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Effects of instability versus high-volume resistance training on thigh muscle cross-sectional area and hormonal adaptations

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Abstract

Introduction: Instability resistance training (IRT) is a combination of unique training movements aimed at improving strength, endurance, coordination, flexibility, power, and core stability within a single workout. The aim of present study was to comparison the effect of instability *vs.* high-volume resistance training (HVRT) on thigh muscles hypertrophy and hormonal adaptations.

Material & Methods: Based on physical health screening, twenty middle-aged men (aged: 26.5 ± 3.6 years; ± SD) selected as the subject. The subjects divided into two groups randomly: HVRT group (n=10) or IRT group (n=10). The subjects in the HVRT group were performed biceps brachii, triceps, chest press, lat pull down, side lateral raise, leg press, dead lift, squat, hamstring and calf sitting with 6 to 10 RMs in 4 sets and 1 min rest between sets for 8 weeks. The subjects in the IRT group were performed total resistance exercise (TRX) suspension training with 10 rep in 2 sets and 20 second rest between the sets for 8 weeks. Paired-sample t-test, independent- sample t-test, wilcoxon and Mann-witney U teases were use for data analyzing.

Results: The results indicated that quadriceps and total thigh muscles cross-sectional area (CSA) were increased after two types of resistance training (P<0.05) and hamstrings CSA was increased only after HVRT method. The data indicated that growth hormone (GH) and testosterone concentration and testosterone/cortisol ratio were increased after HVRT and IRT methods (P<0.05), however for cortisol levels no significant changes were observed.

Conclusions: In conclusion, it seems that instability and high volume resistance training-induced changes in anabolic hormones contribute in thigh muscles hypertrophy in untrained men.

Keywords: High volume resistance training, Instability resistance training, TRX training, Hypertrophy, Hormone

1. Introduction

High-volume resistance training (HVRT) sessions with short to moderate recovery between sets (< 3 min) are common practices employed for muscular hypertrophy (1-3). It has been suggested that a large volume of resistance training stimulus promotes more extensive metabolic stress and mechanical tension resulting in more substrate depletion, metabolite accumulation and muscle damage (4). These factors in turn trigger anabolic responses during recovery that lead to muscular hypertrophy (5). As the intensity of resistance exercise increases (resulting in increased activation of fast-twitch muscle fibers), a greater emphasis is placed on mechanical stress (6). In contrast, high-volume (i.e., greater number of repetitions concomitant with the use of short rest intervals) programs elicit greater metabolic stress (7). A minimum intensity threshold is necessary to maximally stimulate muscle activation for those programs targeting metabolic stress (7,8). Thus, metabolic stress is targeted by increasing resistance exercise volume and volume load and by reducing rest intervals between sets (7,8). 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 (9,10). 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 (9,11,12). Conversely, high-intensity (85-100% 1RM) and low volume programs (1-4 repetitions) primarily target muscle strength increases with secondary improvements in muscle hypertrophy (7,11,12). A high training volume is associated with an augmented anabolic hormone response to exercise (13,14) that thought to provide an enhanced stimulus for muscle hypertrophy (15,16).

Instability resistance training (IRT) and suspension training are relatively new mode of exercise that uses the exerciser's own body weight as resistance. Suspension training employs an assortment of upper and lower body exercises, which all require the individual to maintain balance while performing the various exercises (17). IRT refers to an approach to strength training that uses a system of ropes and webbing called a "suspension trainer" to allow users to work against their own body weight. The field of IRT is a form of resistance training that includes bodyweight exercises in which a variety of multi-planar, compound exercise movements could perform. IRT provides support and mobility to potentially improve strength, endurance, flexibility, and core stability within a single workout. IRT can be utilized by all fitness levels and is currently being used in fields such as physical therapy, occupational therapy, sports training, coaching, recreational fitness, and the military (18,19). The popularity and portability of suspension trainers necessitates that research be completed so that they can be used to their fullest capacity in rehabilitation, fitness, or home settings. IRT develops physical strength while using functional movements and dynamic positions. Total resistance exercise (TRX) suspension training is new sling training for an intense full-body workout in a short time. By the versatile exercises, not only power, but also coordination, stability and mobility can work effectively (18). The effects of IRT on muscle hypertrophy are unclear. Dudgeon et al. (2011) were studied the effects of suspension training on growth hormone axis. Their findings support the use of suspension training as a stimulus for anabolic hormone (18). By our knowledge, there is no study that was performed to examine the effect of IRT versus HVRT on muscle hypertrophy. Thus in the present study, we compared the effects of IRT *vs.* HVRT on thigh muscle cross-sectional area (CSA) and hormonal adaptations in untrained men.

2. Materials and Methods

Subjects

Twenty untrained healthy men (age: 26.5 ± 3.6 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 IRT group (n=10) or HVRT 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.

High-volume resistance 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. 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. 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 the HVRT group were performed biceps brachii, triceps, chest press, lat pull down, side lateral raise, leg press, dead lift, squat, hamstring and calf sitting with 6 to 10 RMs in 4 sets and 1 min rest between sets for 8 weeks (See Table 1). HVRT consisted of 60-90 min of station weight training per day, 3 days a week, for 8 weeks. General and specific warm-up was performed prior to each training session, and each training session was followed by cool-down.

Instability resistance training

For the IRT program, several weight lifting protocols were executed using a nonelastic, adjustable harness suspended 2.5 meters from the floor. The harness made of industrial-strength nylon webbing forms a one-piece system that splits into two handles to hold on to or support any body part (TRX® Suspension Training). Each study participant completed the suspension training workout according to a protocol commonly prescribed by Fitness Anywhere, Inc (20). IRT program is offered 3 days per week for 8 weeks according Table 1.

Table 1. Instability and High-volume resistance training program

	Workout	
N	**IRT**	**HVRT**
1	TRX® Biceps curl	Biceps Curl. Dumbell
2	TRX® Standding Triceps Press	Triceps Pushdown. Cable
3	Double TRX® Push Up	Chest Bench Press. Dumbbell
4	TRX® Chest Fly	Lat pull down. Cable
5	TRX® T Deltoid Fly	Side lateral raise. Dumbbell
6	TRX® Leg Extension	Leg press
7	TRX® Hamstring Runner	Dead lift, Barbell
8	TRX® Decline Pike Crunch	Lower extremity Back Squat,
9	TRX® Hip Press	Hamstring
10	TRX® Sumo Squat	Calf sitting

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. Cortisol and testosterone concentrations were measured in duplicate using Radio Immune Assay (RIA) kits (Immunotech A.S, France).

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):

$$\text{Quadriceps CSA} = [2.52\times \text{ mid-thigh circumference (cm)}] - [1.25\times \text{ anterior thigh skinfold (mm)}] - 45.13$$

$$\text{Hamstrings CSA} = [1.08\times \text{ mid-thigh circumference (cm)}] - [0.64\times \text{ anterior thigh skinfold (mm)}] - 22.69$$

$$\text{Total thigh muscle CSA} = [4.68\times \text{ mid-thigh circumference (cm)}] - [2.09\times \text{ anterior thigh skinfold (mm)}] - 80.99$$

Statistical analysis

Results were expressed as the mean ± SD and Shapiro-Wilk Test was applied to evaluate the normal distribution of variables. Paired-sample t-test, independent- sample t-test, wilcoxon and Mann-witney U teases were use for data analyzing. 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 2. No significant differences were observed on the anthropometric and body composition parameters of the subjects at baseline. The results showed that the body mass, BMI, body fat mass and body fat percent were decreased and lean body mass was increased after 8 weeks IRT and HVRT (P<0.05). The decreases of body mass, BMI, body fat mass and body fat percent in the IRT group were higher than the HVRT group (P<0.05). For lean body mass no significant difference was observed between two groups.

Table 1. Anthropometric, body composition and physiological characteristics (mean ± SD) of the subjects

	IRT (n=10)		**HVRT** (n=10)	
	Pretraining	Posttraining	Pretraining	Posttraining
Age (Year)	28.9 ± 2.4		24.1 ± 3.0	
Height (Cm)	178.6 ± 5.6		175.2 ± 4.1	
Body mass (Kg)	71.7 ± 7.8	69.8 ± 7.7*†	74.3 ± 14.0	74.9 ± 12.9*
BMI (Kg/m^2)	22.4 ± 2.0	21.9 ± 1.8*†	24.1 ± 4.1	24.3 ± 4.0*
Body fat mass (Kg)	10.7 ± 2.3	9.4 ± 2.0*†	11.5 ± 6.2	11.1 ± 5.2*
Body fat (%)	15.0 ± 2.3	13.3 ± 2.1*†	14.8 ± 6.1	14.3 ± 5.2*
Lean body mass (Kg)	61.0 ± 6.3	62.3 ± 6.5*	62.8 ± 8.2	64.0 ± 9.0*

† P<0.01 for between-group differences.

* P<0.01, pretraining *vs.* posttraining values.

As shown in the Table 2, quadriceps CSA and total thigh muscle CSA were increased after 8 weeks HVRT and IRT methods, however hamstring CSA was increased only after HVRT method (P<0.05).

Table 2. Thigh muscle CSA (mean ± SD) of the subjects before and after training

	Baseline (mean±SD)	After intervention (mean±SD)	Paired t-test (Sig)	Independent t-test	Changes (%)
Quadriceps CSA (cm^2)					
IRT (group)	40.8 ± 6.9	42.4 ± 8.2	0.01*	0.09	3.9
HVRT (group)	72.4 ± 4.6	75.2 ± 4.2	0.001*		3.8
Hamstrings CSA (cm^2)					
IRT (group)	13.2 ± 3.2	13.6 ± 3.7	0.09	0.005*	3.0
HVRT (group)	25.7 ± 1.7	27.2 ± 1.5	0.001*		5.8
Total thigh muscle CSA (cm^2)					
IRT (group)	80.8 ± 12.3	84.1 ± 14.6	0.007*	0.1	4.0
HVRT (group)	141.7 ± 9.3	147.0 ± 7.9	0.001*		3.7

* Significant differences (P<0.05)

Changes of GH level after IRT and HVRT methods are presented in the Figure 1. The date revealed that GH concentration was increased after both methods (P<0.05), however no significant differences were observed between two methods.

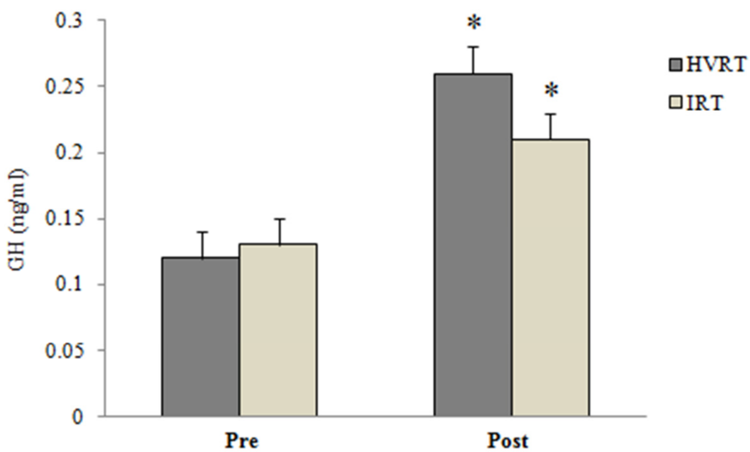

Figure 1. Changes of GH after the intervention
* Significant differences (P<0.05)

Changes of cortisol level after IRT and HVRT methods are presented in the Figure 2. The date indicated that cortisol concentration had not significant changes after these resistance training.

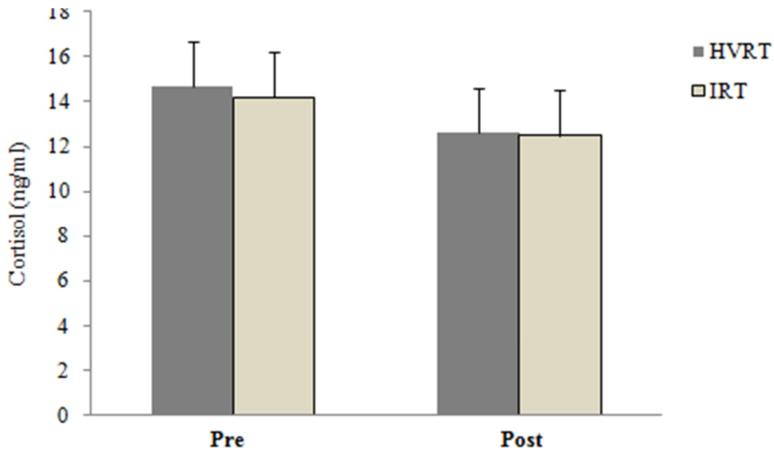

Figure 2. Changes of cortisol after the intervention

As shown in the Figure 3, testosterone level was increased after IRT and HVRT (P<0.05), however no significant differences were observed between these methods.

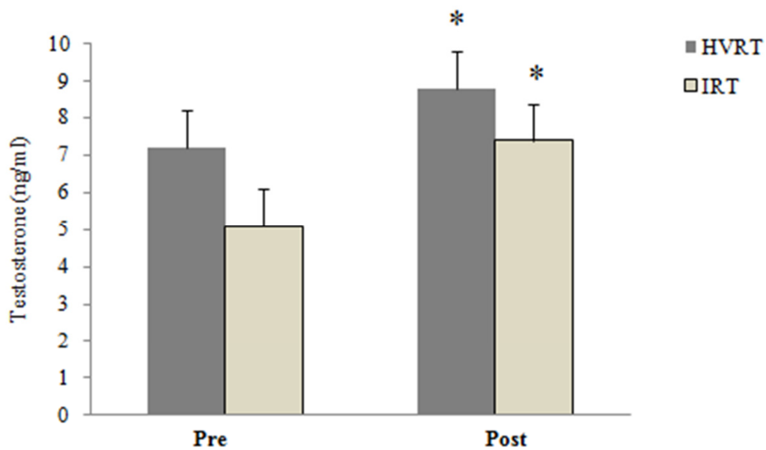

Figure 3. Changes of testosterone after the intervention
* Significant differences (P<0.05)

The data revealed that testosterone/cortisol ratio was increased after IRT and HVRT (P<0.05), however no significant differences were observed between these methods (See Figure 4).

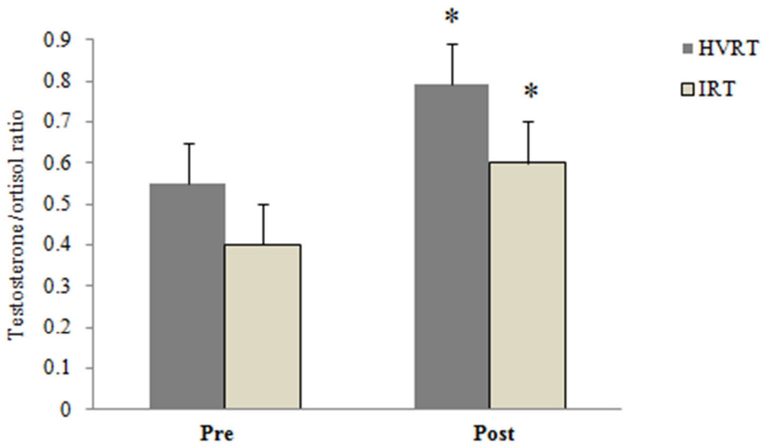

Figure 4. Changes of testosterone/corisol ratio after the intervention
* Significant differences (P<0.05)

4. Discussion

Resistance training is the most effective way for achieving an acute increase in the concentration of anabolic hormones, which in turn stimulates strength and muscle hypertrophy (24,25). Previous studies indicated that HVRT lead to acute hormonal responses (13,14). The amount or time of acute hormonal responses after resistance training may be related to gaining of muscle strength and hypertrophy (26). On the other hand, IRT is relatively new mode of exercise that uses the exerciser's own body weight as resistance. This method provides support and mobility to potentially improve strength, endurance, flexibility, and core stability within a single workout. The role of acute hormonal responses to resistance training is very important because anabolic hormones such as GH and testosterone will increase protein synthesis in muscle cells (27). The effects of IRT on muscle hypertrophy are not well known, thus the present study was done to determine the effect of IRT *vs.* HVRT on thigh muscles hypertrophy and hormonal adaptations.

Our results indicated that quadriceps CSA and total thigh muscle CSA were increased after 8 weeks HVRT and IRT methods, however hamstring CSA was increased only after HVRT method (P<0.05).

Resistance training, especially among initially untrained healthy subjects, leads to functional and structural adaptations in the neuromuscular system. Early training-induced increases in strength are accounted largely for by neural factors with a gradually increasing contribution of muscular hypertrophy of trained muscles as training proceeds (28). The increase in the CSA of trained muscles comes primarily from the increase in size of individual muscle fibers (29). In well-trained subjects, such as strength athletes, further improvements in strength and training-induced muscle hypertrophy are much more limited than in previously untrained subjects (30). Strength development and muscle hypertrophy is also dependent on the type and intensity of loading as well as volume of the resistance training of each individual strength athlete at a given time.

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 (4). The role of hormone regulation may become increasingly important for muscle hypertrophy and strength development in strength athletes with a long and intense training background (31). It has been suggested that muscle hypertrophy may be due to, at least in part, exercise-induced acute increase in endogenous anabolic hormones which may increase the number of receptor interactions thereby mediating changes in muscle size and neuromuscular function (32).

Our results showed that GH level was increased significantly after IRT and HVRT methods. GH levels spike after the performance of various types of exercise (8). Dudgeon et al. (2011) also indicated that the suspension training stimulates the GH axis and it is a useful method for anabolic hormone release (17). The accumulation of metabolic byproducts produced by exercising muscle is involved in the hypothalamic-stimulated release of GH (33,34). Specifically, metabolic acidosis in the form of lactate accumulation is involved in GH release, as evidenced by Luger and colleagues who infused lactate to produce the same serum concentrations observed during an exercise bout and observed roughly half the GH response resulting from exercise (33). An exercise-induced increase in GH has been highly correlated with the magnitude of type I and type II muscle fiber hypertrophy (15). 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 (35). GH is also thought to be involved in the training-induced increase of locally expressed IGF-1 (36). 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 (37).

Furthermore, the data revealed that testosterone concentration and testosterone/cortisol ratio were increased after IRT and HVRT ($P<0.05$), however no significant changes were observed in cortisol level after the intervention. Exercise-induced acute increase in serum testosterone concentration may be due to the increased gonadal secretion (38), testosterone release by vasodilatation (39), increases in luteinizing hormone pulsatility or production (40) and/or a direct (luteinizing hormone independent) stimulatory effect of lactate on the secretion of testosterone (41). The elevated exercise-induced symphatic activity may contribute to the augmented acute testosterone response (42). On the other hand, cortisol is primarily related to catabolic processes, as the degradation of proteins from skeletal muscles. However, a prominent role of the acute cortisol response is to meet the greater metabolic demands caused by the resistance exercise (43). In previous studies the acute cortisol response has occurred when the overall stress of the exercise protocol has been very high (44) and the response has been linked to the volume and/or intensity of total work to a given heavy-resistance exercise protocol (45). Long-term resistance training may lead to an overall reduction of acute cortisol responses to exercise stress in men (46).

5. Conclusion

Generally, the present study suggest that regulate HVRT and IRT stimulate anabolic hormones and these methods are useful for muscular hypertrophy in untrained men.

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Conflict of interests: There was no conflict of interest among authors.

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