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Research Article

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Divergent Resistance Training Programs, Ramification on the Absolute and Relative Strength and Endurance among College Men

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ABSTRACT

The objective of this research was to scrutinize the impact of three resistance-training programs on absolute and reciprocal durability and muscular strength. Forty-three male subjects were assigned to three groups: high resistance-low repetition group (HRLRG, n=15) performed 3 sets of 6-8 RM (repetition maximum) each session, the medium resistance-medium repetition group (MRMRG, n= 16) performed 2 sets of 30-40 RM per session and the low resistance-high repetition group (LRHRG, n= 12) worked out a set of 100-150 RM per session. The training for the participants was bench press thrice a week for nine weeks. The data revealed an improvement of 20% in maximal strength of the HRLRG and this was greater than 8% and 5 % improvements recorded for MRMRG and LRHRG, respectively. Regarding the absolute endurance, the trends however were reversed as LRHRG registered gains of 41%, MRMRG improved by 39% and HRLRG gained only 28%. The results for relative endurance assessment reported that HRLRG's accomplishments essentially was declined by 7 % after training and was considerably inferior to the 22 % and 28 % improvements achieved by other two groups. It was established that skeletal muscles make general and specific modifications to a training stimulus and the stability of these adaptations is primarily reliant upon the intensity and duration of the training protocol.

Key words: *Resistance training, absolute and relative strength, endurance.*

INTRODUCTION

It is a globally acknowledged fact that any resistance training will augment muscular performance. Countless studies have validated enhancements in strength and muscular endurance following resistance training. A few important studies have been carried out in this field by Saric et al. (2019), Mangine et al. (2015) and DeLorme (1997), who maintained that high-resistance low-repetition exercises build powerful muscles, whereas low-resistance high-repetition exercises foster the quality of endurance, suggesting a functional and specific relationship between training stimulus and response [1-3]. Their views were supported from a performance standpoint by the works of Prestes et al. (2019), Carroll et al. (2018), Penman (2006), Berger and Hardage (2001) and Peterson et al. (2001) [4-8]. Carroll et al. (2018) confirmed that three sets of 4-8 repetitions per set with as much resistance as could be handled resulted in optimum strength improvements [5]. Brigatto et al. (2019) and Berger and Hardage (2001) showed that lifting maximal weights for every ten repetitions produced greater gains in strength than performing ten repetitions with 10 RM (repetition maximum) [7, 9]. Penman (2006) measured executing leg extensions against a resistance allowing only 12 repetitions, maximal effort isometric leg extensions and running up and down stadium bleachers. He found that subjects trained by running bleachers made the smallest gains in strength. Todd et al. (2012), and Peterson (2001) found that when subjects exercised at the same relative intensity, gains in muscular endurance paralleled the count of repetitions accomplished in each training session [8, 10].

Zaroni et al. (2019) [11] and majority of other studies, which have assessed the biochemical adaptations to exercise, have also supported the original observations of DeLorme (1997). The results have shown that low-intensity long-duration training increases the activity of aerobic enzymes, whereas high-intensity short-duration training enhances the activity of anaerobic enzymes [12-14].

Brigatto et al. (2018), and Heggelund et al. (2013) were not satisfied with the observations of DeLorme (1997) and wanted to investigate further [3, 15, 16]. Jackson et al. (2007) and DeLateur et al. (1998) [17, 18] tested the axiom of DeLorme with four groups of subjects, two of which were trained with a high-resistance (25 kg), low-repetition program, while the other two were trained with a low-resistance (11.35 Kg), high-repetition program. The results revealed that those who were trained for strength gained as much endurance as those who were trained for endurance, and those who were trained for endurance gained as much strength as those trained for strength. The authors suggested that to produce strength and endurance, choice of weights is not of prime importance as long as the repetitions are continued to the point of fatigue. Tung et al. (2019), and Martin & Martin (2017) comparing the effects of a high-resistance low-repetition program and a low-resistance high-repetition program have suggested that the primary effect of both programs was the enhancement of muscular strength [19, 20].

Hence, by delving further into this problem, this study aims to directly test the hypothesis that adaptations in muscle performance are a function of the training protocol. More explicitly, the aim of the study is to determine the impact of three different resistance-training programs: (1) high-resistance low-repetition, (2) medium-resistance medium-repetition, and (3) low-resistance low-repetition on maximum strength in addition to the absolute and relative muscular endurance.

METHOD

A total of forty-three normal, healthy and untrained college male students were selected as subjects for the study. The consent of the subjects was obtained for participating in this investigation. For the purpose of the study, the participants were recognized untrained if their 1-RM in bench press was less than 120% of their body weight. The mean and standard deviation (SD) for the physical characteristics of the subjects were as follows: age 20.65 ± 1.79 years; height 1.80 ± .13 meters; and weight 75.08 ± 3.91 kilograms. Bench press was as the exercise for all testing and training procedures. Since this exercise was familiar to the subjects, it was easily administered and had shown to be a valid and reliable measure of muscular function [7]. Prior to pre testing, all the subjects were made aware with explicit training measures to be applied. Maximum strength was assessed by determining each subject's 1-RM bench press. Each subject attempted successive bench presses, starting at a weight agreed upon by both subject and investigator, and increasing or decreasing incrementally until two consecutive unsuccessful trails occurred. The maximal count of repetitions that each subject was able to perform, against a resistance equalling 40% of his own 1-RM, done at a rate of 40 repetitions per minute, was served as the test of relative endurance. Total endurance was evaluated correspondingly with all subjects being tested using 27.23 Kilograms at both test phases. These standards were selected in an effort to have the count of repetitions accomplished in the tests to be judiciously central along the repetition continuum [21]. Each subject underwent two pre-test sessions and was arbitrarily allocated to complete the absolute endurance test (one session) or both the 1-RM and relative endurance tests (the other session). The randomized process was used for allocating subjects to their post-tests, which were managed one or two days at the conclusion of the training period. The tests and processes utilized in post testing were similar to those used in pre-testing. The training intervention for the HRLRG was 3 sets of 6-8 repetitions per training phase [7]. The resistance for each set was selected such that maximum performance was limited to 6-8 repetitions. Once the subjects completed more than eight repetitions in a set, the resistance employed in that set was incremented by 2.27 Kg. The LRHRGs training program consisted of one set of 100-150 lbs. bench press performed at a rate of 40 manoeuvres per minute. The MRMRG schedule involved 2 sets of 30-40 repetitions per period. Repetitions were accomplished at a rate of 40 per minute. In the case of high-resistance low-repetitions and medium-resistance medium-repetitions groups, two minutes were permitted between succeeding sets. With each of the procedures, the weight used in each session was selected such that maximum performance was limited to the desired number of repetitions; 6-8, 30-40 or 100-150. The resistance used was also progressively incremented (2.27 kg) each time a subject successfully completed more than the upper limit of bench presses.

The subjects were randomly allocated to protocols of HRLRG (n=15), MRMRG (n=16) and LRHRG (n=12) and trained three times per week, one hour per day for a duration of six weeks. Mean, standard deviation and standard error of mean were determined as a statistical tool for the subject's characteristics and performance component. To ascertain the overall effects of treatments, two-way analysis of variance (ANOVA) with repeated measures across tests was employed. To further explain the precise locations of significance, one-way ANOVA and tests for the simple main effects were engaged. Tukey w-procedure post hoc test was applied to classify meaningfully the different group means. The level of significance was set at 0.05 for all tests.

RESULTS AND DISCUSSION

In Table 1 shows the outcomes with respect to the performance of the three groups which are presented as descriptive statistics:

Table 1. Descriptive Statistics for Maximum Strength, Absolute Endurance & Relative Endurance

Training Regimen	Maximum Strength			Absolute Strength			Relative Strength		
	Pre	Post	% Change	Pre	Post	% Change	Pre	Post	% Change
High resistance-low repetition	67.73 ±4.30	81.43 ±5.04	20.22	40.46 ±11.88	50.00 ±9.63	23.58	40.93 ±5.16	38.07 ±5.23	- 6.99
Medium resistance-Medium repetition	65.96 ±5.18	71.38 ±4.06	8.22	36.81 ±8.71	51.25 ±10.36	39.23	39.25 ±7.30	48.06 ±9.62	22.45
Low resistance-high repetition	65.44 ±5.03	68.66 ±4.91	4.92	35.33 ±12.08	49.92 ±15.31	41.30	37.50 ±6.02	48.17 ±11.04	28.45

The results revealed that all three groups improved in muscular strength and absolute endurance. There were gains in relative muscular endurance for the MRMRG and LRHRG. The gains in maximum strength ranged from 13.70 kg, 20.22% for HRLRG, to 3.22 kg, 4.92 % for LRHRG. In case of absolute endurance, these two groups responded conversely with the LRHRG improving 41.30%; while, the HRLRG gained 23.58%. The scores on the relative endurance tasks revealed that the LRHRG was improved the most. Initially they performed a mean of 37.50 repetitions and after training completed 48.17 repetitions. This gain is in contrast to the performance of the HRLRG. This group performed a mean of 2.81 fewer repetitions (- 6.99%) on the post-test than they had completed before the training.

Statistical analysis of the maximum strength, two-way ANOVA (groups × tests) revealed no noteworthy variation between groups; (2, 40) F = 2.16, $p < .13$. There was, however, a significant pre to post-test gain in strength; (1, 40) F = 94.66, $p < .001$; in addition to a significant group by test interaction; (2, 40) F = 16.10, $p < .001$. This outcome indicated that the 3 resistance training protocols elicited different responses. Application of similar two-way ANOVA to the relative and absolute endurance data revealed no significant change among group difference for relative endurance (2, 40) F = 1.69, $p < .20$, or for absolute endurance (2, 40) F = .20 $p < .82$. However, there were significant overall gains because of training for relative endurance (1, 40) F = 19.28 $p < .0001$ and for absolute endurance (1, 40) F = 123.15 $p < .0001$. The groups by test interaction was significant for relative endurance (2, 40) F= 12.52 $p < .0001$, but was unsuccessful to influence the absolute endurance (2, 40) F = 2.12 $p < .13$.

The analysis of the data with the application of Tukey w-procedure failed to reveal any significant change amongst the groups for maximum strength or absolute and relative muscular endurance. To find out the specific nature of relative effects of the three training regimens on muscular performance characteristics, a combination of analyses for the simple main effects and the Tukey w-procedure was applied.

Table 2. Summary of Analyses of simple Main effects and Application of Tukey's w-procedure

Variable and Level	Simple Main effects, F	Groups means	Differences between Means	
Maximum Strength				
F Tests at HR-LR	104.78*	81.43		
F Tests at MR-MR	17.46*	71.38	10.05**	12.77**
F Tests at LR-HR	4.61*	68.66	2.72	
Absolute Endurance				
F Tests at HR-LR	23.95*	50.00		
F Tests at MR-MR	58.59*	51.25	1.25	.08
F Tests at LR-HR	44.84*	49.92	1.35	
Relative Endurance				
F Tests at HR-LR	2.00	38.07		
F Tests at MR-MR	20.16*	48.06	9.99**	10.10**
F Tests at LR-HR	22.16*	48.17	.11	

HR-LR: High resistance-low repetition *Significant at $\alpha = .05$
MR-MR: Medium resistance-medium repetition **Significant using Tukey's w-procedure, $\alpha = .05$
LR-HR: Low resistance-high repetition

Table 2 revealed that each of the groups demonstrated significant tests for the simple main effects for strength gains with training. The variable nature of this response, suggested by the significant groups by test interaction, was clarified by the use of the Tukey w-procedure to the post-test means. This analysis discovered that the high-resistance low-repetition group was significantly stronger than the two groups that were similar to each other. Although the percentage of improvements in absolute endurance showed by the three groups varied, the lack of a significant group by test interaction, the similar F-ratios for the tests for the simple main effects and the non-significant Tukey results suggest that these responses were essentially parallel in nature. The three training groups responded differently in terms of relative endurance. The significant group × test interaction can be seen in Table 2. The HRLRG did not improve significantly on relative endurance and was significantly different at the post-test from the two groups that were similar at the post-test and did reveal significant simple main effects for gains in relative endurance.

Muscular strength is interpreted as a muscle's aptitude to employ power on an exterior resistance [22]. While muscular strength is advocated to be a perilous feature for many athletic disciplines [23], it is also an indispensable constituent of functionality in everyday living [24]. Individuals from all walks life can employ resistance training as a resources to advance strength [25], and the enormousness of strength enhancement is influenced by the arrangement of the training program [26].

Although the findings of the two-way ANOVA on maximum strength failed to reveal differences among group, consideration of the significant group × test analysis, the tests of simple main effects and the application of Tukey w-procedure leads to the conclusion that the groups responded differently to the training. HRLRG that employed 3 sets of 6-8 RM as its training regimen made greater strength gains than the other groups. This finding supports the original contention of DeLorme (1997) and numerous studies in strength development [27-31]. Using the same logic to consider the observations on the analyses of changes in relative endurance the HRLRGSs protocol was significantly inferior to the two higher repetition programs. This finding supports the assertion that low-weight, high-repetition exercises produce the quality of endurance [32]. It would seem that the mechanism enhancing the activities of enzymes associated with endurance is more dependent on duration of exercise than on maximal intensity, which is backed by the studies of Baz-Valle et al. (2019), Gonzales et al. (2016) and Borde et al. (2015) [25, 33, 34]. Although there was not a significant difference among the groups with respect to the absolute endurance, MRMRG and LRHRGs did exhibit higher improvements of 39.2% and 41.3%, respectively. The training interventions administered in the current investigation elicited gains in both muscular strength and muscular endurance, which is validated by the studies of Ferenc et al. (2019); Suchomel et al. (2018); Yue et al. (2018); Grgic et al. (2018); Brigatto et al. (2018); and Soh et al. (2007) [15, 22, 35-38]. But this result is contradicted by Androulakis-Korakakis et al. (2018), and DeLateur et al. (1998) [18, 39].

CONCLUSION

The outcomes of the current investigation are summarized as follows: the high-resistance low-repetition exercises build powerful muscles as demonstrated by this group. The low-resistance high-repetition exercises produce better quality of endurance. Further, it is concluded that with the exception of the relative endurance task for high-resistance low-repetition group, all training protocols demonstrated significant improvements on each of the criterion tests. Therefore, in designing a resistance-training program one may adjust the resistance and repetitions used to optimize specific outcomes with confidence that concomitant gains will be made in muscular strength or muscular endurance.

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