Muscle Mania: Everything About Muscles: Strength and Performance

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Note: A major part of this lecture is a visual journey through muscle.

I. The structure of skeletal muscle
   A. 430 muscles in 215 pairs, chemical composition (75% H_20, 20% protein, 5% other)
   B. Why do you feel bigger when you start resistance exercise? Inflammation
   C. Epimysium (fascia), perimysium around fasciculus, endomysium around cell
   D. Sarcolemma, sarcoplasm, myofibrils, muscle cell (same as muscle fiber)
   E. How is that muscle can stretch 50% beyond its resting length; connective tissue only 2%? Introducing the fascinating caveolae protein
   F. Discussion of a skeletal muscle fiber (cell): multiple nuclei, nuclear 'domain', polarized plasma membrane (why it is called the sarcolemma-carries a charge)
   G. Sarcoplasm vs. cytoplasm (cytosol); glycogen and myoglobin differences
   H. Sarcoplasmic reticulum structure: mesh-like housing of Ca^{2+}, and T-tubules
   I. Discussion of sarcomere (smallest functional unit of muscle—means segment)
      1. Z disk, I band, A band, H zone
      2. Actin protein
      3. Myosin protein and Titin proteins
      4. Type I, Type IIa, Type II b/x (or Type IIx) isoforms
      5. New research on M-line; (C protein for myosin integrity, desmin—like glue)
      6. New research revelations with Titin—larges protein know; 27,000 amino acids; molecular weight 10x greater than average protein, passive tension

II. Sliding Filament Theory: Andrew Huxley and Emmeline Jean Hanson
   A. The contractile process: a molecular action drama!
      1. Nerve impulse arrives at neuromuscular junction; deporlarization across sarcolemma
      2. Depolarization of T-tubules triggers release of calcium from sarcoplasmic reticulum (terminal cisternae)
      3. Calcium is bound by troponin causing a shift of tropomyosin
      4. ATP goes through 'hydrolysis' to ADP and Pi
      5. Myosin attaches to actin at unblocked sites
      6. ADP and Pi drop off myosin: Actin filaments move toward center of A band: Called Power Stroke
   B. Cross-bridge cycle (or cycling)
      1. New ATP molecules bind to myosin heads. This causes the release of myosin heads from attachments to actin. In the meantime, other myosin heads have been bound to other attachment sites to maintain contraction cross-bridge cycling.
      2. If other nearby attachment sites on actin are unblocked, the previously released myosin heads may be reattached; ATP is split and myosin heads plus thin filaments move further toward the center of the A band (shortening occurs)

3. New ATP molecules bind to myosin heads to cause their release from actin. Cross bridge cycling continues as long as nerve impulses continue and ATP is available.
4. Discussion of ATP's role in muscle contraction
5. Anaerobic glycolysis, ATP-PC, oxidation of carbohydrate
6. Independence of S1 units—practical application to humans

C. End of muscle action: calcium 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. Description of action potential: Resting membrane potential is –70 mV
1. Sodium influx followed by propagation of action potential
2. Repolarization due to potassium efflux
3. Cell homeostasis regulated by sodium/potassium pump
4. Action potential travels 225 miles/hour (or 100-120 meters/s)

III. Real World applications
A. Training and understanding the most adaptable tissue in the body
B. What causes a person's muscles to stop when doing a set (momentary fatigue)?
1. Neuromuscular fatigue: breakdown of aceylcholine at neuromuscular junction
2. Muscle fatigue: 1) H+ interfere with Calcium ions and 2) acidosis slows ATPase

C. Review of fiber types. Type I, Type IIa, Type IIb/x
1. Differences due to different myosin ATPase on the myosin heads
2. Fast twitch have more highly developed sarcoplasmic reticulum

D. Fiber type conversion discussion
E. Can you change your fiber type?
F. What is the motor unit? The ONE nerve and the many fibers innervated by that nerve.
G. Understanding the motor unit recruitment patterns (Type I, Type IIa, Type IIb/x)
H. How much faster do fast twitch fibers contract? 2 to 10 x faster
I. Hypertrophy! How much can fibers grow?
1. 20% to 70% where as most studies show 20% to 45%
2. Fast twitch are two times as large in size

J. Hypertrophy! Visual explanation/discussion of the satellite cell theory
K. Review of hypertrophic factors from resistance training.
1. Increase in size of contractile proteins
2. Increase in number of contractile proteins
3. Increase in sarcoplasm
4. Increase in connective tissue
5. Increase in bone mass and mineral density

6. No change in number of fibers and no hyperplasia (splitting of fibers)

L. What are the early strength gains?
   1. Increase in number of motor units firing
   2. Increase in synchronization of motor units
   3. Increase in synergistic muscles
   4. Thus there is an increase in activation of contractile apparatus

M. Single set versus Multiple Set? Or is it Multiple Exercise?

N. Why does an eccentric action develop more force than a concentric or isometric?

O. More myosin remain attached to actin during the eccentric action

P. Titin's major role in eccentric contraction

Q. How much more testosterone in males than females? 10 to 30 times

R. Why are some people always firm or tone while others are less firm?

S. Muscle bias (firmness): 30% of myosin alternating the binding/unbinding at rest

T. What is the historical root of progressive resistance exercise?

U. Why are muscles angular in shape?

V. What happens as muscle ages? Type grouping (shape of muscle fibers); fiber size decreases, loss of fast-twitch fibers, ability to activate motor units decreases—all phenomenon are modifiable!

W. What happens as you gain flexibility? Lose flexibility? Observe the sarcomeres

X. Periodization: Traditional

Hypertrophy, 1-5 Sets, 9-12 Reps, 2-3 Wks, Emphasis Type I, IIa Fibers
Strength/Hypertrophy, 1-5 Sets, 6-8 Reps, 2-3 Wks, Emphasis Type IIa Fibers
Strength, 1-5 Sets, 1-5 Reps, 2-3 Wks, Emphasis Type IIbx Fibers
Transition, 1-2 Sets, 13-20 Reps, 1-2 Wks, Emphasis Type I Fibers

Periodization: Undulating: day to day variation of intensity program
Rep Zones: 3-5 reps, 8-10 reps, 12-15 reps
Total body workout: change exercises daily and rotate rep zones
Options for 3-day and 2-day training scheme presenter (research review on Len's WEB page—refer to article Circuit vs. Periodized Training for Women)

Periodization: Linear for Strength (12-week mesocycle)

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

Start mesocycle from beginning

References on Len's WEB Page

BEST Sources:

Lieber, R. L. (2002). Skeletal Muscle Structure, Function, & Plasticity (2nd edition). Lippincott Williams & Wilkins publishers.

Jones, D., Round, J., de Haan, A. (2004). Skeletal Muscle: From Molecules to Movement, Churchill Livingstone publishers.

Also see Len's article entitled, The Mystery of Skeletal Muscle Hypertrophy on Len's WEB page: drlenkravitz.com