not available for the authors. The assumption if there are changes happening in the body composition of the included experiment proved to be true. From this research it can be concluded that this

program has impact on changing the anthropometrical measurements of the forearm and upper arm. Mostly, other researches of this kind of methodical procedures for increasing the muscle strength, are not followed with changing of the anthropometrical measurements (Ozmun et al,1994; Ramsay et al., 1990; Fleck&Kraemer,1996). This kind of changes can be subject of some future study, which will include better analyses, with main purpose to explain the physiological mechanisms that make this turbulence of the body composition, during the strength exercise with maximal capacity.

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