Original Research

Increasing Lean Mass and Strength: A Comparison of High Frequency Strength Training to Lower Frequency Strength Training

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ABSTRACT

International Journal of Exercise Science 9(2): 159-167, 2016. The purpose of this study was to determine the effect strength training frequency has on improvements in lean mass and strength. Participants were 7 women and 12 men, age ($\bar{x}$ = 34.64 years ± 6.91 years), with strength training experience, training age ($\bar{x}$ = 51.16 months ± 39.02 months). Participants were assigned to one of two groups to equal baseline group demographics. High frequency training group (HFT) trained each muscle group as the agonist, 3 times per week, exercising with 3 sets per muscle group per session (3 total body workouts). Low frequency training group (LFT) trained each muscle group as the agonist one time per week, completing all 9 sets during that one workout. LFT consisted of a routine split over three days: 1) pectoralis, deltoids, and triceps; 2) upper back and biceps; 3) quadriceps, hamstrings, calves, and abdominals. Following eight weeks of training, HFT increased lean mass by 1.06 kg ± 1.78 kg, (1.9%), and LFT increased lean mass by .99 kg ± 1.31 kg, (2.0%). HFT strength improvements on the chest press was 9.07 kg ± 6.33 kg, (11%), and hack squat 20.16 kg ± 11.59 kg, (21%). LFT strength improvements on chest press was 5.80kg ± 4.26 kg, (7.0%), and hack squat 21.83 kg ± 11.17 kg, (24 %). No mean differences between groups were significant. These results suggest that HFT and LFT of equal set totals result in similar improvements in lean mass and strength, following 8 weeks of strength training.

KEY WORDS: Hypertrophy, exercise prescription, body composition, sarcopenia

INTRODUCTION

Strength training exercise offers many benefits for individuals of all ages and is perhaps critically important for the elderly (13). The benefits associated with strength training are: 1) increase in lean body mass; 2) increase in metabolic rate; 3) increase in bone density; 4) decrease risk of injury; and 5) building back lost muscle tissue that commonly occurs with aging (12, 17). Loss of skeletal muscle results in less strength to perform basic necessary activities such as standing from a seated position, grooming oneself, or preparing a meal. Loss of skeletal muscle is also the largest contributor to a reduction of resting metabolic rate possibly leading to overweightness or obesity (13).

Strength training is essential for athletes in sports that require speed, power, and strength (5). Additionally, strength training may benefit athletes involved in distance running, cycling, or weight class events such as wrestling and boxing for the preservation of lean body mass (5). According to Wernbom et al. the major challenge of strength training research is to isolate variables responsible for increasing lean body mass and strength (20). Wernbom et al. conclude that limited research is available to determine optimal training parameters for increasing lean body mass and strength (20).

There is much debate on the strength training variables most responsible for improvements in lean mass and strength. Frequency of strength training is possibly the most debated topic amongst coaches and fitness professionals (2). Several studies have demonstrated that a lower frequency of training may be as effective as higher frequency training (3, 4, 6, 7, 8). While other research indicates that two or three training sessions per muscle per week may produce up to twice the increase in cross sectional area of the quadriceps and elbow flexors, compared to one training session per week per muscle group (19, 21). However, weekly training volume (sets multiplied by number of repetitions completed) was not equal between groups in these investigations (19, 21). Tesch et al. (18) observed elite strength athletes and bodybuilders training each muscle group just once per week, incorporating many sets per muscle group and concluded that it is unknown if the training programs elite athletes and bodybuilders employ are superior for increasing lean body mass and strength compared to more frequent muscle group training.

The purpose of this investigation was to determine if high frequency agonistic strength training produces greater increases in lean mass and strength compared to lower frequency agonistic strength training, in strength trained participants with both groups completing an equal number of sets. It was hypothesized that high frequency agonistic strength training would result in greater increases in lean mass and strength compared to lower frequency agonistic strength training program.

METHODS

Participants

The study was approved by the University's Institutional Review Board and human subject committee. All participants read and signed a university approved informed consent after filling out a pre participation-screening questionnaire. The participants were healthy, males, and females, over the age of 18. Participants had experience in strength training, free of cardiovascular disease or major orthopedic condition that would limit their participation in a strength training program.

Nineteen participants completed all eight weeks of training and testing. Participants were placed in groups in an effort to balance male female ratio, mean training frequency for the three months prior to the study, cumulative lifetime strength training experience in months (training age), 1-RM strength for chest press, hack squat, and age of participants (see Table 1).

Protocol

To investigate changes in lean mass and strength, participants were assigned to a high frequency training group (HFT) or a low frequency group (LFT) to equal group demographics. LFT group trained each muscle group agonistically one time per

Table 1. Initial subject characteristics: group means and standard deviation.

Variable	HFT Mean ± SD	LFT Mean ± SD	*t*	*p*
n	10 (3 women, 7 men)	9 (4 women, 5 men)		
Age (years)	34.23 ± 10.99	35.14 ± 6.91	-0.214	0.833
Training Age (months)	47.50 ± 46.14	55.22 ± 31.56	-0.421	0.679
Training days per week prior to research	2.7 ± 1.83	3.0 ± 1.87	-0.353	0.728
Total Mass (kg)	80.27 ± 12.81	81.72 ± 15.95	-0.219	0.829
Lean Mass (kg)	55.34 ± 11.25	49.11 ± 11.51	1.192	0.250
Height (cm)	173.58 ± 8.71	167.47 ± 7.44	1.635	0.130
Hack Squat 1 RM (kg)	96.77 ± 40.31	90.15 ± 41.46	0.329	0.747
Chest Press 1 RM (kg)	84.82 ± 31.41	78.62 ± 40.78	0.374	0.713

Note. No significant differences between groups ($p>0.05$).

week, splitting the body over three days. Low frequency split routine: Day 1) pectoralis, deltoids, and triceps, Day 2) upper back and biceps, Day 3) quadriceps, hamstrings, calves, and abdominals. HFT group trained each muscle group agonistically three times per week, by training the whole body on three different days. All workouts were separated by 48 hours. The number of sets performed per week was the same for both groups, which consisted of nine total sets, per muscle group per week. All nine sets performed on one day per week for LFT, while HFT performed three sets on three occasions per week (see Table 1 and Table 2).

After one to two warm up sets, participants then performed their workout sets. All sets were performed to momentary muscle failure. Repetitions per set were eight-12, equaling a load intensity of ~75-85% of the participant's 1-RM (22). Once a participant could perform 12 repetitions with a given resistance, the participant increased the resistance on the following workout by 3%, to the nearest 1.3 kilograms. Repetitions were performed with control during both the eccentric and concentric phases. Both groups rested one to two minutes between sets. Daily workouts lasted ~45-60 minutes and the total training period was eight weeks. Previous research suggest that eight weeks of resistance training appears to be enough to result in increases in lean mass and strength (16). All sets per exercise were completed before moving to the next exercise. Larger muscle groups were trained first in all workouts and workouts were performed in the order they appear in Tables 2 and 3. All participants recorded their workouts in a training log (Excel, Microsoft Inc.). Data in training log included: date, resistance, number of

Table 2. High frequency training routine.

Muscle Group	Monday	Wednesday	Friday
Pectoralis	Flat Presses	Flat Presses	Incline Presses
Upper Back	Pulldowns	Pulldowns	Rows
Quadriceps	Leg Press	Lunges/Squats	Hack Squats
Gastrocnemius	Standing Calf Raises	Standing Calf Raises	Standing Calf Raises
Deltoids	Shoulder Press	Lateral Raises	Lateral Raises
Biceps	Seated Dbell Curls	Seated Dbell Curls	1 Arm Bench Curls
Triceps	Tricep Pushdown	Tricep Pushdown	1 Arm Tricep Ext.
Hamstrings	Seated Leg Curl	Seated Leg Curl	Back Extension
Sets x Reps	3x8-12 all ex.	3x8-12 all ex.	3x8-12 all ex.

Note. Workouts were performed with 48 hours rest between each workout, three days per week. Dbell=dumbbell, Ext=extension

repetitions performed per set, and total workout duration to ensure participant compliance and increasing workload from week to week. Participants were supervised throughout the eight weeks of training. Body composition was determined by dual energy x-ray absorptiometry (GE-LUNAR Prodigy) pre and post training that has a SEE of ~1.0% body fat (14). Participants were positioned supine, in the center of the table, and scanned with the total body default mode of the Prodigy software (encore, 2010). This analysis was used to determine changes in lean mass.

Prior to and following participation in eight weeks of exercise, 1-RM strength testing was performed (22). Participants did not strength train within 48 hours prior to strength testing. Lower body strength was measured on a 45-degree hack squat (Life Fitness, Schiller Park, IL). The hack squat machine was used due to a low learning curve required to perform the exercise at maximal effort. The warm up protocol for the hack squat consisted of one set of 10 repetitions with a load at 50% of participants' predicted 1-RM followed by three to four sets to reach the load required for a 1-RM. Rest interval between warm up sets and all 1-RM attempts was three minutes. Hack squat range of motion consisted of beginning at full extension followed by 90 degrees of knee flexion returning to full extension. Measurement of 90 degrees of knee flexion was measured using a goniometer for each participant while on the hack squat machine. The machine was marked when participants achieved the 90 degrees of knee flexion for consistent range of motion during all testing. Foot placement on the hack squat exercise was approximately shoulder width and measured to the nearest centimeter to aid in consistent exercise performance during pre and post testing. Participants back and hips remained firmly against the support padding on the hack squat.

Upper body strength was measured through the chest press exercise on a flat bench in a smith machine (Keys Fitness, Garland, TX). Warm ups on the chest press involved 10 repetitions with 50% of predicted 1-RM followed by three-four sets to achieve the resistance for a 1-RM (22).

Table 3. Low frequency training routine.

Monday	Wednesday	Friday
Pectoralis, Deltoids, Triceps	Upper Back, Biceps	Quadriceps, Hamstrings, Calves
(sets)x8-12 reps	(sets)x8-12 reps	(sets)x8-12 reps
Incline Press (3)	Pulldowns (6)	Hack Squats (3)
Flat Press (6)	Rows (3)	Leg Press (3)
Shoulder Press (3)	Seated Dbell Curls (6)	Lunges/Squats (3)
Lateral Raises (6)	1 Arm Bench Curls (3)	Seated Leg Curl (6)
Pushdowns (6)	Crunches (3)	Back Extension (3)
1 Arm Extensions (3)		Standing Calf Raise (9)

Note. Workouts were performed with 48 hours rest between each workout, three days per week. Dbell=dumbbell, Ext=extension

Rest intervals between warm up sets and all 1-RM attempts was three minutes. Chest press range of motion consisted of the guards being positioned on level four in the smith machine allowing the bar to travel no lower than 2-3 centimeters from participants chest. A full repetition started from full extension controlling the bar down to the guards followed by full extension. Setting the smith machine (Keys Fitness, Garland, TX) guards provided for stable assessment of strength regardless of participant. Participants performed the chest press with hips, and back positioned squarely on the bench and subjects feet placed flat on the floor. Distance between index fingers was measured to the nearest centimeter per participant to ensure equal exercise performance at pre and post testing. Repetitions were controlled with a one-second eccentric phase to eliminate momentum typical with the chest press followed by maximal effort concentrically.

Statistical Analysis

Mean values and standard deviation were calculated from each group for lean mass and strength changes. A two- tailed paired *t* test was conducted to determine if strength and lean mass improvements occurred within each group and a two-tailed *t* test to determine if the changes in lean mass and strength were significant between HFT and LFT (Excel, Microsoft Inc.). Significance for *t* tests was determined using an alpha level of ≤ 0.05

RESULTS

Both HFT and LFT resulted in similar changes in lean mass following eight weeks of training. Mean increase in lean mass for HFT was 1.06 kg ± 1.78 kg and .99 kg ± 1.31kg for LFT, these changes were not significant between groups, t (17) = 0.09, $p > 0.05$, (see Figure 1). Percent improvements in lean mass was 1.9% for HFT and 2.0% for LFT. There was not a significant effect for changes in lean body mass within groups for HFT, t (9) = 1.89, $p>0.05$ or LFT, t (9) = -2.27, $p > 0.05$ (Figure 1).

Mean (kg) strength changes for the chest press 1-RM was 9.07 kg ± 6.33 kg for HFT, and 5.8 kg ± 4.26 kg for LFT. Percent improvement for the chest press 1-RM was 11% for HFT, and 7% for LFT. Strength changes for the hack squat 1-RM was 20.16 kg ± 11.59 kg for HFT, and 21.83 kg ±11.17 kg for LFT. Percent improvement for the hack squat 1-RM was 21% for HFT, and 24% for LFT (Figures 2, and 3).

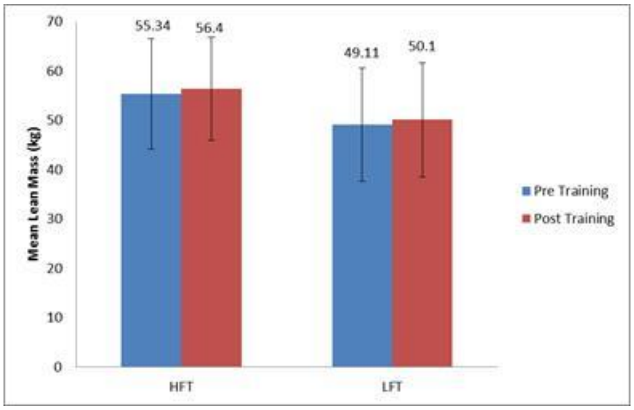

Figure 1. Mean change in lean body mass (kg) from pre to post training. Not significant from pre training ($p > 0.05$).

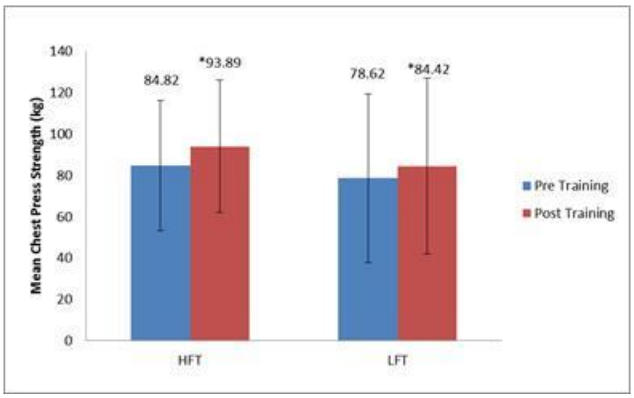

Figure 2. Mean change in chest press strength (kg) from pre to post training.* Significantly different from pre training ($p < 0.05$).

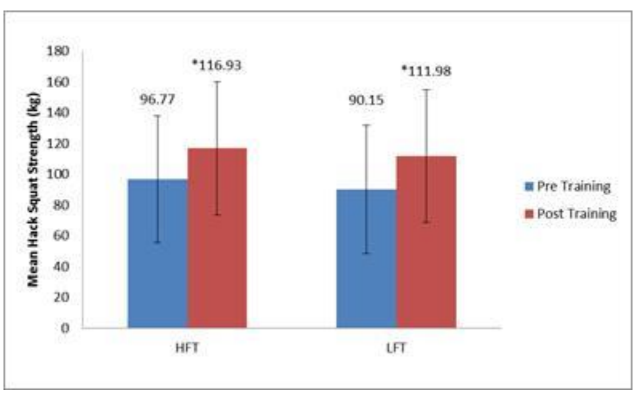

Figure 3. Mean change in hack squat strength (kg) from pre to post training. *Significantly different from pre training ($p < 0.05$).

There was not a significant effect between the two groups in chest press 1-RM t (17) = 1.31, $p > 0.05$ or hack squat 1-RM t (15) = -0.30, $p > 0.05$. There was a significant effect within groups for chest press 1-RM, HFT t (9) = -4.54, p < 0.05, and LFT t (8) = -4.08, p < 0.05. There was a significant effect within groups in hack squat 1-RM for HFT, t (8) = -5.22, $p < 0.05$, and LFT t (7) = -5.53, $p < 0.05$ (Figures 2, and 3).

DISCUSSION

The purpose of this study was to determine if high frequency agonistic strength training (HFT), would produce greater strength and lean mass gains than lower frequency agonistic strength training (LFT) in healthy, trained men and women. Both HFT and LFT produced similar improvements in strength and lean mass, and these findings are supported by other studies (1, 3, 4, 6, 7). Kamandulis et al. in a similar study, examined changes in leg strength and cross sectional area (CSA) in active young men, for seven weeks (8). The authors found no significant difference in quadriceps strength or CSA between a higher frequency group (three workouts per week) versus a lower frequency group (one workout per week) with total set count being 10.

McLester et al. in a similar study, presented results that differ from the current study (10). McLester et al. had participants exercising with three sets once per week vs. one set three times per week, for 12 weeks (10). Their results demonstrated greater gains in strength (62%) for the higher frequency group. The current study had participants exercising with three times as many sets per week, nine vs. three in McLester et al. Perhaps volume of training (number of sets x reps) is more important than frequency per week for increasing lean mass and strength, as Candow and Burke concluded when they compared a frequency of two versus three times per week of equal volume (1). Several studies have investigated changes in lean mass and strength comparing low volume (1 set) vs. higher volume (3 or more sets per week) resulting in superior improvements in lean mass and strength for higher volume programs (9, 11, 15).

The current study resulted in chest press strength improvements of 11 % for HFT and 7 % for LFT. Hack squat strength improved 21 % for HFT and 24% for LFT, not statistically different and these results are similar to Kamandulis et al. (8). Kamandulis et al. demonstrated a 1.5% greater improvement in leg press strength in their LFT group compared to their HFT group (8). The explanation for this difference in adaptation of upper and lower body is unexplained and needs further study.

Lean mass improvements for the current study resulted in almost identical increases with 1.9% for HFT and 2.0% for LFT. These findings are similar to the results of other studies, that lower frequency training is equally as effective as higher frequency training in improving lean mass during an 8 week training period (1, 3, 4, 7, 8).

Controlling for training volume is a limitation of this investigation. Volume is typically defined as sets x repetitions completed x load (22). The LFT group performed all 9 exercise sets for a muscle group on one day. To maintain the repetitions completed per set, at the prescribed number of 8-12, a decrease in training load may be necessary especially for the muscles of the upper body for LFT. This decrease in training load would then result in a decrease in total training volume compared to the HFT group that performed only 3 sets per muscle group and were less likely to experience as much cumulative fatigue in an exercise session. Additionally, having different subjects in each group represents challenges of equal training load per exercise, due to differences in strength on any given exercise or all exercises. The purpose of this investigation was to measure improvements in lean mass and strength with equal set totals per week within the 8-12 repetition range, and this potential variance in volume represents one of the differences between the two protocols. However, the possible decreases in training volume did not impact the effectiveness of LFT for improving lean mass or strength in these participants. Additional inherent limitations include, nutritional status of participants, recovery, strength training experience, and concurrent training.

The results of this study demonstrate that both High Frequency Training (three sets on three occasions per week) and Low Frequency Training (nine sets, on one occasion per week) produced similar improvements in lean mass and strength in these 19 active, men and women, following an eight week training period.

Results from this investigation demonstrate that strength and lean mass improvements are similar in prior strength trained participants when comparing a training frequency of once vs. three times per week completing nine sets per muscle group. Perhaps coaches, therapists, and exercise professionals could use both training frequencies within a periodized training program. Additional research is warranted in examining long term adaptations to a variety of training programs.

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