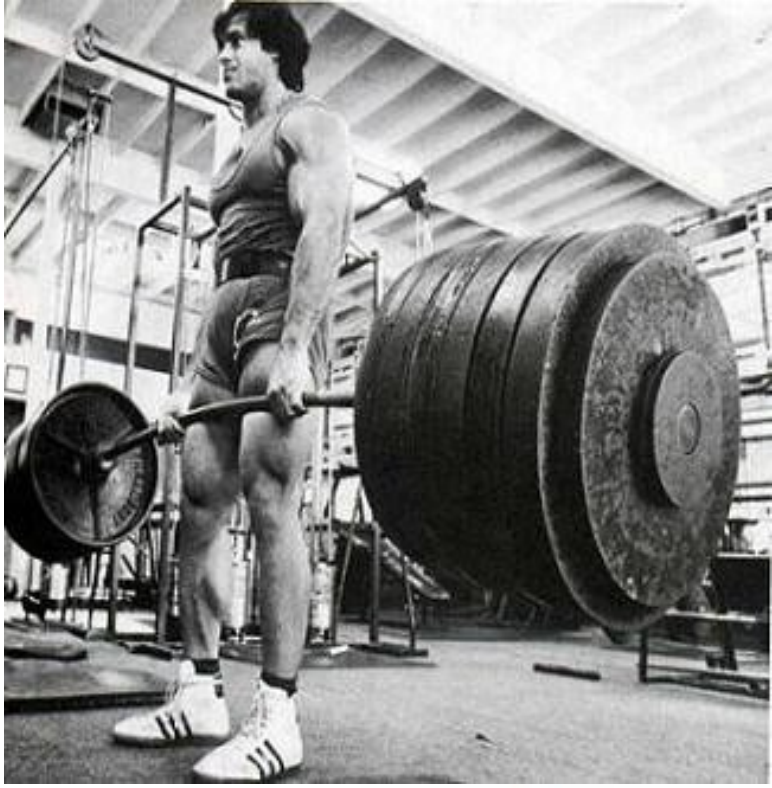
Chapter 4

Muscular Strength and Endurance



KIN 217

Functions of Muscle Tissues

- Functions: provide stability and postural tone, allow purposeful movement, heat production.
- Muscle mass constitutes: 40 to 50% of body weight
  - Heat loss: relation to the square area of skin
  - Heat production: relation to the cubic volume of mass
- Muscles are conductors
  - Respond to electrical stimulation by contracting

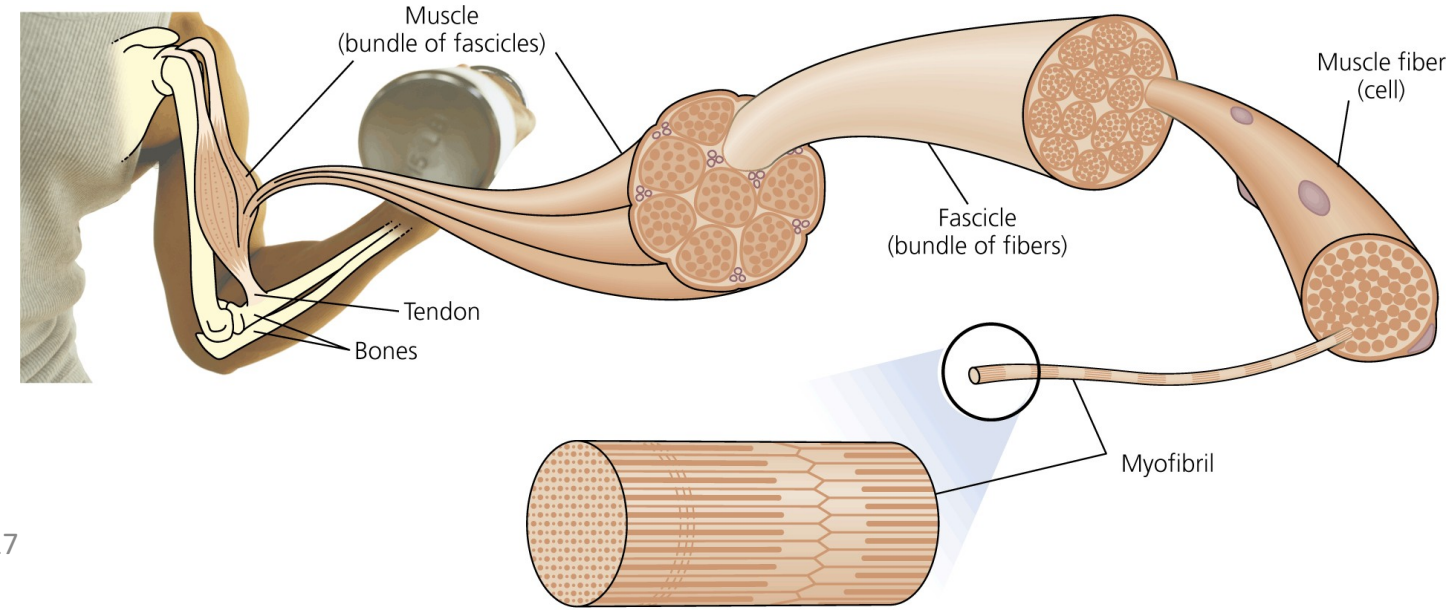
"Muscles shorten actively, cannot lengthen actively"

Muscular Strength and Endurance

- Well-developed muscles can assist with:
  - Daily routines- activities of daily living
  - Protection from injury
  - Enhancement of your overall well being
- Muscular strength: is the amount of force a muscle can produce with a single maximum effort
- Muscular endurance: is the ability to resist fatigue while holding or repeating a muscular contraction

Skeletal Muscle Tissue

- Muscles consist of individual *muscle fibers (cells)* connected in bundles
- Muscle fibers are made up of smaller protein structures called *myofibrils*

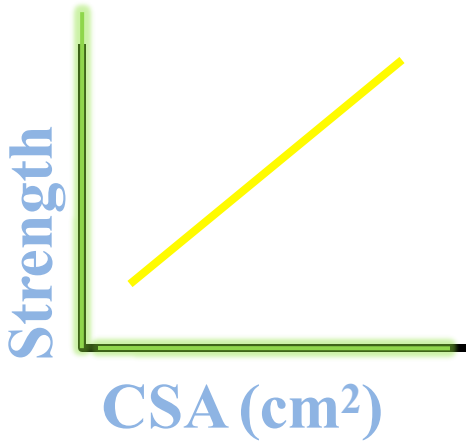


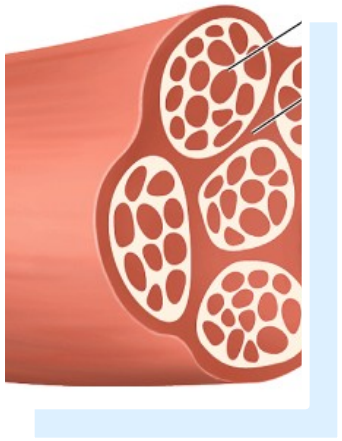
Hypertrophy

Increase in size of muscle fibers (diameter) due to:

- ↑ number of myofibrils per fiber
  - ↑ contractile protein (actin and myosin)
  - ↑ amounts connective tissue

Strength of muscle directly related to its crosssectional area (CSA)





Neural factors

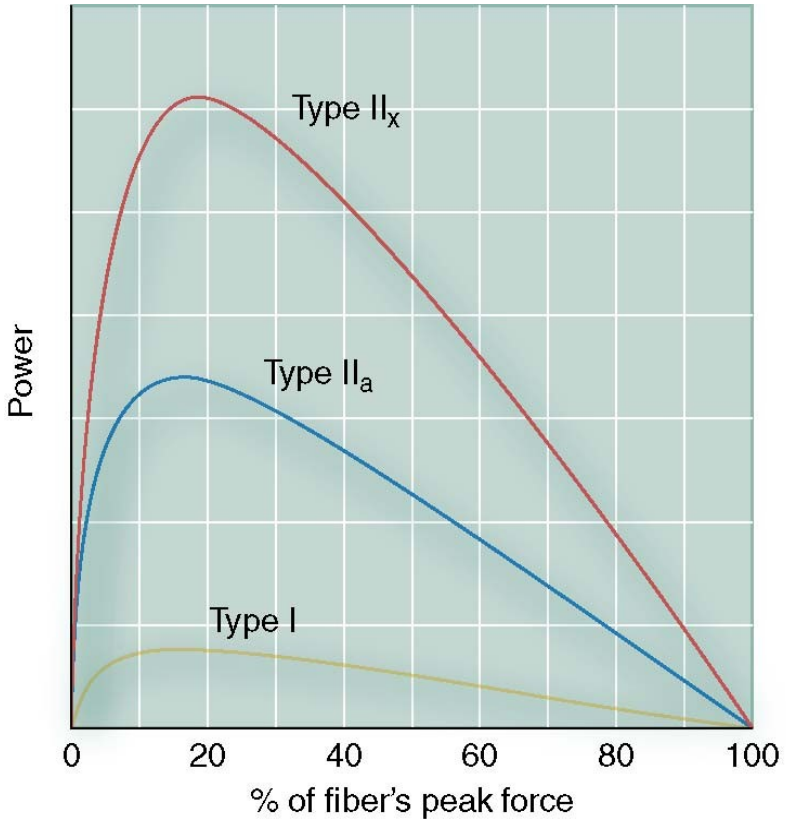
- You can also produce more force because of synchronization of muscle firing. First 6-8 weeks increases in strength are because of this.

Muscle Atrophy: *Immobilization*

- Atrophy is the reduction of the size of the muscle fiber due to inactivity or injury
  - Decreased rate of protein synthesis
  - Decreased strength
  - Decreased crosssectional area
  - Decreased neuromuscular activity
  - Muscles can recover when activity is resume

Muscle Fiber Types

- Slow twitch fibers (Type 1):
  - Fatigue resistant
  - Don’ t contract as rapidly and forcefully as fasttwitch fibers
  - Rely primarily on the aerobic energy system(Oxidative)
  - Smaller fibers
  - Red



Muscle Fiber Types

- Fast twitch fibers (Type 2):

- Contract rapidly and forcefully
- Fatigue more quickly than slow-twitch fibers
- Rely more on the anaerobic energy system
- Glycogen
- white
- larger

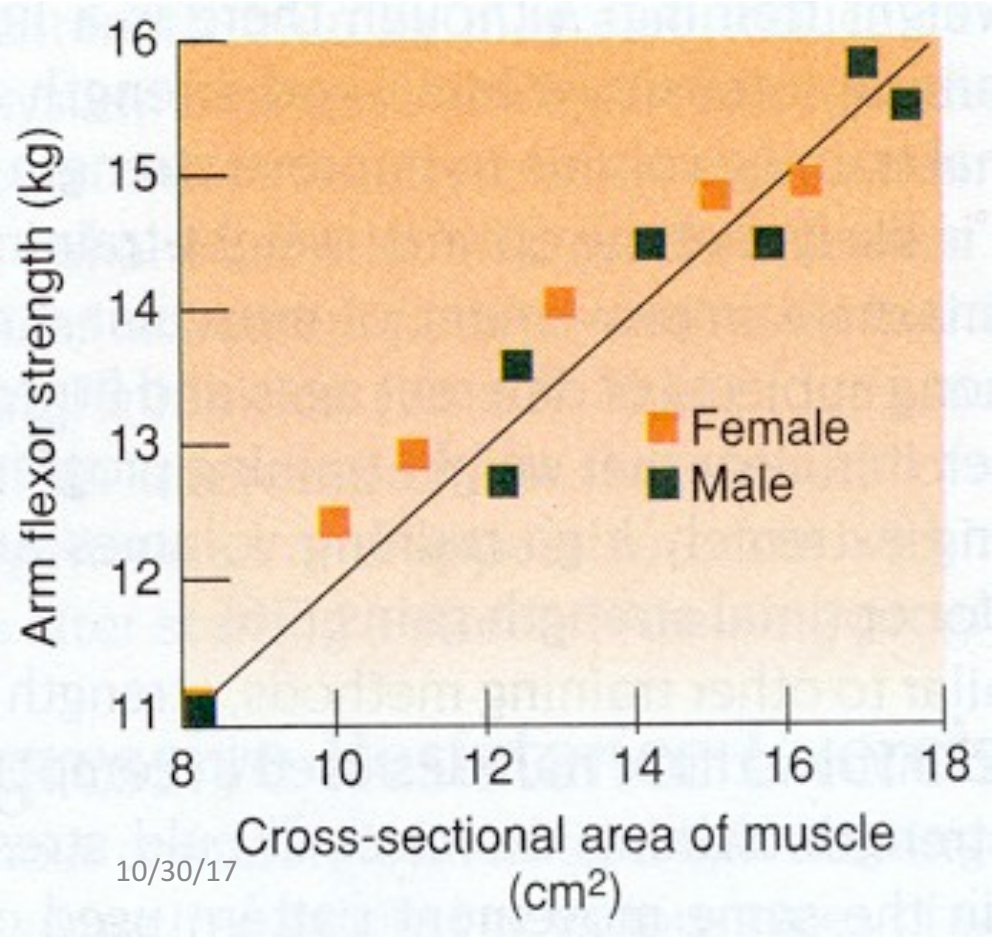
Fiber Types and Performance

- Power athletes
  - Sprinters/divers/gymnasts
  - Possess high percentage of fast fibers
- Endurance athletes
  - Distance runners/rowers/cyclists
  - Have high percentage of slow fibers
- Others
  - Weight lifters and nonathletes
  - Have about 50% slow and 50% fast fibers

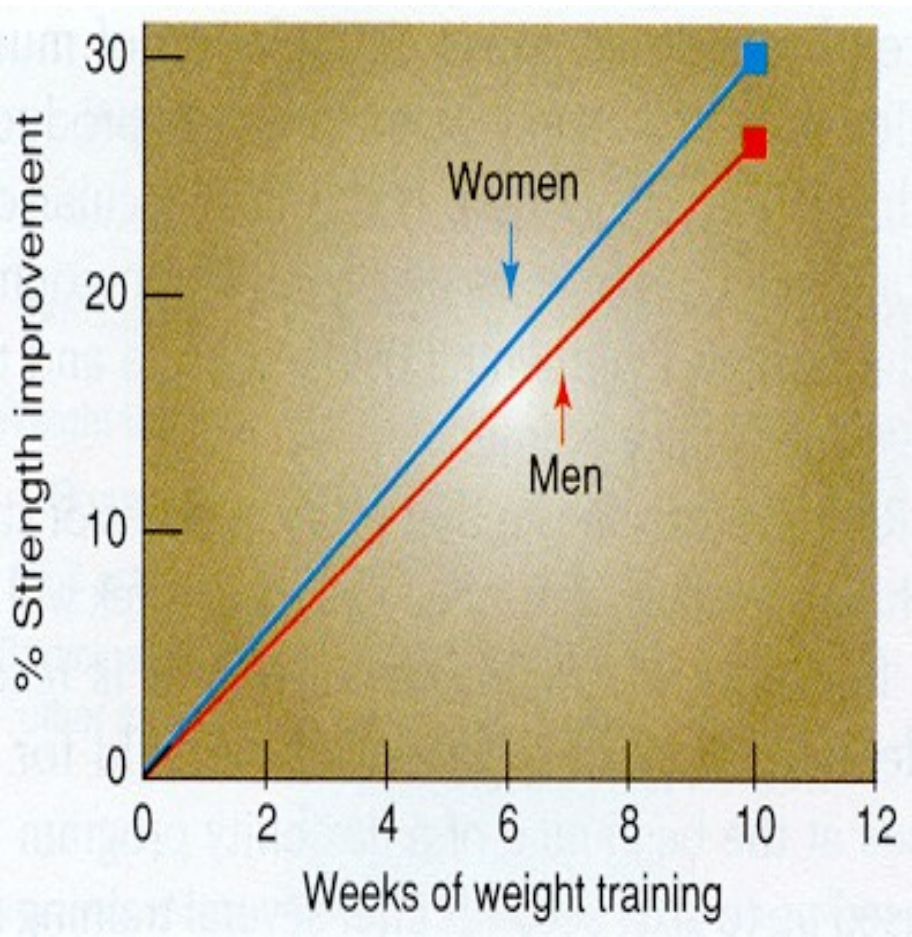
Fiber Type Changes

- To determine fiber type do muscle biopsies
- Easier to go from fast twitch to slow twitch fiber. Not the other way around

Strength as a Function of Muscle Cross Sectional Area



Training Induced Strength Changes in Men and Women

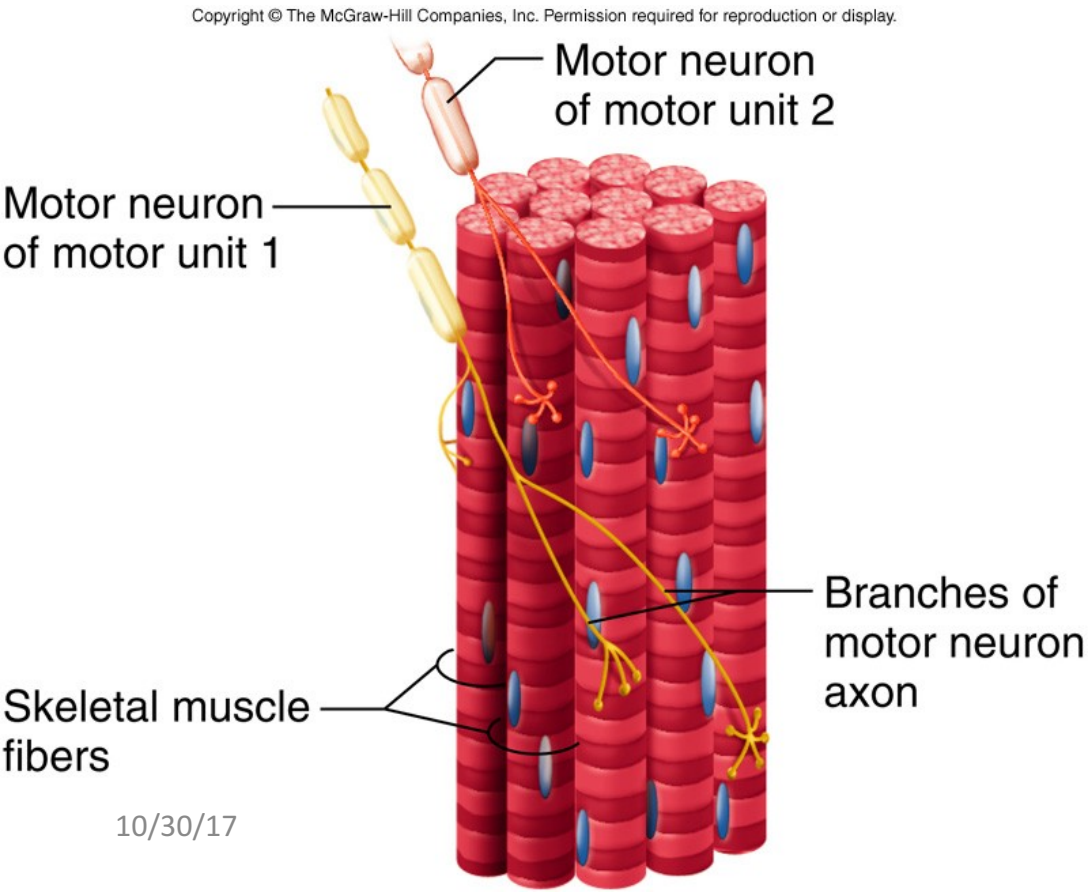


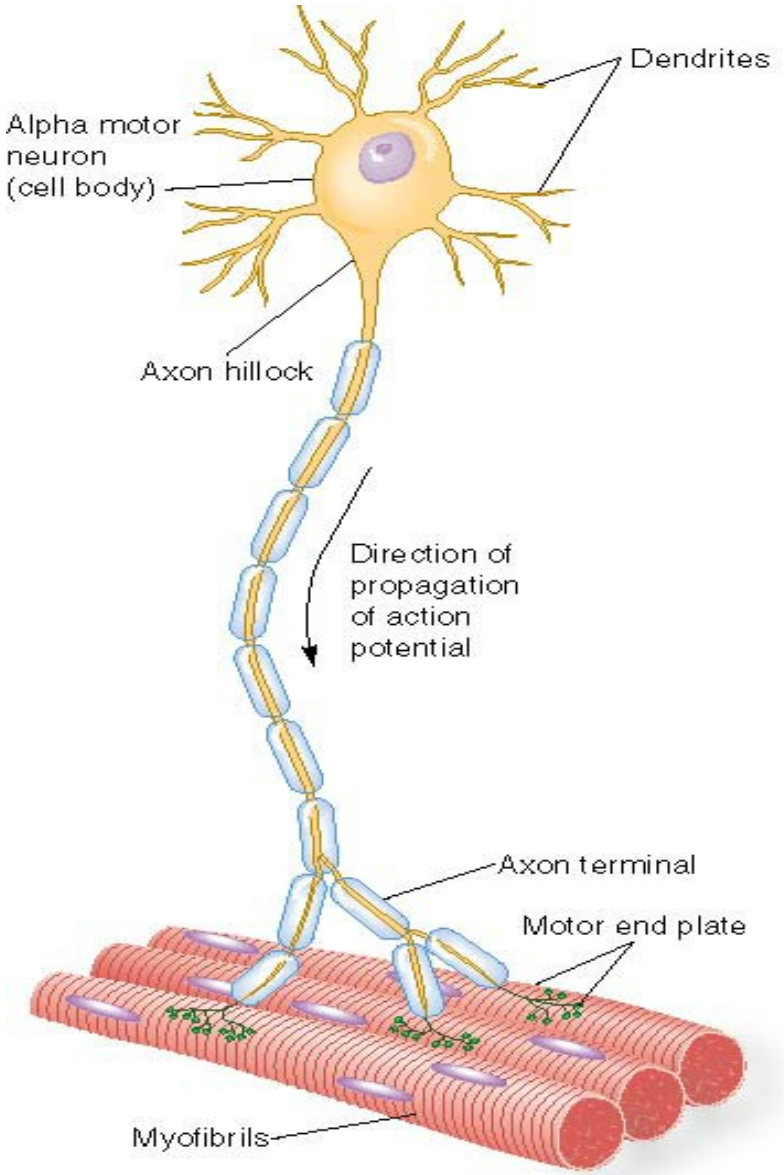
What Are Motor Units?

- A motor unit is made up of a nerve connected to a number of muscle fibers
  - Small motor units contain slow-twitch fibers
  - large motor units contain fast-twitch fibers
- Motor unit recruitment happens when strength is required; nerves assist with the action
  - The number and type of motor units recruited are dependent upon the amount of strength required
- Motor learning is the ability to improve the body' s ability to recruit motor units

Motor Unit

- One motor neuron innervates many muscle fibers, collectively called the *motor unit*

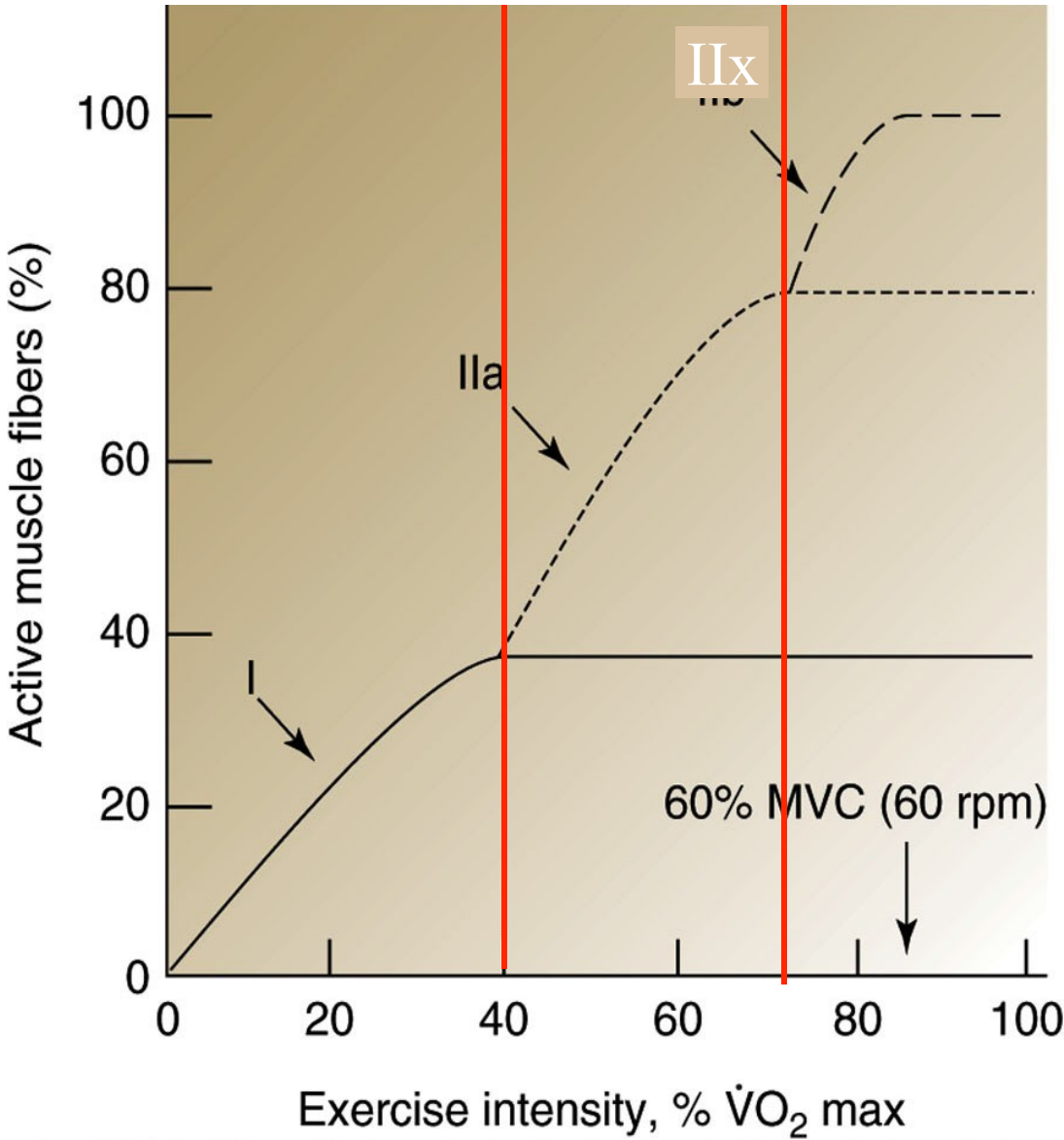




Size Principle: *Order of Muscle Fiber Type Recruitment*

1. Motor units are activated on the basis of a fixed order

   Type I → Type II



Benefits of Muscular Strength and Endurance

- Improved performance of physical activities
- Injury prevention
- Improved body composition
- Enhanced self image
- Improved muscle and bone health with aging
- Metabolic health

Refer to Table 4.1 for more benefits

Assessing Muscular Strength and Endurance

- Muscular strength is usually assessed by measuring the maximum amount of weight a person can lift one time (1 RM)
  - Also can use an estimated maximum test (submaximal lift)
  - Need to train for several weeks before testing
  - Retest after 6 to 12 weeks
- Muscular endurance is assessed by counting the maximum number of repetitions of a muscular contraction a person can perform to fatigue

Refer to Lab 4.1 for assessment instructions

Static vs. Dynamic Strength Training

- Static (isometric) exercise involves a muscle contraction without a change in the length of the muscle or joint angle
  - An example is pushing against a brick wall
  - Considered useful in strength building after an injury/surgery
  - Isometric contractions are usually held for 6 seconds

- Dynamic (isotonic) exercise involves a muscle contraction with a change in the length of the muscle
  - Two types
    - Concentric contraction
    - Eccentric contraction

Types of contractions

- Concentric- muscle force overcomes external force
- Isometric-muscle force equals external force
- Eccentric- external force overcomes muscle force
  - DOMS- Delayed onset Muscle Soreness
    - 24-48 hours after workout can get sore from Eccentric exercises
    - Workout lightly then next day with the same/or different muscle groups to increase circulation and get rid of waste products in the muscle

Comparing Static vs. Dynamic Exercises

- Static exercises: Isometric exercise
  - Muscle contraction without a change in the length of the muscle or the angle in the joint
  - Require no equipment
  - Build strength rapidly
  - Useful for rehabilitation
- Dynamic exercises: Isotonic exercise
  - Muscle contraction with a change in the length of the muscle
  - Can be performed without or with equipment
  - Can be used to develop strength or endurance
  - Use full range of motion
  - Are more popular with the general population

Training Methods

- Other Dynamic Methods
  - Constant and variable resistance
  - Plyometrics
  - Speed loading
  - Isokinetic
- Other Training Methods and Types of Equipment

Resistance Bands

Exercise (stability) balls

Pilates

Body weight exercises

Medicine balls

Suspension training

Acute Program Variables???

- A strength and conditioning expert has specific ″tools″ to work with, referred to as acute program variables
- Acute program variables ensure that the program will meet the specific needs of the athlete, allow optimal progression over time, and prevent training plateaus

Exercise Selection

- It is recommended that all major muscle groups be trained during resistance exercise programs exercise both agonist and antagonist muscle groups to prevent muscle imbalances and minimize *the risk of injury*

- *Several forms of exercise can be used in a sports specific conditioning program*

Exercise Order

- When all major muscle groups are being trained in a workout:

  - Alternate upper and lower body exercises either on a given day or alternating days

  Alternate front and back exercises (agonist and antagonist muscle groups)

  - *For power training* perform total body exercises

Types of Spinal Curvatures

- Kyphosis- excessive thoracic curvature
- Scoliosis- excessive lateral curvature
- Lordosis- excessive lumbar curvature

Applying the FITT Principle

- **F**requency: 2 to 3 non consecutive days/week, allowing 1 day of rest between workouts
  - Based on the ACSM guidelines
- **I**ntensity: Strength requires lifting as heavy as 80% of your 1 RM, Endurance requires 40 to 60% of your 1 RM
- **T**ime: *15 reps for strength*: 15 to 20 *reps for endurance*, 8 to 12 *for a combination of both*, making sure each set leads to overload of that muscle group
- **T**ype: target large muscle groups (8-12 exercises), including opposing muscles
  - Agonist and antagonist muscle groups

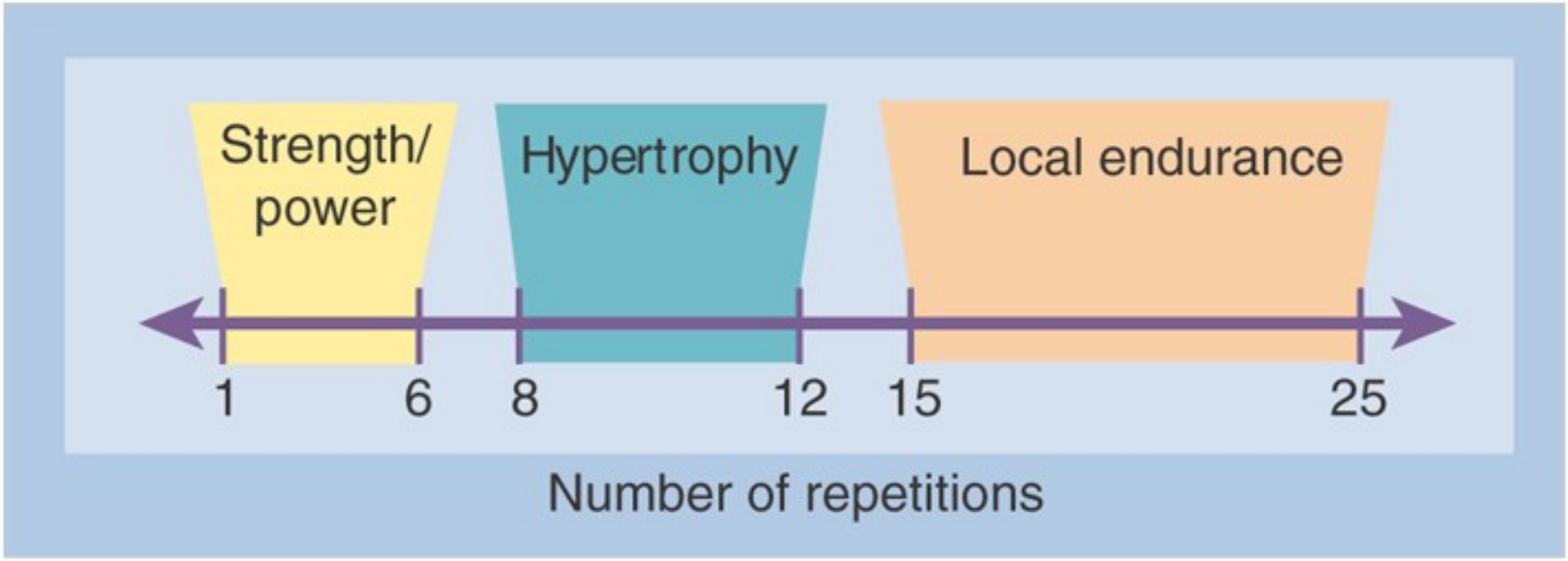
Loading (Intensity)

- Load: amount of weight lifted or resistance with which one exercises
  - *Highly dependent upon other acute program variables such as exercise order, muscle action, and rest interval length*
- Inverse relation between the load and the maximal number of repetitions performed (volume).
- Typically prescribed as a percentage of the athlete's one repetition maximum

Volume (Volume load)

- Training volume is typically expressed as:
  - Volume = sets (number) x repetitions (number) x resistance (weight)
- Training volume can be manipulated by altering
  - number of exercises performed per session,
  - number of sets performed per exercise,
  - number of repetitions performed per set
- Increased metabolic and hormonal responses are associated with high training volume

Volume (Volume load)



Rest Intervals and Frequency and Workout Structure

- Responses to short rest intervals:
  - elevated heart rate
  - subjective ratings of perceived exertion (RPE)
  - increased lactate and growth hormone concentrations
  - reduced performance during subsequent sets

- Training frequency: number of training sessions performed during a specific period

Example Training Frequency and Workout Structure

Workout A- Total Body, Workout B Split routine

TABLE 13.1 EXAMPLE TRAINING FREQUENCIES AND WORKOUT STRUCTURES

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Workout A	1. Back squat	Off	Off	1. Back squat	Off
Frequency:	2. Dead lift			2. Dead lift	
2 sessions · wk^{-1}	3. Bench press			3. Bench press	
Design: Total body	4. Lat pull			4. Lat pull	
Workout B	1. Back squat	1. Bench press	Off	1. Back squat	1. Bench press
Frequency:	2. Dead lift	2. Lat pull		2. Dead lift	2. Lat pull
4 sessions · wk^{-1}	3. Leg extension	3. Arm extension		3. Leg extension	3. Arm extension
Design: Split routine	4. Leg curl	4. Arm curl		4. Leg curl	4. Arm curl

4 x 4 Design

	FREQUENCY	INTENSITY	VOLUME	REST
POWER (force X vel)	1-2 week	30-40%	1-4 reps 1-2 sets	4-6min
STRENGTH	3-4 week	75-85%	4-8 reps 3-4 sets	2-3min
HYPERTROPHY	4-6 week	60-75%	8-12 reps 4-6 sets	30-90s
ENDURANCE	5-7 week	<60%	12-15 reps 5-7 sets	<30s

Types of training protocols intensity means % weight

- Power- emphasizing speed- so use less weight so don't get injured
- Strength- emphasizing the amount of weight so use a higher intensity of amount of weight
- Hypertrophy- want larger numbers of repetition at the most weight you can lift
- Endurance- low intensity- lots of reps

Warm Up and Cool Down

- Everyone should perform a warm up prior to each weight training session

- A general warmup (like walking or exercise bike) and performing light reps of each exercise is recommended before every training session

- To cool down after weight training, relax for 5-10 minutes by stretching, which could possibly prevent soreness. Also stretching while warm could increase flexibility.

Weight Training Safety

- Use proper lifting techniques
  - ACSM recommends a moderate rate for each repetition
  - Strive to maintain a neutral spine position during each exercise
- Use spotters and collars with free weights
- Be alert for injuries
  - R.I.C.E. principle

See the Take Charge box "Safe Weight Training"

Do You Need Supplements?

- Supplement manufacturers often make claims that their products will promote or enhance sport performance or physique
- Most of these substances are ineffective and expensive, as well as possibly dangerous
- Before purchasing and using these products, find other resources that document these dietary aids
- Sports drinks- need to read ingredient label
  - https://nobaloneydotcom.files.wordpress.com/2012/01/rockstar-energy-drink-label1.jpg

Refer to Table 4.2