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:

- Atrophy is the reduction of the size of the muscle fiber due to inactivity or injury.
  - Decreased rate of protein synthesis
  - Decreased strength
  - Decreased cross-sectional area
  - Decreased neuromuscular activity
  - Muscles can recover when activity is resumed
Muscle Fiber Types

• Slow twitch fibers (Type 1):
  • Fatigue resistant
  • Don’t contract as rapidly and forcefully as fast-twitch 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

- **Graph 1:**
  - **X-axis:** Cross-sectional area of muscle (cm²)
  - **Y-axis:** Arm flexor strength (kg)
  - Points for Female and Male

- **Graph 2:**
  - **X-axis:** Weeks of weight training
  - **Y-axis:** % Strength improvement
  - Two lines, one for Men and one for 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
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 $\rightarrow$ 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

10/30/17
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

- **Frequency**: 2 to 3 non consecutive days/week, allowing 1 day of rest between workouts
  - Based on the ACSM guidelines
- **Intensity**: Strength requires lifting as heavy as 80% of your 1 RM, Endurance requires 40 to 60% of your 1 RM
- **Time**: 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
- **Type**: 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)

![Graph showing different training zones: Strength/power, Hypertrophy, and Local endurance, with number of repetitions on the x-axis ranging from 1 to 25.](image)
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>
<thead>
<tr>
<th></th>
<th>MONDAY</th>
<th>TUESDAY</th>
<th>WEDNESDAY</th>
<th>THURSDAY</th>
<th>FRIDAY</th>
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</thead>
<tbody>
<tr>
<td>Frequency:</td>
<td>2. Dead lift</td>
<td></td>
<td></td>
<td>2. Dead lift</td>
<td></td>
</tr>
<tr>
<td>2 sessions (\cdot \text{wk}^{-1})</td>
<td>3. Bench press</td>
<td></td>
<td></td>
<td>3. Bench press</td>
<td></td>
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<tr>
<td>Design: Total body</td>
<td>4. Lat pull</td>
<td></td>
<td></td>
<td>4. Lat pull</td>
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</tbody>
</table>

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<tr>
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<td>2. Dead lift</td>
<td>2. Lat pull</td>
<td></td>
<td>2. Dead lift</td>
<td>2. Lat pull</td>
<td></td>
</tr>
<tr>
<td>4 sessions (\cdot \text{wk}^{-1})</td>
<td>3. Leg extension</td>
<td>3. Arm extension</td>
<td></td>
<td>3. Leg extension</td>
<td>3. Arm extension</td>
<td></td>
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<tr>
<td></td>
<td>FREQUENCY</td>
<td>INTENSITY</td>
<td>VOLUME</td>
<td>REST</td>
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<tr>
<td><strong>POWER</strong></td>
<td>1-2 week</td>
<td>30-40%</td>
<td>1-4 reps</td>
<td>4-6min</td>
<td></td>
<td></td>
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<tr>
<td><strong>STRENGTH</strong></td>
<td>3-4 week</td>
<td>75-85%</td>
<td>4-8 reps</td>
<td>2-3min</td>
<td></td>
<td></td>
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<tr>
<td><strong>HYPERTROPHY</strong></td>
<td>4-6 week</td>
<td>60-75%</td>
<td>8-12 reps</td>
<td>30-90s</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ENDURANCE</strong></td>
<td>5-7 week</td>
<td>&lt;60%</td>
<td>12-15 reps</td>
<td>&lt;30s</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 warm up (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/rocks tar-energy-drink-label1.jpg

Refer to Table 4.2