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 (ADL)
  • 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 cross-sectional area (CSA)
Hyperplasia

Increase in size of muscle fiber numbers due to overload stimulus.
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 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 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
Training Effect

• It’s easier to go from:
• Fast twitch to Slow twitch
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
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  Medicine balls
  Exercise (stability) balls  -Suspension training
  Pilates
  Body weight exercises
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:
  - \( \text{Volume} = \text{sets} \times \text{repetitions} \times \text{resistance} \)

- 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

<table>
<thead>
<tr>
<th>Workout</th>
<th>MONDAY</th>
<th>TUESDAY</th>
<th>WEDNESDAY</th>
<th>THURSDAY</th>
<th>FRIDAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency:</td>
<td>2. Dead lift</td>
<td></td>
<td>2. Dead lift</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 sessions ( \cdot ) wk(^{-1} )</td>
<td>3. Bench press</td>
<td></td>
<td>3. Bench press</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design: Total body</td>
<td>4. Lat pull</td>
<td></td>
<td>4. Lat pull</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency:</td>
<td>2. Dead lift</td>
<td>2. Lat pull</td>
<td>2. Dead lift</td>
<td></td>
<td>2. Lat pull</td>
</tr>
<tr>
<td>4 sessions ( \cdot ) wk(^{-1} )</td>
<td>3. Leg extension</td>
<td>3. Arm extension</td>
<td>3. Leg extension</td>
<td></td>
<td>3. Arm extension</td>
</tr>
</tbody>
</table>
## 4 x 4 Design

<table>
<thead>
<tr>
<th></th>
<th>FREQUENCY</th>
<th>INTENSITY</th>
<th>VOLUME</th>
<th>REST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>POWER</strong></td>
<td>1-2 week</td>
<td>30-40%</td>
<td>1-4 reps</td>
<td>4-6min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-2 sets</td>
<td>4-6min</td>
<td>1-2 sets</td>
</tr>
<tr>
<td><strong>STRENGTH</strong></td>
<td>3-4 week</td>
<td>75-85%</td>
<td>4-8 reps</td>
<td>2-3min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-4 sets</td>
<td>3-4 sets</td>
<td>2-3min</td>
</tr>
<tr>
<td><strong>HYPERTROPHY</strong></td>
<td>4-6 week</td>
<td>60-75%</td>
<td>8-12 reps</td>
<td>30-90s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-6 sets</td>
<td>4-6 sets</td>
<td>30-90s</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>
</tr>
<tr>
<td></td>
<td></td>
<td>5-7 sets</td>
<td>5-7 sets</td>
<td>&lt;30s</td>
</tr>
</tbody>
</table>
Warm Up and Cool Down

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

- A general warm up (like walking or easy jogging) and performing light reps of each exercise is recommended before every training session

- To **cool down** after weight training, relax for 30 minutes by stretching, which could possibly prevent s 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

Refer to Table 4.2
Videos

• **Plyometrics**
  - [https://www.youtube.com/watch?v=Yf4Y9XG8ZmY](https://www.youtube.com/watch?v=Yf4Y9XG8ZmY)

• Upper body
  - [https://www.youtube.com/watch?v=j7HnFtNmDl4](https://www.youtube.com/watch?v=j7HnFtNmDl4)