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BRIDGING THE GAP

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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
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

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- 17 resistance-trained men (over 4 years experience) randomly assigned to either:
  - Bodybuilding group - 3 sets of ~10RM using split routine with 90 sec rest intervals
  - Powerlifting group - 7 sets of ~3RM using total body routine with 3 min rest intervals
- Volume load equated been 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 1RM BP significantly greater for ST versus HT and a trend for greater increases in 1RM BS 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 ≥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 IIa (~25% of fibers in an average muscle)
  – Type IIx (~25% of fibers in an average muscle)
MHC Fiber Continuum

MHC Fiber Type Continuum

I  I/IIa  IIa  IIa/x  IIx

Slow  Fast

Oxidative  Glycolytic
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 \( \alpha \)-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
Muscle activation during low- versus high-load resistance training in well-trained men

Brad J. Schoenfeld · Bret Contreras · Jeffrey M. Willardson · Fabio Fontana · Gul Tiryaki-Sommez

- 12 young men experienced in resistance training
- Performed leg press at 75% and 30% 1RM to muscular failure
- Evaluated quads and hamstrings activity by EMG testing
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

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• 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)
Key Points!

Activation is not just a function of recruitment, but also includes rate coding and other factors!

Activation studies do not necessarily reflect long-term muscular adaptations to RT!
Muscular adaptations in low- versus high-load resistance training: A meta-analysis

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- 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
The Study

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

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- 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
Neither load nor systemic hormones determine resistance training-mediated hypertrophy or strength gains in resistance-trained young men

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

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