

The Titanic Towers of Muscle Strength and Hypertrophy

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“The most successful resistance training programs are those that are designed towards target-specific training goals.” Do you want to be successful in training? “Plan for it.”

Recommended Reading: Ratamess, N. et al. (2009). Progression models in resistance training for healthy adults. *Medicine & Science in Sports and Exercise*, 41(3), 687-708.

- I. The structure of skeletal muscle: Let’s take a visual journey through muscle (smooth, cardiac, skeletal with a comparison of skeletal and cardiac muscle physiology)
 - A. 430 muscles in 215 pairs, chemical composition (75% H₂O, 20% protein, 5% other)
 - B. Epimysium (fascia), perimysium around fasciculus, endomysium around each cell and connective tissue is composed primarily of collagen (tensile strength of steel)
 - C. Muscle cell (same as muscle fiber) may contain up to a 1000 nuclei; nuclear domain
 - D. Sarcolemma (polarized membrane), muscle’s sarcoplasm has glycogen & myoglobin
 - E. Type 1 Fibers: low force, low ATPase, low ATP stores, low PC stores, slow contraction speeds, slow relaxation time, low glycolytic enzyme activity, high endurance, high TG stores, high myoglobin content, high aerobic enzymes, high capillary and high mitochondrial density
 - F. Type 2 Fibers: high force, high ATPase, high ATP stores, high PC stores, fast contraction speeds, fast relaxation time, high glycolytic enzyme activity, low endurance, low TG stores, low myoglobin content, low aerobic enzymes, low capillary and low mitochondrial density
 - G. No difference in Type I and II fibers in intramuscular glycogen stores
 - H. Discussion of sarcomere (smallest functional unit of muscle—means segment)
 1. Z disk, I band, A band, H zone, Actin protein, Myosin protein and Titin protein
 2. Type I, Type IIa, Type IIx isoforms
 3. M-line is housing for creatine phosphate; C protein for myosin, desmin—like glue
 4. New research revelations with Titin—largest protein known; 27,000 amino acids; big contributor to passive tension as it restricts passive stretch of the sarcomere
- II. Sliding filament theory: Andrew Huxley and Ralph Niedergerke (Nature 1954)
 - A. The contractile process
 1. Nerve impulse arrives at neuromuscular junction; depolarization of sarcolemma
 2. Depolarization of T-tubules triggers release of calcium ions from the sarcoplasmic reticulum SR (terminal cisternae is the end housing of SR)
 3. Calcium ion is bound by troponin causing a shift of tropomyosin
 4. ATP goes through ‘hydrolysis’ to ADP and Pi and energy release
 5. Myosin attaches to actin at unblocked binding sites (on actin)
 6. ADP and Pi drop off myosin: Actin filaments move toward center of A band with a ratchet-like movement called the Power Stroke
 - B. ATP Hydrolysis, ATPase, origin of acidosis, S1 unit independence
 1. H⁺ is cause of acidosis from hydrolysis of ATP to ADP, Pi and energy release
 2. Independence of S1 units—practical application to humans

- C. End of muscle action: calcium ions depleted or nerve stimulus ceases: shift of tropomyosin to inhibit actin and myosin binding
 - D. Basic nerve anatomy: dendrite, nucleus, axon hillock, myelin sheath, node of ranvier
 - E. Action potential travels 225 miles/hour which is 100-120 meters/sec
- III. Resistance training concepts and the current theory of hypertrophy
- A. Progression: "The act of moving forward or advancing toward a specific goal over time until the target goal has been achieved." Attain by increase in exercise intensity, increase in total repetitions at a given intensity, altering the repetition tempo, shortening rest periods, and/or increasing training volume (reps x sets)
 - B. Specificity: "All training adaptations are 'specific' to the stimulus applied:" Specificity to muscle actions (CON, ECC, or ISOM), speed of movement, range of motion, muscle groups trained, energy systems involved, and intensity and volume of training
 - C. Maintenance: "Refers to the program's design to maintain the current level of muscular fitness." Note, to attain higher muscular fitness the proper manipulation of load, exercise selection, exercise order, number of reps, number of sets, and frequency of workouts is needed
 - D. Motor unit recruitment: dictated by size of motor units and load placed upon them
 - E. Hypertrophy satellite cell theory discussed and illustrated
- IV. Training characteristics for strength
- A. Novice to Intermediate: loads of 60-70% of 1RM, 8-12 reps, 1-3 sets, 2-3 min rest between multiple sets, slow to moderate contraction speeds, novice train 2-3 days/week while intermediate may train 3-4 days/week
 - B. Advanced: loads of 80-100% of 1RM, 5-6 reps, multiple sets in a periodized sequence, 1-2 min rest between multiple sets, mixed contraction speeds (slow, moderate, fast), train 3-4 days/week
 - C. Novice, Intermediate and Advanced enthusiasts should do unilateral, bilateral and multi-joint exercise selections, large muscle groups prior to small muscle groups, progressively increase load from 2-10%, CON, ECC, and ISOM actions included
- V. Training characteristics for hypertrophy
- A. Novice to Intermediate: loads of 60-85% of 1RM, 8-12 reps, 1-3 sets, 1-2 min rest between multiple sets, slow to moderate contraction speeds, novice train 2-3 days/week while intermediate may train 3-4 days/week for split training
 - B. Advanced: loads of 70-100% of 1RM, 1-12 reps at 6-12RM), 3-6 sets in a periodized sequence, 1-2 min rest between multiple sets, mixed contraction speeds (slow, moderate, fast), train 3-4 days/week
 - C. Novice, Intermediate and Advanced enthusiasts should do unilateral, bilateral and multi-joint exercise selections, large muscle groups prior to small muscle groups, progressively increase load from 2-10%, CON, ECC, and ISOM actions included
- VI. Training characteristics for endurance

- A. Novice to Intermediate: 10-15 reps, 1-3 sets, 1-2 min rest between multiple sets or < 1 min in circuit training, mixed contraction speeds, novice train 2-3 days/week while intermediate may train 3-4 days/week and 4 days/week for split training
 - B. Advanced: 10-25 reps, multiple sets, 1-2 min rest between multiple sets or < 1 min in circuit training, mixed contraction speeds (slow, moderate, fast), train 3-4 days/week
 - C. Novice, Intermediate and Advanced enthusiasts should do unilateral, bilateral and multi-joint exercise selections, large muscle groups prior to small muscle groups, progressively increase load from 2-10%, CON, ECC, and ISOM actions included
- VII. Special Topic: Should you always train to failure?
- A. Muscular fatigue: point during exercise when the neuromuscular system can no longer produce adequate force to overcome workload
 - B. What is the theoretical basis for training to failure? Activate the greatest # of motor units. Mixed and inconclusive research on this topic
 - C. Precautions to always training to failure: may lead to overtraining and overuse injuries; has been shown to lead to a decrease in IGF-1 (a growth promoting hormone)
 - D. Practical applications: alternate going to failure in sets or workouts; training failure should be varied, as all other acute variables of resistance exercise; stop a set when technique is being compromised; for special populations, function and stabilization may be more important than training to failure

What are the BEST resistance training programs? "Periodization programs have consistently been shown in the research to be the superior training programs." Ratamess et al. 2009.

- VIII. Periodization planning overview
- A. Current training status/needs assessment of client
 - B. Individualize goals
 - C. Accessible resources for training (i.e., equipment)
 - D. Time and schedule of training
 - E. Strategically plan phases
 - F. Ongoing evaluation and assessment
 - G. Systematic progression

Periodization models: linear vs. nonlinear! What can we learn from the research?

Periodization: Linear vs. reverse linear vs. daily undulating for Endurance

Study: 60 males & females, trained lower body 2x a week (3 sets) in 15 wk study; knee extension tested

Linear (SPECIAL Note: reverse linear is simply in the reverse order of linear by weeks)

Weeks 1-5 25RM Rep zone

Weeks 6-10, 20RM Rep zone

Weeks 11-15, 15RM Rep zone

Daily undulating periodization (non-linear)

Wk1: Day 1 is 25RM Rep zone, Day 2 is 20RM Rep zone

Wk2: Day 3 is 15RM Rep zone, Day 4 is 25RM Rep zone

Wk3: Day 5 is 20RM Rep zone, Day 6 is 15RM Rep zone

Program continues in this undulating sequence for 15 weeks. **Study results: No difference!**

Periodization: Linear vs. daily undulating for Strength

Study: 20 males trained for 3 sets of bench, 3 sets of leg press in a 12-week study (3 days/wk)

Linear

Weeks 1-4 8RM Rep zone

Weeks 5-8, 6RM Rep zone

Weeks 9-12, 4RM Rep zone

Daily undulating

Each week progressed in the following sequence for the 12-week study

Mon (8RM for all exercises), Wed (6RM for all exercises), Fri (4RM for all exercises)

Results: Daily undulating elicits superior results. Why?...Unknown at this time.

New Periodization Study: Linear vs. Reverse Linear for Strength (12-week mesocycle)

20 females in 12 week total body training workout 3 days/week

Tests for 1RM of bench press, lat pull-down, arm curl, and leg extension

Weeks 1-3 Rep zones: 10-12 reps, 8-10 reps, 6-8 reps

Week 4: High Volume Training Week; 12 RM for all exercises

Weeks 5-7 Rep zones: 8-10 reps, 6-8 reps, 4-6 reps

Week 8: High Volume Training Week; 12 RM for all exercises

Weeks 9-11 Rep zones: 6-8 reps, 4-6 reps, 2-4 reps

Week 12: High Volume Training Week; 12 RM for all exercises

Training Exercises: Alternate 'A' & 'B' Workouts: 'A' (bench press, incline fly, dumbbell shoulder press, lateral raise, standing arm curl, biceps preacher curl, triceps extension, close-grip bench press); 'B' (back squat, leg extension, leg curl, glute kickbacks, hip abduction, hip adduction, standing heel raise, lat pull-down, seated row). Example of training: On one week the subjects did Training 'A' on Mon. & Fri. and Training 'B' on Wed. The next week subjects did Training 'A' on Wed. and Training 'B' on Mon. & Fri.

Rest Intervals between sets: 60 seconds between 10-12 repetitions; 80 seconds between 8-10 repetitions; 100 seconds between 6 to 8 repetitions; 120 seconds between 4-6 reps

Results: Linear periodization superior for strength development

What is the Newest Undulating Periodization Model: Random Order Undulating

Periodization: (Daily) Undulating: day to day variation of intensity/volume program

Rep Zones: 3-5 reps, 8-10 reps, 12-15 reps: weekly random order changes in sequence

Options {12-15 RM, 3-5 RM, 8-10 RM}, {8-10 RM, 12-15 RM, 3-5 RM}, {8-10 RM, 3-5 RM, 12-15 RM}, {3-5 RM, 8-10 RM, 12-15 RM}, {12-15 RM, 8-10 RM, 3-5 RM}

Total body workout: change exercises daily working all major muscle groups

Why does periodization work? Fiber type theory?

What is the Very NEWEST Periodization Approach? Mixed Methods Periodization

Linear periodization, reverse linear periodization, undulating periodization, random order undulating periodization. Order and duration individualized to client needs and goals.

What New Ideas in Resistance Training Are Ahead?

NOTE: Several Periodization Articles with all references on Len's WEB Page!