Chapter 4

Muscular Strength and Endurance
Functions of Muscle Tissues

- **Functions:** provide stability and postural tone, allow purposeful movement, heat production.

- **Muscle mass constitutes:** 40-50% of body weight
  - **Heat loss:** related to square area of skin / volume of mass ratio

- **Muscles are conductors**
  - Respond to electrical stimulation by contracting

  "**Muscle are shortens actively, can not lengthens actively**"
Muscular Strength and Endurance

- Well-developed muscles can assist with:
  - Daily routines
  - 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

1. Hyperplasia is the increase in the number of muscle fibers
2. Fiber splitting
3. Evidence in animals
4. Increased CSA
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 cross-sectional area
  - Decreased neuromuscular activity
- Muscles can recover when activity is resume
Slow- and Fast-Twitch Muscle Fibers

• **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

• **Fast-twitch fibers (Type 2):**
  - Contract rapidly and forcefully
  - Fatigue more quickly than slow-twitch fibers
  - Rely more on the anaerobic energy system
Fiber Types and Performance

• Power athletes
  • Sprinters
  • Possess high percentage of fast fibers

• Endurance athletes
  • Distance runners
  • Have high percentage of slow fibers

• Others
  • Weight lifters and non-athletes
  • Have about 50% slow and 50% fast fibers
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 while 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
- Muscle learning is the ability to improve the body’s ability to recruit motor units
Motor Unit

- One a-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 and quality of life
- 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 6-12 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
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
  - Kettlebells
  - Isokinetic

- **Other Training Methods and Types of Equipment**
  - Resistance Bands
  - Exercise (stability) balls
  - Pilates
  - No-equipment calisthenics
  - Medicine balls
  - Suspension training
  - Stones
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

- Several forms of resistance training can be utilized in developing a sport-specific conditioning program.

- It is recommended that all major muscle groups be trained during resistance exercise programs to ensure that appropriate attention is given to both agonist and antagonist muscle groups to prevent muscle imbalances and minimize the risk of injury.
Exercise Order

- When all major muscle groups are being trained in a workout:
  - Perform large-muscle-group exercises before small-muscle-group exercises
  - Perform multiple-joint exercises before single-joint exercises
  - Alternate upper and lower-body exercises
  - For power training, perform total-body exercises
Applying the FITT Principle

- **Frequency:** 2-3 nonconsecutive 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 40-60% of your 1 RM

- **Time:** 1-5 reps for strength; 15-20 reps for endurance; 8-12 for a combination of both, making sure each set leads to overload of that muscle group

- **Type:** target large muscle groups (8-10 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:
  - \( \text{Volume} = \text{sets (number)} \times \text{repetitions (number)} \times \text{resistance (weight)} \)

- 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)

Number of repetitions

1  6  8  12  15  25

- Strength/power
- Hypertrophy
- Local endurance
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></th>
<th>MONDAY</th>
<th>TUESDAY</th>
<th>WEDNESDAY</th>
<th>THURSDAY</th>
<th>FRIDAY</th>
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<tbody>
<tr>
<td>Frequency:</td>
<td>2. Dead lift</td>
<td></td>
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<td>2. Dead lift</td>
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<tr>
<td>2 sessions • wk(^{-1})</td>
<td>3. Bench press</td>
<td></td>
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<td>3. Bench press</td>
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<tr>
<td>Design:</td>
<td>4. Lat pull</td>
<td></td>
<td></td>
<td>4. Lat pull</td>
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<tr>
<td>Total body</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Frequency:</td>
<td>2. Dead lift</td>
<td>2. Lat pull</td>
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<td>2. Dead lift</td>
<td>2. Lat pull</td>
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<tr>
<td>4 sessions • wk(^{-1})</td>
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<td>3. Arm extension</td>
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<td>3. Leg extension</td>
<td>3. Arm extension</td>
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<tr>
<td>Split routine</td>
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## 4 x 4 Design

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<tr>
<th></th>
<th>FREQUENCY</th>
<th>INTENSITY</th>
<th>VOLUME</th>
<th>REST</th>
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<tbody>
<tr>
<td><strong>POWER</strong></td>
<td>1-2 week</td>
<td>30-40%</td>
<td>1-4 reps, 1-2 sets</td>
<td>4-6min</td>
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<tr>
<td><strong>STRENGTH</strong></td>
<td>3-4 week</td>
<td>75-85%</td>
<td>4-8 reps, 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, 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, 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 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.

Refer to Table 4.2