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Effect of Drop Sets on Muscle Strength and Endurance of Trunk Extensors among Trained Men

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Abstract: Drop set training has been suggested as one of the best high intensity training techniques of all time. Though several studies have shown the effect of drop sets on limb muscles; there is a relative dearth of research on the effect of drop sets on spinal musculature. This study was aimed to determine the effect of drop sets on muscle strength and endurance of trunk extensors among trained men. Methods: A randomized controlled trial was conducted for 6 weeks among 30 trained men recruited through convenient sampling. Participants were randomly assigned into two groups; experimental group that underwent drop sets and control group submitted to high load resistance training. A pre-test and post-test measurement of muscle strength and endurance for both groups was carried out using 1RM Strength Test and Biering-Sorensen test respectively. Data were statistically analysed by Pearson correlation and t-student tests, with a significance level of $p<0.05$. Results: At the end of the trial, significant changes are shown in pre-test and post-test scores of muscle strength ($p=0.001$) and endurance ($p=0.003$) of the trunk extensors in the drop sets training group. The findings proved that drop sets can simultaneously improve muscle strength and endurance of trunk extensors with short term training. Conclusions: In conclusion, drop sets training achieved superior gains in muscle strength and endurance of the trunk extensors compared to high load training. In this context, this programme could potentially be used to improve trunk extensor muscle performance in trained men.

Keywords: drop sets, high load resistance training, trunk extensors, muscle strength, endurance.

INTRODUCTION

Scientific evidence indicates that strength training should be part of comprehensive health maintenance [1]. The paramount activity to promote increase in muscle strength is strength training and optimally designed training programs which are based on scientific principles that govern the prescription of different training variables. Both strength and endurance training are often performed concurrently in most exercise programs in wellness, fitness and rehabilitative settings, in an attempt to reach different physical fitness goals [2]. Several methods to increase the intensity of effort in resistance training such as forced repetitions, eccentric training and drop sets are widely used by athletes in an attempt to increase muscle mass. Drop sets training has been advocated by multiple commercial and academic publications and authors, seemingly as a result of the acute hormonal and muscle activation responses it produces.

Drop set (DS) is a type of advanced weightlifting technique that most strength athletes perform to maximize their muscle size and to increase their strength endurance. Unlike other methods of training, this allows to continue to train just a bit longer beyond muscle failure. Although not recommended for beginners, drop sets can be used by seasoned strength athletes and weightlifters to overcome training plateaus. Drop set is a training technique designed to help the athlete fatigue the muscles by lifting progressively lighter weights to failure per set. In the bodybuilding world, drop sets picked up steam and have been ingrained in the sport due to the "pump" they create upon completion. The goal of drop sets is to exhaust the high threshold fibers within the first working set. Upon lowering the weight (percentage depending on the specific technique), time under tension is increased by completing more volume. Working through each subsequent drop in weight, provides greater time under tension than if stopped after one set, giving the type I fibers the stimulus they need to get growing. The

increased fatigue will act as a safe-guard to ensure hit type II fibers, as fatigue can actually make it easier to recruit type II fibers at a weight where their use wouldn't be normally is required [3]. A fatigued muscle will still receive maximum overload because the reduced weight is proportionally as heavy as the weight used at the beginning of the set.

Unfortunately, the scientific community has not given much thought to the drop set training. Only a few studies have endeavoured to specifically investigate the effects of DS training on muscular adaptations [4, 5]. A study conducted to determine muscular adaptations to combinations of high and low-intensity resistance exercises reported significantly greater increase in cross-sectional area, strength (1 Repetition Maximum) and maximum voluntary contraction after 4 weeks of resistance training when a single drop set was added to a traditional strength-type routine versus performing the strength routine alone. However, no direct comparison with fixed load multiple set resistance training was made [6]. Recently, the popularity of DS has been gradually increasing in professional bodybuilding or weight training routines as many researches and information regarding DS have been published and the researchers have successfully demonstrated that DS has superior effects on muscle strength and muscle hypertrophy than conventional training. For instance, researchers found that performing resistance training with a single DS can achieve similar effectiveness as 3 sets of conventional resistance training in muscle growth and strength gains due to higher mechanical tension and metabolic stress [7]. Besides that, it enhances anabolism by increasing time under tension; also one of the working mechanisms behind DS training [8].

Even though the exact hypertrophic mechanisms and pathways triggered by DS training are not yet completely understood, the authors hypothesized that the increased mechanical and metabolic stress and muscle damage occurring with DS would result in superior muscle strength and endurance as compared to conventional resistance training. The human spine is a lever subjected to external loads created by the weight of the trunk and any object lifted, and the forces created by the various muscles and ligaments surrounding the spine [9]. The back extensors are essential to lifting and bending activities. These muscles act both to extend the spine and to balance the flexion movement produced by the trunk and weight being lifted [10]. The outcomes with regard to muscle performance as compared to conventional training are of great interest. However, little is known about the efficiency of drop set on trunk muscles. To our knowledge; no study has been found in the available literature on the effect of drop sets on trunk extensors. Gaps in the current literature surrounding the use of this methodology suggest the need to further examine its use and impact. This study was aimed to determine the effect of drops sets on muscle strength and endurance of trunk extensors among trained men.

MATERIALS AND METHODS

Participants

Thirty trained men (Age: 21.67±2.19; Height: 172.12 cm±6.26; Body weight: 67.46 kg±9.15; BMI: 22.73±2.97) volunteered to participate in this randomized controlled trial. Participants were divided into intervention group (DS) and control group (HL) using block randomization to ensure that roughly equal numbers of samples are randomly assigned to the two groups in a way that both known and unknown prognostic factors are balanced at the start of the trial. Randomization was performed using computer-generated random numbers. Participants were recruited based on inclusion and exclusion criteria and sorted into control group and experimental group. Males between the age of 18 and 30 years were included. Physically healthy subjects screened by Physical Activity Readiness Questionnaire (PAR-Q) and undergone resistance training for at least one year were included. Subjects with spinal problems, hypermobile, unstable and painful joints were excluded. The study was conducted at Enrich Fitness Centre, Sungai Long, Malaysia.

All participants were informed about the potential risks of the experiment and signed written informed consent was obtained from the participants prior to the trial. The experiments were performed in accordance with the ethical standards of the Helsinki Declaration. This study was approved by the Scientific and Ethical Review Committee (SERC) of Universiti Tunku Abdul Rahman (UTAR).

Outcome measurements

1RM Strength Test

1RM strength test is considered as the 'gold-standard' test for measuring maximum strength or explosive strength in non-laboratory environments. It is simply defined as the maximal weight an individual can lift for only one repetition with correct technique. The test was performed for trunk extensors of each participant to examine the pre-test and post-test muscle strength using the back extension weight training station. Before the test, a warm up session was given, started with 5 minutes of stationary cycling, followed by familiarization of dynamic back extension exercise using weight training station with light load (50% of 1RM) at 8-10 repetitions. One minute resting interval was given after the warm up. Afterwards, the participant performed similar exercise with particular load through full range of motion, increment or decrement of 2kg for each trial, until the exact 1RM is acquired. Moreover, the 1RM test has been proven as a

valid and reliable measure of performance in dead lift exercise. The safety and reliability of 1RM back squat testing has been proven in healthy young adults [11].

Biering Sorensen Test

The Biering-Sorensen test is a timed measure used to assess the endurance of the trunk extensor muscles. The subject lies prone on the examining table with the upper edge of the iliac crests in alignment with the edge of the table. The lower body is fixed to the table by three straps around the pelvis, knees, and ankles, respectively. With the arms folded across the chest, the patient isometrically maintains the upper body in a horizontal position while time is recorded. The researchers used a stop watch to measure the duration of holding while the subject in horizontal position, and the calculation stops when the subject's trunk drop below 10 degree. High reliability indices were reported for the Biering-Sorensen test [12].

Exercise Procedure

DS Training protocol: The training session started with warm up session that consisted of static cycling for 5 minutes. Participants rested for 1 minute, and performed 3 sets of Quarter Deadlift without inter-set resting interval. Each set was performed until concentric failure. The subsequent set was decreased by 20% as the load in the previous set. The first set used 85% of 1RM. It was followed by descending to 65% of 1RM in the second set and 45% of 1RM in the third set. Afterward, 5 minutes of static cycling was performed as cool down session.

HL Training: The warm up and cool down sessions were the same like DS group. Participants performed 3 sets of Quarter Deadlift (QD) with HL (85% of 1RM) at 8-12 repetitions with 3 minutes of inter-set resting intervals.

Both groups performed 3 sets of Quarter Deadlift (QD); the experimental group used the DS training technique, while the control group utilized the HL training technique. The frequency of training was one session per day, 3 days per week, for 6 weeks.

STATISTICAL ANALYSES

The data were tabulated using Microsoft Excel and Statistical Package for the Social Sciences (SPSS) version 22 was used to analyze data. The data are expressed as means (± standard deviation (SD)). A paired t-test was used to analyze the significance of within-group comparisons of the data. The statistical analyses of between-group data were performed using an independent t-test. Pearson correlation analysis was used to analyze the correlation of age, height and body mass index with outcome measures. A value of $p<0.05$ was accepted as statistically significant.

RESULTS

Participants in both experimental and control group showed no significant differences between groups in terms of age, height, weight, BMI and duration of prior training; ensuring homogeneity between the groups. Demographic characteristics of participants are shown in Table No: 1. The mean age of the participants is 21.67±2.19, the mean height; 172.12 cm±6.26, the mean body weight; 67.46 kg±9.17 and the mean BMI; 22.73±2.97 and the mean training experience is 17.83 months.

The correlation between the age, BMI and training experience with post-test muscle strength and endurance is shown in Table No: 2. Comparison of pre and post-test mean muscle strength and endurance between two groups is shown in Table No: 3. There is no statistically significant difference in pre-test muscle strength and endurance between DS and HL group with p value of 0.052 and 0.140 respectively. However, DS group showed a statistically significant difference in muscle strength ($p = 0.001$) and endurance ($p = 0.003$) after the trial compared to the HL group.

Table-1: Characteristics of the participants in experimental and control groups

Variable	DS	HL	Total	Sig.
	(M±SD) (n=15)	(M±SD) (n=15)	(M±SD) (n=30)	
Age (years)	21.2±0.87	22.13±2.95	21.67±2.19	0.249
Height (cm)	171.77±5.98	172.47±6.72	172.12±6.26	0.765
Body Weight (kg)	68.81±9.17	66.11±9.24	67.46±9.15	0.427
BMI	23.33±3.15	22.13±2.75	22.73±2.97	0.278
Training Experience (months)	21.40±18.09	14.27±12.34	18±15	0.218

Note: n=number of participant ; M=mean ;SD=standard deviation ;DS= drop set ; HL=HL; Sig=significant difference; *indicates Sig. is <0.05

Table-2: Correlations between the Age, BMI and Training Experience with Post-Test Muscle Strength and Muscle Endurance

Variables		Post Test Muscle Strength	Post Test Muscle Endurance
Age	Pearson Correlation	-0.12	-0.14
	p	0.60	0.44
BMI	Pearson Correlation	0.41	-0.05
	p	0.03*	0.80
Training Experience	Pearson Correlation	0.51	0.03
	p	0.00*	0.86
Note : p value ; *indicates significant difference with p value <0.05			

Table-3: Comparisons of Pre and Post-Test Mean Muscle Strength and Muscle Endurance between Two Groups

Test	Group	Dependent Variables	
		Muscle Strength (kg) (M±SD)	Muscle Endurance (s) (M±SD)
Pre	DS (n=15)	27.50±6.05	88.13±38.52
	HL (n=15)	22.00±5.36	75.09±40.88
	P	0.052	0.140
Post	DS (n=15)	44.00±4.20	131.07±32.80
	HL (n=15)	35.67±7.23	88.13±38.52
	P	0.001*	0.003*
Mean Difference (pre-test & post-test difference within the group)	DS (n=15)	16.50±3.87	34.20±11.63
	HL (n=15)	13.67±3.26	13.05±3.50
	P	0.000*	0.000*
	P	0.000*	0.000*
Note: n=number of participant ; M=mean ;SD=standard deviation ;DS= drop set; HL=HL;P=p value; *indicates significant difference with p value <0.05			

DISCUSSION

This investigation was aimed to evaluate the effect of drop sets on muscle strength and endurance of trunk extensors among trained men. The results indicated that participants in DS group attained statistically significantly greater gains in muscle strength (p=0.001) and muscular endurance (p=0.003) of trunk extensors.

Previous studies on DS recommended further study to examine the effect of DS when performing multiple joint exercises [7, 13]. Thus, the present study included deadlift as the intervention; as it is one of the most popular and effective multiple joint resistance exercises for trunk extensor strengthening. The major finding in this study is that performing QD with DS and HL protocols can simultaneously improve muscle strength and endurance of the trunk extensors in 6 weeks of training. The results of strength gains are consistent with most of the previous studies that had compared DS with HL training. For instance, a recent study from Japan successfully demonstrated that both DS and HL resistance training can significantly improve muscle strength of the elbow flexors after 8 weeks of training [13]. Furthermore, researchers also found that even a single DS can achieve significant improvement in muscle strength of the triceps similar to 3 sets of conventional resistance training. The researchers concluded that DS promotes better strength gains than typical resistance training [7].

The advanced technique of immediately reducing the load when reaching momentary muscular failure and performing subsequent repetitions with moderate-load resulted in greater gains in improvement in muscular performance beyond that of performing high load training. Resistance training (RT) leading to momentary muscular failure (MMF) has been evidenced as producing significantly greater muscular strength and hypertrophic adaptations when compared to RT not performed to MMF [14]. It is thought that the sequential recruitment of motor units and muscle fibres which occurs during RT performed to MMF through Henneman's size principle [15] amongst other potential mechanisms of adaptations [16] might stimulate the greatest increase in muscular strength and hypertrophy [17]. A recent meta-analysis further supports that, when controlled for effort by training to MMF, significant strength and hypertrophy occur with both light and heavy loads [18]. Besides that, the findings of a previous study indicated that protocols that consist of high intensity resistance immediately followed by low intensity resistance training such as DS is able to increase the stimulation of growth hormone secretion

which is crucial for muscle development as well as strength gains [19].

In addition, our findings also indicated that DS protocol can significantly improve muscle strength and endurance than typical resistance training with multi-joint exercise similar to single joint exercise. This can be related with the previous study that proved there is no significant difference between multi-joint exercise and single-joint in improving muscle strength and muscle thickness [20]. However, a previous literature is underpinning the fact that total work is comparatively higher when DS is done with multi-joint exercise than single joint exercise. This increased total work is required for increasing muscle strength [21].

Furthermore, our results showed significant improvement in muscle endurance after HL training. This observation is not in accordance with the findings of a previous study that stated HL resistance training did not produce significant improvement in muscular endurance [22]. However, it can be justified as evidences showed thoracic and lumbar muscles at the back tend to have higher amount of slow twitch muscle fibres, as these muscles are postural control muscles that consistently activate in daily activities [23].

Our findings indicate that muscle strength has increased in participants subjected to high load training. Muscle activation is proportional to the intensity of exercise. Increasing mechanical stress theoretically stimulates growth in a larger percentage of muscle fibers while also encouraging a faster and more coordinated response from the activated fibers [24]. A considerable increment in muscle strength was not demonstrated by participants of control group compared to DS group. Training experience is known to significantly affect training outcomes. During the initial weeks of a new training regimen, novice lifters experience several neurological adaptations that help improve exercise technique, muscular recruitment, activation efficiency, and ultimately maximal strength [25]. Individuals with resistance training experience appear to be limited in their capacity to stimulate muscle adaptations from nonspecific training designs [26].

Maintaining high levels of muscle strength and hypertrophy is important to a variety of populations. For the general public, these attributes facilitate the performance of activities of daily living and have wide-ranging implications for health and wellness, including evidence of a clear inverse relationship between muscular fitness and mortality. The need to maximize strength and endurance of trunk extensors is also of particular importance for athletes in many sports.

This study has several limitations. The short duration of the trial does not allow the researchers to predict the outcomes for longer time periods. It would be of interest to investigate if the groups adapt differently over a longer time period.

CONCLUSIONS

The findings from the present study suggest that considerable increase in muscular performance can be attained by the use of drop sets training in persons with previous resistance training experience. Furthermore, this study has filled the void left by the relative dearth of empirical research that drop sets training technique appear to produce greater gains in muscular performance of trunk muscles. More importantly, strong back muscles can help heal most types of back pain, especially the most common form of back pain caused by soft tissue injury or back muscle strain.

Conflicts of interest

The authors declared no conflict of interests regarding the publication of this manuscript.

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