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Effects of Heavy Duty versus traditional resistance training on thigh muscle cross-sectional area

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Abstract

Introduction: Heavy Duty resistance training (HD) is a new method that might improve muscle strength and hypertrophy. The effect of this method on thigh muscle hypertrophy is not well-known. The purpose of the present study was to examine the effects of HD versus traditional resistance training (TRT) on thigh muscle cross-sectional area (CSA).

Material & Methods: Twenty untrained healthy men (age: 25.6±2.0 mean±SD) volunteered to participate in this study. The subjects were divided into HD group (n=10) or TRT group (n=10) randomly. The subjects in HD and TRT executed five resistance exercises selected to stress the thigh muscle groups in the following order: leg press, squat, leg

extension, prone leg curl, and dead lift. HD and TRT consisted of 50-60 min of station weight training per day, 3 days a week, for 8 weeks. TRT training was performed in 5 stations and included 4 sets with 6-12 maximal repetitions at 70-80% of 1-RM in each station with 2-3 minute of rest. HD training was performed in 5 stations and included 4 sets with 6-10 maximal repetitions at 70% of 1-RM in each station with 10 second of rest. Thigh muscle CSA and grow hormone (GH) were measured before and after the intervention.

Results: The results showed that maximum strength in each station was increased after HD and TRT ($P<0.05$). Thigh muscle CSA also was increased after HD and TRT; however the increase in thigh muscle CSA was higher in HD than TRT. For GH no significant differences were observed after the HD and TRT methods.

Conclusions: In summary, HD method is better than TRT method for thigh muscle CSA however no significant differences were found for GH level after these resistance training methods.

Keywords: Heavy Duty resistance training, Traditional resistance training, Muscle hypertrophy, Growth hormone.

1. Introduction

Muscle mass is important from a human health standpoint, as it plays a significant role in locomotion, force production, and glucose disposal (1). Low levels of muscle mass may lead to an increased risk of several diseases such as type II diabetes, metabolic syndrome, and cardiovascular disease (2,3). Moreover, there is a positive correlation between muscle mass and many aspects of athletic performance (4) and overall muscle size is a primary consideration in bodybuilding competition (5).

Resistance training (RT) is an effective tool for stimulating muscle hypertrophy and improving strength. By manipulating acute training variables (i.e., exercise selection and order, intensity, volume, and

duration, frequency, and rest intervals), differences in mechanical and metabolic stresses can be imposed (6,7). As the intensity of resistance exercise increases (resulting in increased activation of fast-twitch muscle fibers), a greater emphasis is placed on mechanical stress (8). In contrast, high-volume (i.e., greater number of repetitions concomitant with the use of short rest intervals) programs elicit greater metabolic stress (9). A minimum intensity threshold is necessary to maximally stimulate muscle activation for those programs targeting metabolic stress (9,10). Thus, metabolic stress is targeted by increasing resistance exercise volume and volume load and by reducing rest intervals between sets (9,10). The combination of mechanical and metabolic stress has been shown to increase the potential for muscle damage, and it also appears to be a potent stimulus for inducing muscle hypertrophy and strength increases (7,11). Traditionally, it has been suggested that high volume (6-12 repetitions) and moderate to high intensity (70-80% 1RM) RT programs primarily target muscle hypertrophy with secondary strength increases (7,12,13). Conversely, high-intensity (85-100% 1RM) and low volume programs (1-4 repetitions) primarily target muscle strength increases with secondary improvements in muscle hypertrophy (9,12,13). A high training volume is associated with an augmented anabolic hormone response to exercise (14,15) that thought to provide an enhanced stimulus for muscle hypertrophy (16,17).

Mike Mentzer, a famous bodybuilder, introduces a novel RT method for muscle hypertrophy that named Heavy Duty (HD) training system. In this system, athletes performed RT in 4 sets with 6-10 maximal repetitions at 70% of 1-RM with 10 second of rest. They used a repetition duration of 3-4 seconds concentric, 1 second isometric contraction at the top of the range of motion, and 3-4 seconds eccentric (18). By our knowledge, there is no study that was performed to examine the effect of HD versus traditional resistance training (TRT) on muscle cross-sectional area (CSA) and its related hormones. Thus in the present study, we compared the effects of HD versus TRT on thigh muscle CSA and growth hormone (GH) in untrained healthy men.

2. Material & Methods

Subjects

Twenty untrained healthy men (age: 25.6±2.0 mean±SD) volunteered to participate in this study. All the subjects were asked to complete a personal health and medical history questionnaire, which served as a screening tool. All the subjects were complete inactive at least 6 month before the study and they were nonsmokers and free from unstable chronic condition including dementia, retinal hemorrhage and detachment; and they have no history of myocardial infarction, stroke, cancer, dialysis, restraining orthopedic or neuromuscular diseases. Thereafter, the subjects were divided into HD group (n=10) or TRT group (n=10) randomly.

Measurements

Anthropometric and body composition measurements

Height and body mass were measured, and body mass index (BMI) was calculated by dividing body mass (kg) by height (m^2). Body fat percentage was assessed by skinfold thickness protocol. Skinfold thickness was measured sequentially, in chest, abdominal, and thigh by the same investigator using a skinfold caliper (Harpenden, HSK-BI, British Indicators, West Sussex, UK) and a standard technique.

Exercise training

Two familiarization sessions were designed to habituate subjects with the testing procedures and laboratory environment. The main aim of these sessions was to familiarize subjects with different resistance exercises using weight-training machines and also to familiarize them with performing the 1-RM test. Maximal strength was determined using a concentric, 1-RM (19), as previously described (20). The warm-up consisted of riding a stationary bicycle for 5 min, two sets of progressive resistance exercises similar to the actual exercises utilized in the main experiment, and 2-3 min of rest accompanied by some light stretching exercises. After the warm-up, subjects performed the 1-RM test, and the heaviest weight that could be lifted once using the correct technique was considered as 1-RM for all the exercises and used to calculate the

percentage of resistance. During the familiarization sessions, it was ensured that all the subjects used the correct techniques for all exercises prior to taking part in the main test sessions. The subjects in HD and TRT executed five resistance exercises selected to stress the thigh muscle groups in the following order: leg press, squat, leg extension, prone leg curl, and dead lift. HD and TRT consisted of 50-60 min of station weight training per day, 3 days a week, for 8 weeks. TRT training was performed in 5 stations and included 4 sets with 6-12 maximal repetitions at 70-80% of 1-RM in each station with 2-3 minute of rest. HD training was performed in 5 stations and included 4 sets with 6-10 maximal repetitions at 70% of 1-RM in each station with 10 second of rest. The HD group used a repetition duration of 3-4 seconds concentric, 1 second isometric contraction at the top of the range of motion, and 3-4 seconds eccentric. General and specific warm-up were performed prior to each training session, as explained for the 1-RM determination, and each training session was followed by cool-down.

Biochemical analyses

Resting blood samples (5 ml) were taken at the same time before and after 8 weeks intervention and blood sample was obtained by venipuncture. Serum obtained was frozen at -22 ^{oC} for subsequent analysis. The growth hormone (GH) level was measured in duplicate using an electrochemiluminscent method by Roche (Cobas e411 model, Germany) instrument. The sensitivity of measurement was 0.1 ng/ml.

Determination of thigh muscle CSA

Housh et al. (1995) equations were used for thigh muscle CSA estimation (21). Knapik et al (1996) reported that this method applicable for use in populations studies of young, healthy, active men and women (22). The mid-thigh circumferences were measured to nearest 0.1 cm with a tape fitted with a Gulick handle using the procedures described by ACSM (2005) (23). The anterior thigh skinfolds were measured to nearest 0.5 mm with Harpenden caliper by standard technique (23). The mid-thigh circumstance and skinfold measurements were taken midway between the inguinal crease and the proximal border of the patella. All anthropometric dimensions were taken by the same tester who had

previously demonstrated test-retest reliability of r > 0.90. Quadriceps, hamstrings and total thigh muscles CSA were estimated by following equations (21):

Quadriceps CSA = [2.52 × mid-thigh circumference (cm)]
– [1.25 × anterior thigh skinfold (mm)] – 45.13

Hamstrings CSA = [1.08 × mid-thigh circumference (cm)]
– [0.64 × anterior thigh skinfold (mm)] – 22.69

Total thigh muscle CSA = [4.68 × mid-thigh circumference (cm)]
– [2.09 × anterior thigh skinfold (mm)]– 80.99

Statistical analysis

Results were expressed as the mean ± SD and Shapiro-Wilk Test was applied to evaluate the normal distribution of variables. ANCOVA was used to assess the impact of the intervention while controlling the co-variant effects of the pre-test. Assumptions of normal distribution of scores and homogeneity of variance were evaluated. Paired t-test also, was used to assess the inter-group changes. The significance level of this study was set at $P<0.05$ and the data were analyzed using SPSS software for windows (version 17, SPSS, Inc., Chicago, IL).

3. Results

Anthropometric and body composition parameters of the subjects are presented in Table 1. No significant differences were observed on the anthropometric and body composition parameters of the subjects at baseline.

Table 1. Demographic characteristics (mean ± SD) of the subjects at baseline

	TRT group (mean±SD)	HD group (mean±SD)
Age (year)	26.6 ± 2.1	24.6 ± 1.3
Height (cm)	177.0 ± 6.7	174.8 ± 2.2
Body mass (kg)	79.4 ± 10.7	69.0 ± 6.8
BMI (kg/m^2)	25.4 ± 3.6	22.5 ± 2.0
Body fat (%)	9.1 ± 4.5	7.3 ± 2.5

There were no differences in strength between groups at baseline (Table 2). Our results showed that muscle strength increased after 8 weeks TRT and HD in leg press, squat, leg extension, prone leg curl, and dead lift ($P<0.05$). The results indicated that the increase of maximum strength in leg press, squat, prone leg curl, and dead lift was higher after 8 weeks TRT compared to the HD method ($P<0.05$). For leg extension no significant differences were observed between TRT and HD method.

As shown in the Table 2, quadriceps CSA, hamstring CSA and total thigh muscle CSA increased after 8 weeks TRT and HD and the increase of quadriceps CSA and total thigh muscle CSA was higher after 8 weeks HD compared to the TRT method ($P<0.05$). For hamstring CSA no significant differences were observed between TRT and HD method.

At the end, our data demonstrated that GH level had not significant changes after 8 weeks TRT or HD methods.

Table 2. Maximum strength, GH level and thigh muscle cross-sectional area (mean ± SD) of the subjects before and after training

	Baseline (mean±SD)	**After intervention (mean±SD)**	**Paired t-test (Sig)**	**ANCOVA**	**Changes (%)**
Leg press (kg)					
TRT (group)	180.0 ±11.5	222.5 ± 14.9	0.001*	0.02*	23.6
HD (group)	173.5 ± 4.7	205.5 ± 8.3	0.001*		18.4
Squat (kg)					
TRT (group)	75.5 ± 6.8	97.0 ± 9.7	0.001*	0.04*	28.4
HD (group)	72.5 ± 6.3	89.5 ± 3.6	0.001*		23.4
Leg extension (kg)					
TRT (group)	46.0 ± 3.9	63.0 ± 6.3	0.001*	0.2	36.9
HD (group)	42.5 ± 2.6	57.0 ± 3.4	0.001*		34.1
Prone leg curl (kg)					
TRT (group)	45.0 ± 5.7	65.6 ± 5.9	0.001*	0.003*	45.7
HD (group)	43.5 ± 3.3	58.0 ± 5.8	0.001*		33.3
Dead lift (kg)					
TRT (group)	49.0 ± 5.1	69.5 ± 6.8	0.001*	0.02*	41.8
HD (group)	44.0 ± 4.5	60.0 ± 4.7	0.001*		36.3

	Baseline (mean±SD)	After intervention (mean±SD)	Paired t-test (Sig)	ANCOVA	Changes (%)
GH (ng/ml)					
TRT (group)	0.58 ± 0.7	0.78 ± 0.7	0.2	0.9	34.4
HD (group)	0.57 ± 1.1	0.76 ± 0.9	0.4		33.3
Quadriceps CSA (cm^2)					
TRT (group)	80.3 ± 15.3	84.2 ± 15.9	0.001*	0.002*	5.2
HD (group)	70.9 ± 6.3	77.7 ± 6.1	0.001*		9.5
Hamstrings CSA (cm^2)					
TRT (group)	29.5 ± 6.8	31.6 ± 6.4	0.001*	0.2	7.1
HD (group)	26.3 ± 2.7	29.5 ± 2.6	0.001*		12.1
Total thigh muscle CSA (cm^2)					
TRT (group)	154.5 ± 28.9	160.5 ± 20.9	0.001*	0.001*	3.8
HD (group)	136.2 ± 11.8	148.3 ± 11.5	0.001*		8.8

Data are the mean ± SE of baseline and final values of the maximum strength GH level and thigh muscle CSA changes in each group. Comparison different significance between TRT and HD group after 8 weeks was determined by using the ANCOVA test. *P<0.05.

4. Discussion

Resistance training (RT) is an effective tool for stimulating muscle hypertrophy and improving strength. HD training is a new method that might improve muscle strength and hypertrophy. The effect of this method on thigh muscle hypertrophy is not well-known. The purpose of the present study was to examine the effects of HD versus TRT on thigh muscle CSA. Our results indicated that quadriceps CSA, hamstring CSA and total thigh muscle CSA increased after 8 weeks TRT and HD and the increase of quadriceps CSA and total thigh muscle CSA was higher after 8 weeks HD compared to the TRT method (P<0.05). For hamstring CSA no significant differences were observed between TRT and HD method.

In untrained subjects, muscle hypertrophy is virtually nonexistent during the initial stages of resistance training, with the majority of strength gains resulting from neural adaptations (24). Within a couple of months of training, however, hypertrophy begins to become the dominant factor, with the upper extremities shown to hypertrophy before the lower extremities (24,25). Genetic background, age, gender, and other factors have been shown to mediate the hypertrophic response to a training protocol, affecting both the rate and the total amount of gains in lean muscle mass (26). Further, it becomes progressively more difficult to increase lean muscle mass as one gains training experience, heightening the importance of proper routine design. Although muscle hypertrophy can be attained through a wide range of resistance training programs, the principle of specificity dictates that some routines will promote greater hypertrophy than others (27). During hypertrophy, contractile elements enlarge and the extracellular matrix expands to support growth (28). This is in contrast to hyperplasia, which results in an increase in the number of fibers within a muscle. Contractile hypertrophy can occur either by adding sarcomeres in series or in parallel. The majority of exercise-induced hypertrophy subsequent to TRT programs results from an increase of sarcomeres and myofibrils added in parallel (29,30). When skeletal muscle is subjected to an overload stimulus, it causes perturbations in myofibers and the related extracellular matrix. This sets off a chain of myogenic events that ultimately leads to an increase in the size and amounts of the myofibrillar contractile proteins actin and myosin, and the total number of sarcomeres in parallel. This, in turn, augments the diameter of individual fibers and thereby results in an increase in muscle CSA (31). Exercise-induced muscle hypertrophy is facilitated by a number of signaling pathways, whereby the effects of mechano-stimulation are molecularly transduced to downstream targets that shift muscle protein balance to favor synthesis over degradation. Several primary anabolic signaling pathways have been identified including Akt/mammalian target of rapamycin (mTOR), mitogen-activated protein kinase (MAPK), and calcium-(Ca^{2+}) dependent pathways.

Hormones and cytokines play an integral role in the hypertrophic response, serving as upstream regulators of anabolic processes. Elevated

anabolic hormone concentrations increase the likelihood of receptor interactions, facilitating protein metabolism and subsequent muscle growth (32). Many are also involved in satellite cell proliferation and differentiation and perhaps facilitate the binding of satellite cells to damaged fibers to aid in muscular repair (28,31).

The hormonal regulation of hypertrophy is complex, with many hormones and cytokines believed to contribute to the response. Hepato growth factor, Interleukin-5 (IL-5), Interleukin-6 (IL-6), fibroblast growth factor, and leukemia inhibitory factor, all have been shown to promote anabolism (31,33). Insulin also has been shown to possess anabolic properties, with greater effects on attenuating proteolysis rather than heightening protein synthesis. Insulin also is believed to induce mitosis and differentiation of satellite cells (28). Given that insulin levels are suppressed during exercise, however, it is not a modifiable aspect of an exercise regimen and thus will not be addressed further here. Various types of exercise have been shown to cause acute, and in some cases chronic, hormonal alterations that appear to play a role in mediating hypertrophic signaling systems (34). The 3 most widely studied of these hormones are insulin-like growth factor (IGF-1), testosterone, and GH. Whether the acute hormonal response to exercise provides a significant anabolic stimulus has been questioned by some researchers (35), however with the inherent experimental limitations in these studies and a larger body of prevailing basic and applied evidence to the contrary, such an overt dismissal of the importance of hormonal signaling in the physiological adaptations resulting from resistance exercise over a training period is without context and premature GH is a polypeptide hormone considered to have both anabolic and catabolic properties. Specifically, GH acts as a repartitioning agent to induce fat metabolism toward mobilization of triglycerides, and stimulating cellular uptake and incorporation of amino acids into various proteins, including muscle (28). In the absence of mechanical loading, GH preferentially upregulates the mRNA of systemic IGF-1, and mediating nonhepatic IGF-1 gene expression in an autocrine/paracrine manner (36). GH is secreted by the anterior pituitary gland and released in a pulsatile fashion, with the greatest nonexercise secretions occurring during sleep. More than 100 molecular isoforms of GH have been identified; however, most resistance

training studies have focused solely on the 22-kDa isoform, limiting conclusions. Recent research suggests a preferential release of multiple GH isoforms with extended half-lives during exercise, allowing for sustained action on target tissues (37). In addition to exerting effects on muscle tissue, GH also is involved in the regulation of immune function, bone modeling, and extracellular fluid volume. In total, GH is implicated as promoting over 450 actions in 84 cell types (38).

GH levels spike after the performance of various types of exercise (39). An exercise-induced increase in GH has been highly correlated with the magnitude of type I and type II muscle fiber hypertrophy (16). It is postulated that a transient GH increase may lead to an enhanced interaction with muscle cell receptors, facilitating fiber recovery and stimulating a hypertrophic response (40). GH is also thought to be involved in the training-induced increase of locally expressed IGF-1 (41). When combined with intense exercise, GH release is associated with marked upregulation of the IGF-1 gene in muscle so that more is spliced toward the MGF isoform (42). Some researchers have questioned whether GH does, in fact, have a significant hypertrophic effect on muscle tissue (43). Our results showed that GH level had not significant changes after 8 weeks TRT or HD methods. Several studies failed to find significant increases in muscle mass when GH was administered as part of a resistance training protocol (44,45). However, these protocols did not replicate the large spikes in GH seen post-exercise, nor did they take into account the time course of GH elevation in conjunction with myotrauma. Thus, it is impossible to draw conclusions from these studies as to whether an exercise-induced GH response is associated with skeletal muscle anabolism. Much is still unclear about the anabolic actions of GH, and further research is needed to fully elucidate its role in muscular development.

5. Conclusion

Generally our results suggested that HD is effective method than TRT method for increases of thigh muscle CSA. Buresh et al. (2009) show that strength training with <1 minute of rest between sets elicits a greater hormonal response than 2.5-minute rest intervals (46). Thus different time of rest between sets in HD and TRT methods might be

responsible for the higher increase of thigh muscle CSA in HD method compared to the TRT method.

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