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THE EFFECTS OF RESISTANCE EXERCISES ON MUSCLE STRENGTH IN THE RECREATION OF WOMEN

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Abstract. *The aim of this research is to study the effects of resistance training on muscle strength in the recreational training of women. The sample of examinees used consisted of 45 women ages 40 through 50. The examinees were divided into three groups (two experimental groups and one control group), each numbering 15 women. The first experimental group trained two times a week. The intensity of the training was 75% of 1RM. Each exercise was repeated eight times over three sets with a two-minute break between sets. The second experimental group trained three times a week. The intensity of the training was also 75% of 1RM. Each exercise was repeated ten times, but only within one set. The experiment lasted for four months. The program included in the experiment consisted of the following exercises: the bench press, the lat pulldown, the biceps curl, the triceps extension, the leg press, the leg curl, the leg extension and the squat. The effect of the training was studied by changing the extent of the resistance over a period of two experimental micro cycles. The examinees of the control group did not train using resistance exercises. All groups were tested prior to and after the experiment by means of the following tests: the bench press 1RM and the leg extension 1RM. The data was analyzed using a variance analysis (MANOVA/ANOVA and the MANCOVA/ANCOVA) and the student's T-test. In the case of the first and second experimental group, a significant increase in strength was found at the final measuring. In the process of analyzing the data on the multivariate and univariate level for the E1 and E2 groups, a statistically relevant difference for the bench press 1RM and the leg extension 1RM was found. The findings of the research and the discussion show that the exercise program with a 75% of 1RM intensity, a wider extent and with two training sessions a week, had a better effect on the development of muscle strength, compared with the program of the other experimental group that trained with the same intensity, three times a week but with a lesser extent of resistance.*

Key words: *the recreation of women, muscle strength, resistance exercises, a weekly micro cycle*

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1. INTRODUCTION

The problems involved in the muscle strength training of adults, carried out in recreational form, differ from the training of athletes. Special attention is paid to the problems involving the selection of exercises, determining the proper intensity and extent of the resistance and, therefore, the characteristics of the training micro cycle.

The data found in any available research on the muscle strength of adult men and women points to various approaches to determining the training program which would have the best effects on muscle strength in the recreation of adults, especially women. The decrease in muscle strength in adults is related to the reduction of muscle tissue. The overall muscle mass decreases with age. People over thirty should devote a part of their free time for the resistance exercises used in strength training.

The decrease in muscle strength between the ages of 20 and 75 is around 30%. A man of 50 will have lost 1/3 of his muscle mass after his twentieth year of life (Rogers and Evans (1993).

When it comes to older men and women, resistance training has several significant effects. Strength training, besides having an effect on the overall muscle mass and muscle strength, is an important factor in the preservation of any existing bone mineral density, as well as in aiding the increase of bone mineral content.

The use of resistance training in the exercise of older people has confirmed an increase in muscle hypertrophy and muscle strength (Charette, McEvoy, & Pyka et al. (1991), Hurley, Redmou, Pratley, Treuth, Rogers and Goldberg (1995), McCartney, Hicks, Martin and Webber (1995), Pyka, Lindenberger, Charette and Marcus (1994)).

Ben Sira, Ayalon, and Tavi (1995) compared the effects of four types of resistance training on the concentric strength and thigh girth of young women. Four experimental groups were formed which trained using special training models: only the concentric model (group E1, 12 examinees), only the eccentric model (group E2, 10 examinees), the conventional model (group E3, 8 examinees), and the supramaximal eccentric model (group E4, 8 examinees). A control group was also formed, which did not train and which numbered 10 examinees. The subjects trained on a knee extension Schnell machine twice weekly for eight weeks, performing three sets of 10 reps with a starting load of 65% of 1RM. Each week the load was increased by 5% of the initially determined amount for each of the examinees. ANCOVA indicated that the E4 and E1 groups improved significantly in relative (1 RM/body weight) dynamic strength when compared with initial strength levels. Similar, though not statistically significant trends were observed for the E1 and E2 groups. However, none of the differences among the four training groups were significant. There was no change in thigh girth in any of the training groups.

The study of the effects of resistance training is often connected with not only the increase in muscle strength but also with the improvement of functional abilities. The conclusion was drawn that a resistance program of moderate intensity has positive effects on the everyday functioning of older individuals, including women (Nichols, Hitzelberger, Sherman, and Patterson, 1995).

The research in which older men and women do exercises of decreased intensity as part of their training, showed that the increase in muscle strength was quite small (Aniansson and Gustavsson (1981) and Bevier, Wiswell, Pyka, Kozak, Newhall and Marcus (1989)).

In order for the training of both younger and older individuals to bring about an increase in muscle power, it is necessary that it involve progressive resistance, but that the

intensity of the exercises be around 80% of 1RM (Fiatarone, O Neill, Ryan, Clements, Solares, Nelson, et al. (1994).

There are people of the opinion that the intensity could even be 70-80% of 1RM.

Rhodes, Martin, Taunton, Donnelly, Warren and Elliot (2000) worked on determining the effects of progressive resistance training on the dynamic strength of muscles and its relation to bone mineral density in women. The sample of examinees was made up of 44 women, all around 68 years of age, who were divided into an experimental and control group. The experimental group trained three times a week for one hour, for 52 weeks, with an intensity of 75% of 1RM, all the while focusing on the large muscle groups. Bone mineral density was measured by dual energy X ray absoptiometry (Lunar DPX) at the lumbar spine and at three sites in the proximal femur. The statistical analysis (the analysis of covariance) found a change in power after 52 weeks of training and the muscle increases may parallel changes in bone mineral density; however, the correlation coefficients were moderate.

Rhodes et al. (2000) cited the research of Ryan, Hunter et al. where the effects of resistance training on the strength and mineral density of bones in women in menopause were studied. They found a 36%-65% increase in strength in the upper extremities and a 32%-98% increase in the lower extremities.

Morganati, Nelson, Fiatarone et al. (1995) researched the effects of resistance training on a sample of women aged around 60. They formed both an experimental and a control group. The experimental group trained twice a week for one year. After 12 months, the results indicated a strength increase of 18% to 77% of 1RM in the lateral pull down, the knee extension and the double leg press.

Nicholas et al. after the work of Rhodes et al. (2000) trained women who were in their postmenopausal period over a period of twenty-four weeks, by using three sets of exercises with 8 repetitions of each exercise, and an intensity of 80% of 1RM. The experimental program included seven exercises. After four weeks the results indicated an increase in strength.

In their critique of 13 studies (among other things), Fleck and Kraemer (1997) presented various forms of isotonic resistance training which proved that for a certain exercise program to be successful, it was not only the intensity of the exercises, the duration or the number of repetitions that was relevant, but the very way in which the testing was carried out. They presented research related to the evaluation of strength using the bench press. When the examinees were, after completing a certain exercise program, tested using the equipment they used in training, the increase in strength on the bench press was 23%. When the same examinees were tested using a special isotonic ergonometer, the increase in strength was less, only 16,5%.

The subject matter of this research are the effects of resistance exercises on a sample of women aged 40 through 50, when the number of training sessions and the extent of training over a weekly micro cycle is changed.

The main goal is to determine, by means of an experiment, the effects of two types of weekly recreational resistance training cycles on the increase of muscle strength.

The main supposition of the research involving the effect of increased muscle strength is that for women aged 40 through 50, who train with the same intensity (75% of 1RM), a weekly micro cycle of two training sessions with an increased extent of resistance would be more suitable than a weekly micro cycle consisting of three training sessions, but with a lesser extent.

2. METHODS

The Sample of Examinees

The research was carried out on a sample of 45 examinees aged 40-50, who prior to the experiment were members of fitness clubs and occasionally, for recreational purposes, trained using resistance exercises. All the examinees of the experimental group agreed to participate in the experiment. Prior to the start of the experiment, the examinees that had some chronic disorder of the cardiovascular system or any joint disorders were excluded. All measurings and training sessions were carried out in fitness clubs in Niš and Vrnjačka Banja.

The Variable Sample

The maximum strength of the examinees was determined by two tests: the bench press and the leg extension.

A description of the test: **The Bench Press**

The necessary testing equipment: the bench press bench, barbell and weights of 25, 15, 10, 5, 2,5 and 1,25 kg.

The procedure: the necessary preparation for this test includes lifting a progressive submaximal load. The examinee lies on her back with her knees bent at an angle of 90 degrees and with her feet on the bench. She should then push the pole upwards, vertically, while extending her elbows. The resistance should be increased progressively, from 2,5 to 5 kg. The break between attempts should last between 3-5 minutes, up until the examinee has finished the lifting. The last lift is what constitutes 1RM (Young and Bilby, 1993).

A description of the test: **The Leg Extension**

Equipment: a leg extension machine.

The procedure: the examinee should sit and take hold of the handlebars. Knees should be level with the hips. The ankles should be placed beneath the Roller pad. The back should be straight and propped. The examinee should straighten her legs at the knees and raise her feet until the knees are fully extended. The preparation consists of raising the submaximal progressive load. A breath should be taken with every extension. The last lift constitutes 1RM.

A description of the exercise program

All the examinees were divided into three groups, two of which were experimental and one which was the control group. Each group numbered 15 women.

The first experimental group (E1) trained following the specified resistance exercise program twice a week, with three sets per training session which consisted of eight reps of each exercise. The break between sets lasted for two minutes.

The second experimental group (E2) trained following the specified resistance exercise program three times a week, with each session consisting of one set with ten reps of each exercise.

The experiment lasted for four months, so that the first experimental group had 32 training sessions overall, and the second experimental group had 48 training sessions.

After the initial measuring, the examinees of the control group were asked not to train using resistance exercises during the course of the experiment.

The structure of the training sessions: ten minutes of aerobic exercise (speed walking in place, jogging in place, riding a stationary bicicyle, various jumps, combinations of various stretches with the aim of aerobic activation or group exercise to music of the same duration), and around 10 minutes of various stretching exercises with the aim of preparing the joints for resistance exercises. The main part of the training session lasted around 30 minutes and included the resistance exercises, which in the end, was followed by 5-10 minutes of exercises aimed at stretching the upper and lower extremities.

The following exercises were included: the bench press, the lat pulldown, the biceps curl, the triceps extension, the leg press, the leg curl, the leg extension, and the squat. The exercise intensity was 75% of 1RM. After six to eight training sessions the resistance was increased in accordance with the progress of every individual examinee, but the intensity remained at 75% of 1RM. The progress of each examinee was closely monitored and noted. The complete concentric phase of each exercise should have been performed in two seconds, and the eccentric phase in four seconds.

The experimental program and the testing were carried out by professional fitness trainers who had previously been familiarized with the aim of the research.

Methods of Data Analysis

For the purpose of calculating the multivariate statistical significance of the differences between the groups at the initial and the final measuring, a multivariate analysis was used (MANOVA), and at the univariate level, the ANOVA (testing the relation between the variability of the results between the groups and the variability within the groups) was used. In order to determine the multivariate statistical significance of the differences between the experimental groups and the control group at the final measuring, the multivariate covariance analysis (MANCOVA) was used, and at the univariate level, the ANCOVA analysis was used (on the basis of the adjusted means of the individual groups in relation to their common means).

The testing of the nul-hypothesis (that the centroids of the groups are equal to their common centroid) was carried out by means of the WILK'S Lambda test. The obtained relation was tested by means of the Rao-vom F approximation, including the appropriate degree of freedom (df for the F relation). When the WILK'S Lambda and the F coefficients are significant, it points to the existence of statistically significant differences between the groups' centroids (the means of the groups).

At the univariate level, the coefficients of the F-test were calculated, along with its significance (p) and the degree of freedom (df1 and df2).

The testing of the significance of the differences between the means was carried out by calculating the T-test and its significance (p).

The means (Mean), standard deviation (SD), the increase in the means given in percentiles (Increase %) were all calculated.

3. RESEARCH RESULTS

Tables 1, 3 and 5 show the results at the multivariate level, where we find the WILK'S Lambda, Rao's R (F), df (the degree of freedom) and p (the significance at the multivariate level) coefficients. Tables 1 and 3 show the results of the MANOVA analysis, and Table 5 shows the results of the MANCOVA analysis.

Tables 2 and 4 show the results of the ANOVA analysis, while Table 6 shows the results of the ANCOVA analysis.

Table 7 shows the values of the T-test for both experimental groups and the control group along with a comparison of the initial and final measurings. The percentage (%) of the increase was calculated separately for both the experimental groups and the control group.

Table 1. The coefficients in the MANOVA analysis among the groups at the initial measuring

Groups	WILK'S Lambda	Rao's R (F)	df1	df2	p
E_1 and E_2	.296	32.04	2	27	.000
E_1 and K	.336	12.49	8	138	.000
E_2 and K	.446	10.19	4	82	.000

Table 2. The univariate difference among the groups at the initial measuring

Groups	Test	ANOVA			
		df1	df2	F	p
E1 and K	Bench press	4	70	2.70	.03
	Leg extens.	4	70	31.86	.000
E2 and K	Bench press	2	42	9.98	.000
	Leg extens.	2	42	18.93	.000
E1 and E2	Bench press	2	42	2.33	.109
	Leg extens.	2	42	56.55	.000

There is no statistically significant difference in the bench press variable at the initial measuring between the E1 and E2 group, as well as the control group (Table 2).

A statistically significant difference does exist between the E1 and E2 group in the leg extension variable at the initial measuring (Table 2).

Table 3. The coefficients for the MANOVA analysis between the initial and final measuring

Groups	WILK'S Lambda	Rao's R (F)	df1	df2	p
E1	.264	19.35	4	82	.000
E2	.349	25.17	2	27	.000
K	.963	.51	2	27	.602

There is a statistically relevant difference between the initial and final measuring of the E1 and E2 groups even when both variables are taken into consideration (Table 4).

Table 4. The univariate difference between the initial and final measuring of the individual groups

Group	Test	Initial measuring		Final measuring		ANOVA			
		Mean	SD	Mean	SD	df1	df2	F	p
E1	Bench press	27.50	1.64	31.00	1.93	1	28	10.30	.000
	Leg extens.	43.50	2.01	51.00	2.91	1	28	65.71	.000
E2	Bench press	27.50	2.15	31.00	2.29	1	28	18.63	.000
	Leg extens.	42.50	2.33	47.50	2.14	1	28	39.37	.000
K	Bench press	28.50	2.48	28.50	2.11	1	28	.290	.594
	Leg extens.	44.50	2.47	43.50	2.33	1	28	.519	.477

Table 5. The coeffients of the MANCOVA between the groups at the final measuring

Groups	WILK'S Lambda	Rao's R (F)	df1	df2	p
E_1 and E_2	.268	19.05	4	82	.000
E_1 and K	.319	13.26	8	138	.000
E_2 and K	.542	7.34	4	82	.000

Table 6. Coefficients of the ANCOVA analysis among the groups at the final measuring

Groups	Test	ANCOVA			
		df1	df2	F	p
E1 and E2	Bench press	2	42	13.54	.000
	Leg extens.	2	42	44.67	.000
E1 and K	Bench press	4	70	9.51	.000
	Leg extens.	4	70	30.25	.000
E2 and K	Bench press	2	42	7.34	.002
	Leg extens.	2	42	12.23	.000

There is a statistically significant difference between the E1 and E2 group at the final measuring when both variables are taken into consideration (Table 6).

A statistically significant difference exists between the E1 group and the control group at the final measuring, as between the E2 group and the control group at the final measuring (Table 6).

There is no statistically significant difference between the initial and final measuring of the control group at the multivariate level (Table 3), so the effect of the individual variables on the overall difference need not be discussed.

Table 7 shows the coefficients of the T-test, their significance (p) and the increase in strength at the final measuring of all groups, given in percentiles.

Table 7. The increase and the values of the T-test.

Groups	Variables	Increase	T- test	P
Experimental 1 initial and final	Bench press	13%	-5.73	.000
Experimental 1 initial and final	Leg extens.	15%	-8.15	.000
Experimental 2 initial and final	Bench press	11%	-4.31	.000
Experimental 2 initial and final	Leg extens.	11%	-6.27	.000
Control initial and final	Bench press	2%	-.53	.59
Control initial and final	Leg extens.	-2%	.72	.47

4. DISCUSSION

Considering the importance of strength to people of all ages and either sex, the research related to the problem of strength increase holds a special place in past and current research trends. There exists a great amount of research where the samples consisted of men and women over 30. All the results show that organized and systematic recreational training always has a positive effect on the development of muscle strength.

Within the research carried out on the effects of certain programs relying on exercises used for the increase of strength, what is emphasized, mainly, is the strength increase given in percentiles. Nevertheless, it is difficult to find matching research which we could compare the results of our research to. Resistance exercise programs which are used in research, generally speaking, differ in duration, intensity and content. The samples on which the programs are carried out differ in age, sex and number. Quite often even the ways of testing differ. As a result of all this, the percentages of the increase in strength differ, but are almost always positive and statistically significant.

In the research of the effects of resistance training on a sample of older men and women, Pyka, Lindenberger, Charette and Marcus (1994) carried out an experiment over a period of four months. The examinees trained three times a week, performing three sets of exercises with eight reps each. The intensity of the exercises ranged between 65% and 75% of 1RM. The authors state that the strength increase during the first eight weeks reached three quarters of the overall increase for the whole training period.

Braith, Graves, Pollock, Leggett, Carpenter and Colvin (1989) compared the effects of resistance training on two experimental groups. The examines of one experimental group trained using a specific program twice a week, and the examinees of the other experimental group trained three times a week, over a period of 10 and 18 weeks. The results showed that better results on the leg press test are achieved if there are three training sessions a week.

The research that is comparable to ours to a large extent appears to be the research of Schlumberger, Stec and Schmidtbleicher (2001). They compared the effects of single set and multiple set resistance training on a sample of 27 women with training experience, ages between 20 and 40, who were divided into two experimental groups and one control group. The first experimental group trained twice a week, performing only one set, while the other trained twice a week, performing three sets with a break of two minutes between sets. Each exercise was repeated six to nine times. Two tests were used: the bilateral leg extension of 1RM and the seated bench press of 1RM. The experiment lasted for six weeks. Both training groups achieved a significant increase in strength which was measured using the bilateral leg extension test (single set group 6%, multiple-set group 15%) and the seated bench press test (multiple-set group 10%). The authors concluded that the superior resistance training for strength increase was the one involving three sets performed twice a week, rather than the one involving one set performed twice a week.

The results of our research point to and emphasize the fact that the experimental program used on the two experimental groups was beneficial to the development of maximum strength and that it had, as its result, concrete percentages of increase (Table 7). The control group offered an interesting piece of information regarding positive and negative increase which could be the result of the activation or non-activation of the examinees during the experiment. The values of the T-test and the MANOVA between the initial and final measurings of the control group were not significant for any test, so the obtained increase could be ascribed to the conditions and way of life.

In the case of the bench press variable at the initial measuring of all groups, numerically similar results were obtained, and there were no statistically significant differences among them. At the final measuring, there were statistically significant differences among all the groups of examinees. The differences appeared at the multivariate and univariate level (the value of the F test and its significance). At the final measuring, a greater increase was noted in the E1 group (13%), compared with the E2 group (11%). The value of the T-test on the bench press between Experimental group1 and Experimental group 2 at the final measuring is not significant so it is assumed that the used exercise program has similar effects if implemented twice a week with three sets per session as with one set per session with an increase in reps, performed three times a week.

The values of the F test on the multivariate and univariate level indicate that the implemented program involving resistance exercises was beneficial to the development of strength in lower extremities in both experimental groups. In the case of the leg extension, a greater increase was noted in the E1 group at the final measuring (15%), compared with the E2 group (11%). The value of the T-test is statistically significant. It can be assumed that the resistance exercise program, when repeated twice a week, with three sets, is better for the development of leg strength.

5. Conclusion

The experiment had as its aim the study of the effect of two models of weekly recreational micro cycles used in training muscle strength involving resistance exercises on women ages 40 through 50. Two models of weekly micro cycles were used in the experiment and two different extents of resistance.

A greater increase in muscle strength was found in the first experimental group which used a micro cycle of two training sessions a week with a greater extent of resistance and with a training intensity of 75% of 1RM, than in the second experimental group which used a micro cycle of three training sessions a week, with a lesser extent of resistance and an intensity of 75% of 1RM.

By testing the differences in muscle strength of the examinees using the bench press and leg extension tests in two experimental groups and one control group, a statistically significant difference in favour of the experimental groups was detected.

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EFEKTI VEŽBI SA OPTEREĆENJEM NA MIŠIĆNU SNAGU U REKREACIJI ŽENA

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Cilj istraživanja je da se istraže efekti vežbanja sa opterećenjem na mišićnu snagu u rekreativnom vežbanju žena. Uzorak je činilo 45 ispitanica starih od 40 do 50 godina. Ispitanice su bile podeljene u tri grupe (dve eksperimentalne i jednu kontrolnu) sa po 15 žena. Prva eksperimentalna grupa je vežbala dva puta nedeljno. Intenzitet vežbanja je bio 75% 1RM. Svaka vežba je ponavljana osam puta u tri seta sa odmorom od dva minuta između setova. Druga eksperimentalna grupa je vežbala tri puta. Intenzitet vežbanja je bio 75% 1RM. Svaka vežba je ponavljana 10 puta, ali u jednom setu. Eksperiment je trajao četiri meseca. Eksperimentalni program je obuhvatio vežbe: bench press, lat pulldown, biceps curl, triceps extension, leg press, leg curl, leg extension and squat. Efekat vežbanja je istraživan promenom obima opterećenja u dva eksperimentalna mikrociklusa. Ispitanice kontrolne grupe nisu vežbale vežbe sa opterećenjem. Sve grupe su testirane pre i posle eksperimentalnog tretmana sa testovima: bench press 1RM i leg extension 1RM. Podaci su obrađeni analizom varijance (MANOVA/ANOVA i MANCOVA/ANCOVA) i Studentovim t-testom. U prvoj i drugoj eksperimentalnoj grupi postignut je značajan prirast snage na finalnom merenju. U analizi podataka na multivarijantnom i univarijantnom nivou za E1 i E2 dobijena je statistički značajna razlika na bench press 1RM i leg extension 1RM. Rezultati istraživanja i diskusija su pokazali da je program vežbi sa intenzitetom od 75%, većim obimom i sa dva treninga nedeljno imao bolje efekte na razvoj mišićne snage u odnosu na program druge eksperimentalne grupe koja je vežbala istim intenzitetom, tri puta nedeljno, ali sa manjim obimom opterećenja.

Ključne reči: *rekreacija žena, mišićna snaga, vežbe sa opterećenjem, nedeljni mikrociklus.*