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Loading Zones: Implications for Strength and Hypertrophy

Intensity of Load Basics

- Expressed as a percentage of 1RM for a given exercise
- Easiest application is to a "repetition range"
  - Heavy loading: 1-5 RM (~87-100% 1RM)
  - Moderate loading: 6-12 RM (65-85% 1RM)
  - Low loading: 15+ RM (<60% 1RM)
The Strength-Endurance Continuum

![Strength-Endurance Continuum Diagram]

**Literature Summary**

- Good evidence that muscular strength and endurance exist at opposite ends of the continuum.

- Studies to date are conflicting as to whether an optimal hypertrophy range exists:
  - Conclusions limited by a paucity of research in resistance-trained subjects
  - Differences in training volume can confound results

**Effects of Different Volume-Equated Resistance Training Loading Strategies on Muscular Adaptations in Well-Trained Men**

- 17 resistance-trained men (over 4 years experience) randomly assigned to either:
  - Bodybuilding group: 3 sets of ~10RM using split routine with 30 sec rest intervals
  - Powerlifting group: 7 sets of ~3RM using total body routine with 3 min rest intervals

- Volume load equated between groups

- Training carried out 3 days/week for 8 weeks
Hypertrophy Findings
• Similar increases in thickness of biceps and quadriceps from pre- to post-testing for both HT and ST (12.6 and 12.7%, respectively).

Results for Strength
• After adjusting for baseline values, increases in 1RMBP significantly greater for ST versus HT and a trend for greater increases in 1RMBS noted in favor of ST versus HT.

Perspective on Findings
• Findings suggest that hypertrophy can be equally achieved either through heavy or moderate loading provided volume load is equated in well-trained subjects.
  – Supports a dose-response relationship for hypertrophy.
Beyond the Numbers

• Continued heavy loading seems to increase the potential for injury
  — 2 subjects pulled out because of injury and several others complained of “sore joints” on exit interview
• The bodybuilding-type routine took about ¼ as much time to complete with similar results for hypertrophy
  — Capacity to increase volume and potentially improve gains
• Those in ST group generally felt highly fatigued from the workouts; those in the HT group did not
  — HT potentially could have endured additional volume.

Other Studies Equating Volume

• Similar hypertrophy increases in quads and pectorals shown by Klemp et al (2016) in a cohort of 16 resistance-trained males using 8-12RM vs 2-6RM


Reconciling Volume Equated Data

• Hypertrophy-related improvements in experienced lifters appear to be similar at the lower end of the strength-endurance continuum when volume is equated
  — Either heavy or moderate loads can be employed to promote hypertrophic increases given equated volume loads
  — The greater efficiency for bodybuilding-type training makes it a more attractive option for many individuals
  — The shorter workout duration and less fatigue in bodybuilding-type routines may allow for additional volume and thus greater overall gains
What About Non-Equated Volume?

- 29 resistance trained men assigned to either a 4 x 10-12RM or 4 x 3-5RM for 8 weeks
  - 1 min rest for moderate rep; 3 mins rest for low rep
- Greater increases in lean arm mass in low rep group and greater percentage of subjects exceeded minimum difference for arm and leg mass, and VL muscle thickness
- 1RM bench increases greater for low rep; no differences in 1RM squat

New Study from Our Lab!

- Schoenfeld et al (in review) investigated 3 x 2-4 versus 3 x 8-12
  - Significantly greater increases in vastus lateralis thickness seen for moderate; ES favored moderate for elbow flexor thickness
  - 1RM squat significantly greater for low rep and ES favored low for 1RM bench
Reconciling Non-Equated Volume Data

- Differences between studies could be due to short rest intervals for moderate rep condition in Mangine et al.
- Jury still out

What About Low Loads?

- Current guidelines state loads of \( \geq 65\% \) 1RM are necessary to elicit favorable increases in hypertrophy.
- Postulated that heavy loading is required to fully recruit higher threshold motor units.

Key Point!

- Maximal muscle growth is predicated on recruiting as many MUs as possible in the target muscles and achieving high firing rates in these MUs for a sufficient length of time to fully stimulate the fibers.
Fiber Types 101

- Type I - “Endurance-related”
  - ~50% of fibers in an average muscle
  - Peak tension in 110 ms (slow twitch)
- Type II – “Strength-related”
  - Peak tension in 50 ms (fast twitch)
  - Type Ila (~25% of fibers in an average muscle)
  - Type IIX (~25% of fibers in an average muscle)

MHC Fiber Continuum

Fiber Type Proportions in Humans

- Each person has different fiber type ratios
- Arm and thigh ratios are similar in one person
  - Endurance athlete: type I predominates
  - Power athlete: type II predominates
- Can be specific to a given muscle
  - Soleus: high proportion of type I in almost everyone
Colin Jackson vs. Other Sprinters

Hypertrophy in Fiber Types

- Both type I (slow twitch) fibers and type II (fast twitch) fibers have the ability to hypertrophy.
- Research shows that the growth capacity of fast twitch fibers is approximately 50% greater than that of slow twitch fibers.

Training Specificity and Hypertrophy

- Findings of hypertrophic superiority of type II muscle fibers are specific to training intensities at which study is performed (>60% 1RM).
- Superior capacity for growth may be more a consequence of the models in which we study them than an intrinsic property of the fiber itself.
- Bodybuilders display greater Type I fiber hypertrophy than powerlifters, presumably as a result of routinely training with higher repetition ranges.
Basics of Fiber Recruitment

- Recruit minimum number of motor units needed
  - Smallest (type I) motor units recruited first
  - Midsized (type IIa) motor units recruited next
  - Largest (type IIx) motor units recruited last
- Recruited in same order each time
- Size principle: order of recruitment of motor units directly related to size of α-motor neuron

Size Principle Illustrated

The Role of Fatigue in Recruitment

- Often claimed that only high intensity or power training recruits the highest threshold MUs
- Discounts the role of fatigue in the stimulation of hypertrophy, and its ability to influence motor unit recruitment.
  - As fatigue increases in a low-load set, recruitment threshold of higher threshold MUs is progressively reduced
  - Provides a mechanism whereby low-load strength training can activate fast-twitch motor units and ultimately, stimulate the growth of these fibers.
Recruitment in Low Load Training

- Cook et al. found that EMG amplitude of the quadriceps during knee extension exercise to failure was significantly greater at a high intensity (70% 1RM) than at low intensity (20% 1RM).
- Wernbom et al. showed similar EMG activity in low-load training vs. BFR at 30% 1RM
  - Suga et al. found BFR at 30% did not achieve extent of recruitment seen at high-intensities

What We Found

- Markedly greater activation seen during heavy load training compared to using light loads
  - ~35% greater mean activation of VM
  - ~54% greater mean activation of VL
  - ~68% greater mean activation of RF
  - ~131% greater mean activation of BF
Example of EMG Tracing

- EMG amplitude remained greater at 80% vs 30% 1RM
- mCSA increased more from pre- to post-exercise for 30% than 80% 1RM
  - Mechanism for growth response due to cell swelling?

Follow Up Activation Study

Upper body muscle activation during low- versus high-load resistance exercise in the bench press

- Bench press at 80% 1RM shows significantly greater mean EMG amplitude in the pec major compared to 50%
  - ~17% greater in sternal head
  - ~9% greater in clavicular head
• 15 men performed 3 sets to failure of dumbbell forearm flexion with 80% (n = 8) or 30% (n = 7) 1RM
• Results showed no significant differences in EMG amplitude between groups
• Findings suggest possible muscle specific differences in the responses to high- vs low-load RT.

• Absolute differences favored the heavier load condition and these differences magnified across sets
• Between-subject design compromised statistical power (n=15)
• Analysis comprised 191 subjects from 8 studies.
• Both high- and low-load training produced significant growth but there was a trend for greater growth with heavier loading.

Fiber Type Adaptations
• There is some evidence that lower load training promotes greater hypertrophy of type I fibers while higher load training optimizes type II hypertrophy.
• Hypothetically increased time-under-tension is necessary to fully stimulate type I fibers.
• Higher loads may be necessary to fully stimulate fibers associated with the highest threshold MUs.

Bottom Line
• Substantial hypertrophy can be achieved with low load training provided it is carried out to muscular failure.
• Emerging research indicates there is a fiber type specific response to training with low- vs. high loads.
Caveat to the Meta-Analysis

• All previous studies were carried out in untrained subjects

**UNTIL NOW...**

The Study

**EFFECTS OF LOW- vs. HIGH-LOAD RESISTANCE TRAINING ON MUSCLE STRENGTH AND HYPERTROPHY IN WELL-TRAINED MEN**

Edmond J. Durrinaga, MD, D. D. Peters, and B. C. Conti

• 18 well-trained subjects (>3 years RT experience)
• Random assignment to either a ~10 RM or 30 RM group
• All subjects performed 3 sets of 7 different exercises for upper and lower body 3 days/week
• Training carried out over 8 weeks

Results

• Hypertrophy similar between groups:
  - Biceps brachii: 8.5% low vs. 5.2% high
  - Triceps brachii: 5.2% low vs. 6.0% high
  - Quadriceps femoris: 9.5% low vs. 9.3 high
• Strength:
  - 1RM bench press: 2% low vs. 6.5% high
  - 1RM squat: 8.7% vs. 19.6 high
• Muscular endurance:
  - 50% 1RM bench press to failure: 16.6% low
• Recent study reports similar results
  – No differences in hypertrophy
  – Greater gains in maximal bench press strength for the heavy load condition

What About Combining Rep Ranges?

• 19 resistance-trained men randomly assigned to 1 of 2 experimental groups:
  − Constant-rep routine that trained using 8-12 RM per set
  − Varied-rep routine that trained with 2-4 RM per set on Day 1, 8-12 RM per set on Day 2, and 20-30 RM on Day 3 for 8 weeks.
Results

- No statistically significant differences found between conditions in any of the outcomes studied.
  - P-values favored the VARIED condition in several outcome measures showing likelihood of an effect.
  - Magnitude-based statistics indicated a benefit for VARIED for upper body hypertrophy, strength, and muscular endurance; no effect size differences noted for lower body outcomes.

Graded Response to Loading

CSA values of vastus lateralis pre, 6 weeks and post TF for the groups G20, G40, G60 and G80. * greater than the corresponding pre training values (p< 0.05). # greater than the corresponding post training values G20 (p< 0.05).

Graded Response to Loading

CSA values of elbow flexor pre, 6 weeks and post TF for the groups G20, G40, G60 and G80. * greater than the corresponding pre training values (p< 0.05). # greater than the corresponding post training values G20 (p< 0.05).
Practical Applications

- If goal is to maximize overall muscle mass, train across a wide spectrum of repetition ranges.
  - Higher intensity exercise appears necessary to fully stimulate fast-twitch fiber growth while lower intensity exercise preferentially enhances hypertrophy in slow-twitch fibers.
- If goal is to maximize strength, higher loads should be favored over lighter loads
  - Gains in strength are greater with high as compared to low load training even when a comparable hypertrophic response occurs

“Light Weights” is a Relative Term!

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Questions?

Thank you for coming!

I can be reached through my site:

www.lookgreatnaked.com