The Effects of Two Resistance Training Programs in Maximum Strength and Muscular Endurance of Male Adults

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ABSTRACT

ffect of two training programs and to compare the changes that occurred in maximum strength (1 RM) and the muscular endu erage trained and healthy men 20-30 years (M=24,3, SD=0,6) and they were randomly divided into two groups. One group e muscular group training. The total volume and the intensity of training were the same in both groups. The CT group trained 3 of the body and two exercises for the legs. The DMG group performed 3 exercises of 3 sets for each muscular group. Meas f the program and 12 weeks after the training. The results showed that the two groups presented significant improvement in r muscular endurance the DMG group was better in most exercises, but this increase was not significant. Furthermore it was c ar training and the training which was distributed in muscular groups, increased the maximum strength equally. Regarding m were better when the training was distributed in muscular groups.

Key words: Maximum Strength, Muscular Endurance, Resistant training.

Introduction

Over the last several years exercise has been included in the daily program of most people since knowledge of its beneficial effects are spread worldwide. Through exercise people improve their health, robustness, well-being and generally their quality of life. Robustness is important in order for the body to function effectively. The components that constitute robustness are: bodily constitution, cardiovascular robustness, flexibility and muscular robustness. Muscular robustness is constituted by two components: strength and the muscular endurance. The probability of suffering from injury in the joints is significantly less in an individual who attains muscular robustness (Corbin, Lindsey and Welk, 2000). Strength is defined as the ability of the muscle to work. Maximum strength is sometimes defined as the greatest possible weight that a muscle or a group of muscles can lift for maximum

repetitions. It is also reported that maximum strength is fixed as the biggest possible strength that the neuromuscular system can develop with maximum constriction (McArdle, Katch and Katch, 2000).

Muscular endurance is the muscle's ability for endurance to tiredness of strength or the ability of maintaining a percentage of strength. Endurance of strength is fixed as the ability of the body to resist tiredness for long periods of time (McArdle, Katch and Katch, 2000; Fleck and Kraemer, 2004). Training of strength mainly increases the size of quick twitch fibres while the medium fibres increase also in size but not in that extent. At the training of muscular endurance, the muscles are adapted via changes in the fibres of slow constriction as well as of increased activity of their aerobic muscular ferments. According to the American College of Sports Medicine (2002), progressive overloading is the continuous increase of workload on the body, "tolerance in continuously increasing charges of" which is vital for progress in a program. In fact the body continues to adapt as long as it is given stimuli of a higher workload than of what it is used to.

There are many ways to increase the work load: (1) Increasing the endurance, (2) Increasing the repetitions in a given resistance, (3) Changing the speed of repetitions depending on the objectives, (4) Reduction of breaks in order to improve the endurance in the strength, (5) Increasing the training volume, (6) Giving variety of skills (ACSM, 2002). Training involves continuous changes (adaptations) that vary from the level of training, the experience and the genetic characteristics of each individual. Untrained individuals showed adaptations to most programs, something that renders it difficult to appreciate the value of each different program. The level of improvement in trained individuals was much slower comparing to those untrained (ACSM, 2002).

Concerning the resistance, 45-50% muscular endurance (ME) has been found to increase the maximum strength in untrained people. For trained people at least 80% ME resistance was needed in order to have greater neuromuscular adaptations. Many advanced studies showed that 1-6 ME, were the most effective for the increase of maximum strength, even though increases of strength were also observed with 8-12 ME. Moreover it has been found that a variety in the resistance brought better results than the utilisation of only one repetition in the long run (ACSM, 2002). The increase of muscular strength depended to a great extent from the volume of the training. The volume of the training depended on the number of exercises that occurred, the number of repetitions in each set and/or the number of sets in each exercise. Researches of Dudley and Djamil (1985) used two sets per exercise of 30 repetitions in isokinetic dynamometer; also Kraemer (1997) and Staron (1994), used three sets per exercise, and

observed important increases in the maximum strength.

In order to have improvement of muscular endurance a higher volume of training has been shown to be more effective (Iickson, Hidaka and Foster, 1994; Kraemer, 1997). In this case, it was recommended that a break of 1-2 minutes should be taken for every 15 repetitions or more and less than 1 minute for every 10-15 repetition. Participants that trained for increase of muscular endurance appeared to be more effective when they used a set with a lot of repetitions and small periods of rest (30 seconds-90 seconds or even less) (Anderson and Kearney, 1982). In research conducted by Campos, Gerson, Luecke, Wendeln, Toma and their colleagues (2002), 32 untrained men took part and were separated into 4 experimental groups. A group executed 3-5 maximum repetitions of 4 sets in each exercise with a resting time between the sets to be 3 minutes. There was also an intermediary group, who had performed 9-11 maximum repetitions of 3 sets with 2 minutes break, while there was another group who did a high number of maximum repetitions (20-28) of 2 sets with 1 minute break. Three exercises were done (leg press, seats and leg extension) with a frequency of 2 times per week for the first 4 weeks and 3 times per week for the last 4 weeks. The group that executed few maximum repetitions showed better results in the measurement for increasing maximum strength, than the group that executed a high number of maximum repetitions. In contrary in the measurement for muscular endurance the group that executed a high number of maximum repetitions showed better results than the group that executed few maximum repetitions in all exercises. In another research where untrained men participated and were trained 3 times per week for an interval of 12 weeks, no differences occurred in the maximum strength when the trained volume and the intensity were equal. Participants were divided into 3 different trained groups where the intensity and the trained volume were equal (Baker, Wilson and Carlyon, 1994). In untrained participants where circular training was used with weights for interval of 10 weeks with a frequency of 3 times per week, significant increase in maximum strength was observed (1 RM) in 9 from 10 exercises (15-42%) (Harber, Fry, Rubin, Smith, and Weiss, 2004).
The aim of the present study was to determine the effect of two different training programs (circular training and distributed in muscular groups training) and to compare the changes that occurred over
the maximum strength (1 RM) and the muscular endurance of adult men in three exercises: bench press, frontal pull downs and squat.

Method

In the present study there was an attempt to investigate whether the distribution of volume of training influenced the muscular strength and muscular endurance. For this reason two different programs with different ways of distributing training volumes and progressive weight load, as well

as time between rests were selected. According to recent bibliographies two of the most widespread types of programs were chosen so as external conclusions on the adaptations could be derived from this study.

Participants

Participants were 18 healthy, slightly trained men of 20-30 years (M=24,3, SD=0,6), who were randomly selected among 100 individuals. They were divided randomly in 2 groups of 9 participants. The first group executed circular training (N=9) while the second executed training distributed in muscular groups (N=9). Participants of each group were selected and were evaluated so as to have similar natural characteristics (age, height and weight) and performance in strength before the beginning of the experiment and they were placed randomly in the two experimental groups. The characteristics of participants are presented in table 1. The men that participated in the experiment did not face medical or endocrinal problems. Participants took part on their own free will and they had been informed of the possible injuries that were related to the experiment. Before the recording of measurements an interval of one week was applied, in order for the participants to become familiarized with the equipment and the proper techniques of the exercises. The measurements were recorded before the beginning of program (M2) and after 12 weeks of training (M2). The means of anthropometrical characteristics (age, height and weight) were presented in table 1.

Table 1: The anthropometrical characteristics (age, height and weight) of participants.

	Age (years)	*Height (cm)*	*Weight (kg)*
Group A (CT, N=9)	22,5 ± 3,1	183,6 ± 6,7	82,8 ± 9,1
Group B (DMG, N=9)	21,9 ± 3,6	185,2 ± 5,7	83,1 ± 7,1

Measures

Test of maximum muscular strength

For the measurement of maximum strength the upper and lower part of the body was used for the equation for the finding of the 1 RM: (1+0.0333 X number of repetitions) X weight in kg. Participants initially performed 1-2 set of warm-up executing 5-10 repetitions in 40-50% 1 RM. Then they performed 1 set with slightly more weight executing maximum number of repetitions. The break between the sets and exercises was 5 minutes so that there was complete recovery.

Test of muscular endurance

For the measurement of muscular endurance, participants initially performed 1 set of warm-up executing 5-10 repetitions at 40-50% 1 RM. Then they executed up to exhaustion 1 set with a weight load that corresponded to 60% of the 1 RM. The measurements of maximum strength were performed in different days from the measurements of the muscular endurance.

Procedure

Depending on the distribution of the training volume, two different training programs were used. The researchers observed all of the participants as well as the implementation of each exercise daily. The CT group (N=9) executed circular training and the DMG group (N=9), training which was distributed in muscular groups. The total volume and the intensity of training were the same in both groups. The group that executed circular training (CT), trained 3 times per week performing 1 exercise at 3 sets for each muscular group of the upper part (chest, back, triceps, biceps, shoulders) and two exercises for the legs. The second group that was distributed in the muscular group (thoracic-triceps, biceps, shoulders-leg) (DMG) trained 3 times per week performing 3 exercises of 3 sets for each muscular group. The exercises included mainly free weights and few gym instruments (pulleys and the leg instruments). The duration of the training program was 12 weeks. In the first 4 weeks all exercises were constituted from 3 sets of 12 repetitions in the 70% of 1 RM with a break of 1 minute and 30 seconds. The following 4 weeks all exercises were constituted from 3 sets of 10 repetitions in the 75% of 1 RM with a break of 1 minute. The last 4 weeks all exercises became 3 sets of 8 repetitions at 80% of 1 RM with a break of 45 seconds.

Results

Effectiveness of program in maximum strength

In the first measurement a one-way analysis of variance was conducted in order to explore statistical differences in maximum strength. There were not any statistical differences between groups at the $p>.01$ level in the scores of the first measurement in all type of exercises. This means that the groups had started from the same level.

One-way repeated measures ANOVA were conducted so as to compare scores in maximum strength of three exercises, with statistical test at measurement 1 (prior to intervention), and measurement 2 (12 weeks following-up). The mean and standard deviations of the two groups in first and second measurements for the maximum strength in all three exercises were presented in table 2.

There was significant effect for measurement in the first exercise, Wilks' Lambda=.233, $F_{(1,16)}=52,76$, $p<.005$, multivariate eta squared=.77. Also there were significant effect for measurement in the second and third

exercise, Wilks' Lambda=.702, $F_{(1,16)}$=6,87, p<.005, multivariate eta squared=.3 and Wilks' Lambda=.36, $F_{(1,16)}$=29, p<.001, multivariate eta squared=.64 respectively. This meant that the two groups after 12 weeks of training improved equally the maximum strength in all three exercises, which had been selected.

Table 2: Measurements in maximum strength

	1st measurement				*2nd measurement*			
Group	A (CT)		B (DMG)		A (CT)		B (DMG)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Bench press	83,6	18,9	83,6	21,7	90,7	20,9	89,1	20,3
Frontal pulls	82,2	10,9	79,4	12	93	17,4	91,2	18,2
Squats	102,6	21,6	94,6	24,7	123,7	22,1	109,1	23,9

Effectiveness of program in muscular endurance

A one-way between groups analysis of variance was also conducted, so as to explore significant differences in muscular endurance in the first measurement. There were not statistically significant differences between groups at the p>.01 level in the scores of the first measurement in all typesof exercises. This meant that both groups had started from the same level. Mean scores and standard deviations of both groups in first and the second measurements for the muscular endurance in all three exercises was presented in table 3.

One-way repeated measures ANOVA were conducted in order to compare scores in maximum strength of three exercises, with statistical test at measurement 1 (prior to intervention), and measurement 2 (12 weeks following-up). The mean and standard deviations of the two groups in first and second measurements for the maximum strength in all three exercises were presented in table 3.

There was no significant effect for measurement in all exercises in muscular endurance *(*p<.005) between two groups. This meant that none of the two groups improved muscular endurance in any of the three exercises.

Table 3: Measurements in muscular endurance

	1st measurement				*2nd measurement*			
Group	A (CT, N=9)		B (DMG, N=9)		A (CT, N=9)		B (DMG, N=9)	
	M	SD	M	SD	M	SD	M	SD
Bench press	21,2	3,11	21,3	2,2	22	2,8	22,4	2,4
Frontal pulls	22,2	4,8	20,6	2,8	22,3	1,4	22,4	3,3
Squats	26,6	3,8	26,3	4	28,3	3	29,4	5,1

Discussion

In the present study average trained men were selected (trained for one year at least) and were trained for a period of 12 weeks with a frequency of 3 times per week. Untrained participants couldn't be selected due to the fact that the first weeks of observed improvement in strength and endurance were mainly due to neurological factors (Chalet, 1992; Fleck, 1999). Furthermore, the results of researches where untrained participants took place had certain restrictions and couldn't be representative for athletes or averaged trained individuals.

Hakkinen and his colleagues (1989) showed that highly trained participants improved strength at a slower rate in comparison to untrained participants. In the present study the frequency of trainings was 3 times per week for both of the experimental groups. This frequency appeared to be good for the beginners and also for slightly trained individuals. Training at a frequency of 1-2 times per week showed that it was enough to maintain those already trained. For those already trained a frequency of 3 times per week showed better results than those who trained two times per week (McLester, Bishop and Guilliams, 2000). Adding to that according to Gilliam (1981), 3-5 times per week was superior to 1-2 times per week. Based on Tan (1999), the ideal frequency of training was 3-5 times per week, while it was observed that the upper part of the body tended to correspond better with even more frequent training (5 times per week) in contrast to the lower part. Most researchers who study training endurance suggested duration of 8 to 12 weeks. In this period of time any increase in maximum strength and muscular endurance can be reported accurately (Starkey et al, 1996).

In the present study 3 sets for each exercise were used. Most studies showed that multiple sets are more ideal in contrast to one set alone. Berger (1962) compared training programs with 1, 2 and 3 sets and concluded that the

programs with 3 sets had the biggest improvement in strength. Ostrowski and his colleagues (1997) compared protocols of training with 3, 6 and 12 sets (n=9, and all used the same MAE charge) and their findings showed that the three protocols of training had increased in strength (1 RM) and were not considerably different between them. It should be noted of course that each muscular group trained 1 time a week although participants exercised 4 times a week.

According to Mazzetti and his colleagues (2000), direct supervision in training of long endurance in average trained men resulted in a higher training volume and cause by the profit of higher strength in comparison to non-supervised training. For this reason, in the present study, all participants had continuous supervision from the researchers. The muscular endurance was measured with a weight of 60% of the 1 RM bench press, in the frontal pulls and in the squat. It was also observed that the two groups presented an increase in muscular endurance which could be due to the small periods of rest that were also included in both of the two groups. Moreover, participants who trained for an increase of muscular endurance appeared more effective in those sets who had lots of repetitions and small periods of rest (30 seconds-90 seconds or even least) (Anderson and Kearney, 1982).

The American College of Sports Medicine (ACSM, 2002) in order to have an increase of muscular endurance proposed a lot of repetitions and small breaks. The results showed that the DMG group dominated in the bench press and in the frontal pulls at 1.80% and 19.93% equivalents. In the squat the DMG group presented bigger improvements than the CT group at 5.60 percentage units. The high number of repetitions that participants in the DMG group reported in the test of muscular endurance could be due to the high volume of training per muscular group each day of the training. According to Hickson and his colleagues (1994), high volume of training is mandatory for the increase of the muscular endurance.

Observing the results of maximum strength it is revealed that the two groups presented important improvements in maximum strength (1 RM) in three exercises, without any significant differences. The CT group presented a smaller improvement in maximum strength than the DMG group in squat but it wasn't significant. For trained participants at least 80% ME endurance was needed for upper nervous adaptations. Many advanced studies showed that 1-6 ME, was the most efficient for the increase of maximum strength. Nevertheless increases of strength were also observed with 8-12 ME as the results of the present study testified. In any case it has been found that variety in the endurance brought better results than the utilisation of one and only percentage endurance in the long run (ACSM, 2002). In the present study the bench press results supported the Anderson and Kearny (1982)

study although in this research the differences were less significant.

Regarding the increase of muscular endurance the DMG group presented better results than CT group in all exercises even though this increase wasn't significant. Comparatively, in Anderson and Kearney (1982) research 15 trained individuals were examined for 9 weeks, 3 times per week executed each time 3 sets of 6-8 maximum repetitions bench press. The increase of strength was at 20% and the increase of relative endurance was 28%. The added weight of relative endurance was fixed at 40% ME, despite the fact that relatively small breaks between the sets and exercises were used, important increases in maximal strength (1 RM) were observed contrary to the study that supported the notion that for an increase of strength longer periods of rest were recommended.

The results of Robinson's (1995) study showed that the experimental group who had 3 minutes break improved in the 1 RM in the squat by 7% comparing to the group that had a break of 30 seconds (2%) and/or to the present study where despite the fact that the break was from 1 minute 30 seconds and less, big improvements in the squat exercise the strength in both of the groups were presented. The results of the study carried out by Pincivero and his colleagues (1997) indicated that the longer the breaks the better the improvements in the isokinetic strength in the legs. The American College of Sports Medicine (2002) proposed breaks of 2-3 minutes in cases where no active big muscular groups used for maximum weight (squat, pressures of bench) while for auxiliary exercises (for example leg extension, leg curl) a 1-2 minute rest could be applied. Furthermore, in a study carried out by Campos (2002) the sample was constituted by 32 untrained men, which were separated in 4 experimental groups. The group that executed few maximum repetitions (3-5) of 4 sets in each exercise with rest time 3 minutes between each set and exercises, presented better results in the measurements for the 1 RM compared to all of the remaining groups. In the measurements for the maximum strength in the upper part of the body no significant differences between the two experimental groups were observed. The results agreed with the study of Baker, Wilson and Carlyon, (1994) where the trained participants had a training of 3 times per week of intervals at 12 weeks. Participants were separated into 3 different training groups where the intensity and the training volume were equal. No significant differences existed in the maximum strength when the training volume and the intensity were equal. According to Tan (1999) it was observed that the upper part of the body tended to correspond better in higher frequency of training (5 times per week) in comparison to the lower part. Furthermore it is concluded that in the maximal strength, bench press and in the frontal pull downs there were no statistically significant differences, while in the squat the DMG group dominated. In the muscular endurance the DMG

group slightly dominated in the bench press and in the squat while a big difference in favour of the DMG group was found in the frontal pull downs.

Conclusion

Observing the results it was concluded that the two groups presented important improvements in maximum strength (1 RM) from the first to the last measurement. In the bench press, the frontal pulls and in squat no significant differences were observed between the two methods. In the muscular endurance the method that the DMG group followed appeared to have better results in all exercises. In the squat exercise the DMG group slightly prevailed over the CT group.

The above results indicate that when the total volume and the intensity of training were the same, the circular training and the training distributed in muscular groups increased equally in maximum strength (1 RM). Regarding muscular endurance it appeared that there were better results in the training distributed in muscular groups. Consequently it was recommended when the objective of exercise was the increase of maximum strength trainers could use either of the methods. If the objective was to increase of muscular endurance it was better to follow the training that was distributed in muscular groups. Future researches could examine the effect of distribution of volume of training in the maximum strength and in the muscular endurance using different weight loads and longer or smaller periods of rest. Moreover studies could further examine the effect of*higher* frequency of training in order to increase maximum strength and muscular endurance.

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