



The effect of repetition ranges on maximal strength and hypertrophy

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Abstract: This study investigated the effects of repetition ranges with modified intensity and volume on muscle mass and maximal strength. Fourteen healthy athletes from a sports club were randomly assigned to either a low repetitions or high repetitions group. The low repetitions (LR) group performed 3 sets of 3-5 reps at 90-95% one repetition maximum (1RM) and high repetitions (HR) group performed 5 sets of 10-12 repetitions at 60-70% 1RM in specific strength training exercises for eight weeks. Muscle strength and muscle thickness measures were taken at baseline, four weeks and after the eight weeks of training. Results show LR gained better maximal strength than the HR group after the eight weeks of training in both the flat bench press and the squat test ($p=0.0201$ and $p=0.0165$ respectively). As for muscle thickness, outcomes of the quadriceps cross section thickness were almost identical between the two groups. There was no significant difference in 4 or 8 weeks ($p=0.8776$ and $p=0.9335$ respectively). Our findings suggest performing low repetitions with high intensity (load) is more beneficial for gaining maximal strength and muscle mass in short training cycles. Further research is needed to substantiate these findings in a larger cohort.

Key Words: Repetition range, Maximal strength, Muscle hypertrophy



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1. Introduction

Strength is considered as one of the important elements of training, wherever you were an athlete aiming to get better performance and results or seeking better shape or a healthy cause, you will need to train and develop your strength at some point. Methods of strength training have been developed over the years and at some point; you will be introduced to bodybuilding. Strength training is paramount in the development of athletes, but it must consist of more than just lifting weights without

a specific purpose or plan. The purpose of any strength training method should be to prepare athletes for competition, the ideal test of their skills, knowledge, and psychological readiness. To achieve the best results, athletes need to be exposed to a periodization program or sport and phase specific variations in training [1]. Resistance training is a physical activity that is commonly used to develop muscle strength and stimulate muscle hypertrophy (anatomical adaptation, hypertrophy and maximal strength). Maximizing these training adaptations involves the appropriate manipulation of resistance training variables [2-3]. Arguably, one of the most critical variables influencing the effectiveness of resistance training on muscle strength and hypertrophy is volume [4-5] and resistance load (intensity).

While some trainers believe that to achieve maximal strength they need to train hypertrophy first, some of the previous literature studies showed that having more muscle mass does not mean having more strength [6-8]. Hypertrophy relies more on volume than intensity. A recent study [7] done on thirty four healthy resistance training men comparing low volume resistance training to moderate and high volume, found out that while all groups showed significant pre-intervention to post-intervention in strength and endurance, results favorite the group with high volume. While these studies were done on more advanced athletes or participant that have some experience in resistance training, we could not find recent study done on athletes that just started strength training.

Our study has been done on the athletes trained for years in sports team which make us conclude they have some sort of basic strength. The question we based our study on is (i) should we train hypertrophy first in order to pass to maximal strength training or is it possible to train hypertrophy throughout maximal strength training? (ii) does performing a low range of sets and repetitions increase muscle mass gains? (iii) how does intensity and weekly volume training effect hypertrophy and maximal strength?

The ultimate aim of our study was to investigate to effect of a resistance training program

with low sets and high intensity vs high sets and low intensity for 8 weeks. Based on our study, flat bench press and squat are the only modified exercises between the two groups. All the other exercises stayed the same and both the groups had the same volume and same effort produced for each exercise.

2. Methods

2.1 Experimental design

These eight weeks study was performed to determine the effects of repetition range and intensity on muscle strength and hypertrophy. Tests' outcomes were obtained at the start, 4 weeks and 8 weeks after. Program consisted of two resistance training sessions a week with all sessions supervised by the researcher and an ex-weightlifter athlete.

2.2 Participants

Fourteen healthy male athletes were randomly assigned for the experiment (Table 1). A group with low repetitions, low volume and high intensity (**LR**) that aimed to train maximal strength and a moderate intensity with high repetitions group and a higher volume (**HR**) that aimed to develop muscle mass. Subjects practice team sport (basketball) and preform at least two training sessions per week without counting competition days. All subjects reported a no-use for any kind on drugs or enhancement substances before commencing the study. Participants were also asked to avoid any resistance or strength training that does respect neither the program designed for them by the researcher nor sessions preformed without a supervisor.

2.3 Resistance training

Since we based our study on athletes who play in a championship tournament, we could not imply a training program that involved three training sessions per week, thus, we were limited to only two. We based our program on a split routine that involved performing different exercises targeting specific muscle groups during the two training sessions per week (Table 2).

Table 1. Baseline descriptive statistics. Data are expressed as the mean (\pm SD).

Variables	HR (n=7)	LR (n=7)
Age	21 (1.41)	22.86 (2.19)
Weight (Kg)	75.43 (4.99)	75.57 (4.11)
Height (cm)	182.1 (7.24)	180.3 (5.35)

Table 2. Details of the resistance training intervention of HR and LR

1st session			2 nd session		
Exercises	Load (1RM)	Sets X Reps	Exercises	Load (1RM)	Sets X Reps
Flat bench press	60-70% Or 90-95%	5x10-12 Or 3x 3-5	Flat bench press	60-70% Or 90-95%	5x 10-12 Or 3 x 3-5
Squat	60-70% Or 90-95%	5x10-12 Or 3x 3-5	Squat	60-70% or 90-95%	5x10-12 Or 3x 3-5
Leg press	70%	3 x 6 - 8	Inclined bench press	70%	3 x 6 - 8
Shoulder press	70%	5 X 6 - 8	Pull ups	-	5 X 5 reps
Seated row	70%	3 X 8 - 12	Lat-pulldown	70%	3 X 8 - 12
biceps curl	70%	3 X 8 - 12	Triceps	70%	3 X 8 - 12
Core workout	Close to failure	3 sets for each section (abs – lower back – oblique)	Core workout	Close to failure	3 sets for each section (abs – lower back – oblique)

2.4 Muscle thickness

Imaging Ultrasonography measurements were taken 50% between the lateral condyle of the femur and greater trochanter for the quadriceps femoris [9-11]. The data collected can give us an idea about the development of the muscle mass for each participant. The images were taken at baseline, 4 weeks and post-intervention.

2.5 Maximal strength test

Maximal strength in the bench press and squat exercises was measured before, during and after training, participants were scheduled for testing on the weekends where they had no competition assigned for that week. Participants have been told to avoid any form of exercise other than daily activities for 48h before test day to avoid any manipulation in our final results. We gave each participant 3 trials for

the 1RM test with 3-5min rest after each successful try and documented the best result obtained out of the three trials.

2.6 Nutrient intake and dietary analysis

Subjects have been given a paper that includes some tips about what eat before, during and post training sessions, we advised to take a healthy amount of proteins and carbohydrates two hours before the training session, focus on hydration during the workout and taking a good amount of protein-rich foods in a 12 hours window after a workout.

Participants reported what they consumed in the last 24 hours each day before the training session and 24 hours after so we can help guide them to choose the best nutrition plan for building more muscle mass and strength.

2.7 Statistical analysis

For statistical analyses, we used SPSS v24 for Windows and an online T test calculator from GraphPad.com. Means and standard deviations (SD) were calculated with conventional statistical methods [12-13]. We used the dependent T test to analyze differences within the groups and used the independent T test to compare baseline characteristics (muscular strength and muscle thickness) and the training variables (volume and intensity) of the two groups (LR and HR) over the 8 weeks.

Furthermore, the 95% confidence intervals (CI) in addition to the effect size for each outcome to determine the magnitude of differences found within and between the two groups. For the effect size (ES) we used Cohen's d (Cohen's $d = (M2 - M1) / SD$ pooled -where $SD \text{ pooled} = \sqrt{((SD1^2 + SD2^2) / 2)}$ -)

For classification, an ES of 0.20 or less was considered a trivial effect, 0.21 to 0.59 a small effect, 0.60 to 1.19 a moderate effect, 1.20 to 1.99 a large effect, 2.0 to 3.9 a very large effect, and >4.0 a nearly perfect effect [12].

3. Results

3.1 Muscle thickness

For the quadriceps muscle, both groups noted a significant increase in muscle thickness at 4 weeks ($p=0.0009$ for LR and $p=0.0003$ for HR) and 8 weeks ($p=0.0008$ for LR and $p=0.0003$ for HR). However, when comparing between the two groups, there was no significant difference in muscle thickness at any time during the study period ($p=0.8776$ at 4weeks and $p=0.9335$ at 8weeks). Both groups had similar results for lower body muscle hypertrophy despite the different training regimens (Table 3).

These results show that even with different volumes and loads taken by both groups, both HR and LR saw an increase in muscle mass. While these outcomes prove that it is possible to get similar increased muscle mass when training with higher loads to a volume focused training regimen, our study only measured the lower body.

3.2 Maximum muscle strength

Both groups showed an increase for the 1RM flat bench press test but it was more significant for the LR group at 4 weeks ($p<0.0001$ for HR; $p<0.0001$ for LR), although it was not significant ($p=0.1650$ between HR and LR). At 8 weeks, both groups showed an increase in the 1RM test ($p=0.0013$ for HR; $p<0.0001$ for LR) but the outcomes became more significant favoring the LR group ($p=0.0201$ between HR and LR) (Table 4).

Squat 1RM test results were similar to the bench press test, both groups showed an increase in maximum strength but results favored the LR group over HR ($p<0.0001$ for HR; $p<0.0001$ for LR at 4weeks, $p=0.0054$ for HR; $p<0.0001$ for LR at 8 weeks). When comparing between the two groups, there was no statistical significant between HR and LR at baseline or 4weeks ($p=0.8391$ at baseline; $p=0.0152$ at 4weeks). LR were statistically significant compared to HR at 8weeks ($p=0.0165$) (Table 5).

Table 3. Comparison of absolute means of quadriceps muscle thickness at baseline, 4 weeks and 8 weeks.

Muscle thickness	HR	LR
Baseline	5.48 ±0.52 cm	5.50 ±0.45 cm
4 weeks	5.65 ±0.52 cm	5.61 ±0.45 cm
8 weeks	5.81 ±0.49 cm	5.79 ±0.5 cm

Table 4. Comparison of absolute means of 1RM test of HR and LR.

Muscular strength	HR	LR
Flat bench press (Kg)	Baseline	59.86 ±7.71
	4 weeks	64.14 ±8.35
	8 weeks	67.29 ±8.86
Squat (Kg)	Baseline	84.29 ±7.2
	4 weeks	90.29 ±7.2
	8 weeks	95.14 ±8.8

Table 5. Effect sizes for muscle thickness and maximum strength.

Tests	Period	HR		LR		Between groups	
		Effect size	95% CI	Effect size	95% CI	Effect size	95% CI
1RM bench press	4 weeks	0.53	From -5.31 to -3.26	1.21	From -8.85 to -6.87	0.79	From -14.49 to 2.77
	8 weeks	0.36	From -4.5 to -1.79	1.30	From -10.31 to -7.40	1.43	From 20.99 to -2.16
1RM squat	4 weeks	0.83	From -7.41 to 4.59	1.29	From -15.15 to -9.42	0.78	From 17.67 to 3.39
	8weeks	0.60	From -7.65 to 2.06	1.07	From -13.33 to -8.67	1.42	From 24.44 to -2.99
Muscle thickness	4 weeks	0.32	From -0.23 to -0.11	0.24	From -0.15 to -0.06	0.08	From -0.53 to 0.61
	8weeks	0.31	From 0.21 to -0.10	0.37	From -0.25 to -0.10	0.04	From 0.56 to 0.60

4. Discussion

Studies showed that the changes in the muscle mass gain of the lower versus upper body are not the same. A 2000 study gave us some evidence that the upper body have an increased hypertrophic capacity than the lower body [14-17]. In our muscle thickness measurement's method we only measured the thickness of the quadriceps' cross section, which means muscle mass development of the lower body [18-21]. For future research, it is advised to measure elbow flexors and forearms muscles' thickness in order to deem the study more accurate. Even though there were no adverse events reported by the participants we did not use any methods or monitors to measure fatigue and soreness, which could help make conclusions that are more definitive [22-23].

This study investigated the effects of low repetitions range with high intensity versus high repetition ranges with moderate intensity and volume. Both groups had different training programs, while LR focused on developing maximum strength, HR focused on muscle gain or hypertrophy. Both groups saw an increase in maximal strength, but results show that LR group that had a higher intensity percentage had better results. Also, the LR showed a consistent development for chest press and HR group shows that performance increase rate was slowing down (ES= 0.53 at 4 weeks and ES=0.36 at 8 weeks).

But both groups displayed a significant increase in maximum strength for the squat 1RM test during the whole experiment. While this increase was considered large at 4 weeks (ES= 0.83 for HR and ES=1.29 for LR), the rate –or consistency- of this development slowed down compared to the first 4 weeks for both groups (ES=0.60 for HR and ES=1.07 for LR) [24]. This could be a result of overtraining since the participants were in a team sport and had a competition day –sometimes two- during the experiment period, or it could be related to other uncontrolled factors like nutrition [25]. Another study is recommended here to investigate these changes in the developing rate.

Contrary to what we hypothesized, muscle thickness results show a significant increase in cross section of the quadriceps muscle throughout all the

study stages for both groups [26]. Results were almost identical at 4 weeks (ES=0.32 for HR and ES= 0.24 for LR) and at 8 weeks (ES= 0.31 for HR and ES=0.37 for LR). Results show that LR had a consistent developing rate of the quadriceps muscle while HR stagnated at 8 weeks. It is difficult to explain if this slack in muscle mass development was due to overtraining or recovery, further investigation is need here.

A 2017 study [27] about the effects of a modified German volume training program on muscle strength and hypertrophy also found similar results, the study was done on participants with less than a 1-year experience. Results show a decrease in lower body muscle mass after between 6 and 12 weeks of training. Which explain our outcomes considering the decrease in muscle mass gains [28]. More and more findings have shown us in the last years that hypertrophy training relies more on volume (especially for experienced athletes), one of the ways to describe the training volume is a week period that is used by most athletes and trainers. A 2010 study by Nicholas A. brud et al. showed that low load-high volume resistance training stimulate more muscle protein synthesis than a high load-high volume training for young men [29]. Another study [30] also showed that resistance training volume plays a big role in gaining muscle mass but not strength development in trained men. Despite the recent finding about the relation between training volume and hypertrophy, it is still unclear whether athletes should focus only on volume to gain more muscle mass. A 2015 study found that using low volume-high intensity training program utilizing a long rest interval (3 min) and 3-5 repetitions in each set is more advantageous that a moderate intensity-high volume (10-12 repetitions) program using a short rest interval (1 min) for stimulating upper body strength gains and hypertrophy [30]. This study supports our finding that a higher load and a low volume training program can lead to a significant increase in maximal strength and muscle mass.

5. Conclusion

This study investigated the effects of repetition range on maximal strength gains and

hypertrophy. The final results of these 8 weeks resistance training program suggests that it's possible to gain better muscle mass with higher loads (intensities) and a low number of repetitions (3-5) compared to training with moderate loads, a higher volume and a higher number of repetitions (10-12). These observations question the utility of a high-volume training programs used as a second phase in strength training periodization by coaches and trainers. Emphasizing training intensity over volume may provide an advantage for accelerating muscle growth and strength gains in a short-term training cycle. Further complimentary studies are needed with better monitoring system and control on critical variables like nutrition and recovery to consider our findings valid.

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Conflict of interest

Author declare have no conflicts of interest.

Informed consent

All participants gave written informed consent to participate in this study.

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