Chapter 7
MUSCULAR STRENGTH AND ENDURANCE

Strength training

A program designed to improve muscular strength and/or endurance through a series of progressive resistance (weight) training exercises that overload the muscular system and cause physiological development

Benefits of strength training are numerous

- Improvement and maintenance of everyday functional capacity
- Optimal performance in daily activities
- Higher resting metabolic rate
- Decrease in fatty tissue around the muscles
- Joint stabilization
- Weight loss and maintenance
- Blood sugar control
- Increases bone density, prevents osteoporosis
- Reduces high blood pressure, cholesterol and triglycerides
Strength training is very important for older adults

- Strength promotes independent living more than any other fitness component
- It promotes successful performance of activities of daily living
  - Improves balance and restores mobility
  - Makes lifting and reaching easier
  - Decreases risk for injury and fall
  - Stresses the bones and decreases risk for osteoporosis

- Reduces sacropenia
  Loss of lean body mass, strength and function commonly associated with age

- Increases metabolism
  All energy and material transformation that occur within living cells and necessary to sustain life

- Increases muscle mass, or hypertrophy which increases resting metabolism
  Amount of energy an individual requires during resting conditions to sustain proper body function

Muscle hypertrophy is greater in men than women

- Endocrinological differences do not allow women to achieve the same amount of muscle hypertrophy (size) as men
  - Men have more muscle fibers and testosterone allow for greater hypertrophy of each fiber

- Anabolic steroids and human growth hormones produce detrimental and undesirable side effects, especially in women.
Change in Body Composition With Aerobic & Strength Program

- Changes in body composition
  - Assess body composition regularly to monitor changes in percent body fat rather than simply measuring changes in total body weight.
  - Decreased adipose tissue is more obvious when combined with aerobic exercise.

Assessment of muscular strength

- **Muscular strength**
  - Ability of a muscle to exert maximum force against resistance.
    - **One repetition maximum (1 RM)**
      - Maximum amount of resistance an individual is able to lift in a single effort.

Muscular Strength: The Hand Grip Test

- When time is a factor, the Hand Grip Test can be used to roughly estimate strength.
- An isometric test— involves a static contraction.
- If the proper grip is used, no finger motion or body movement is visible during the test.
Assessment of muscular endurance

- **Muscular endurance**
  Ability of muscle to exert submaximal force repeatedly over time. Tested by number of repetitions that can be made or length of time contraction can be held
  - Endurance test shown in Figure 7.3
    - Includes 3 exercises each for the upper, lower and midbody
    - Total number of points for each exercise is summed and given a percentile rank

Muscular endurance test
- Upper body
  - modified dip (men) or modified push-ups (women)
- Lower body
  - bench jumps
- Mid-body
  - bent-leg curl ups or abdominal crunches

**Muscular Endurance Scoring Table**

<table>
<thead>
<tr>
<th>Percentile Rank</th>
<th>Bench Jumps</th>
<th>Modified Dips</th>
<th>Bench Leg Curl-Ups</th>
<th>Abdominal Crunches</th>
<th>Bench Jumps</th>
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Understanding strength: It begins with the nervous system

Neurons are responsible for muscular contraction

- **Motor neurons** are nerves connecting nervous system to muscle
- **Motor unit** is the motor neuron and the muscle fibers it innervates
- As the number of fibers innervated and frequency of stimulation increase, so does the strength of muscular contraction

Understanding strength: It begins with the nervous system

- Motor units

Understanding Strength: Muscles have varied composition

Muscles are made up of two types of fibers

- **Slow-twitch** greater aerobic potential and slow speed of contraction
- **Fast-twitch** greater anaerobic potential and fast speed of contraction. Used in strength training.

Proportion of slow to fast-twitch fibers is individual and genetically determined

Slow-twitch fibers are always recruited first. As speed and force increase, fast-twitch fibers become more important.
Understanding Strength: The overload principle

- Demands placed on a system must be increased systematically and progressively over time to cause physiological adaptation
- For strength training, overload can be achieved through any combination of the following:
  - Increased resistance
  - Increased repetitions
  - Increasing or decreasing the speed of repetitions
  - Increasing or decreasing rest intervals
  - Increasing volume

Understanding Strength: Specificity of training

- For a muscle to increase strength or endurance, training program must be specific to the muscles the person is attempting to improve
  - Applied to sports, this is referred to as specific adaption to imposed demand (SAID) training
- Training volume quantifies the amount of work performed during a training session

Training Volume

- Sum of all repetitions multiplied by the resistances during a training session
  - Used to quantify the amount of work performed in a given training session
    - Sets x Reps x Weight
- High training volumes and low intensities are used to achieve muscle hypertrophy.
- Low volumes and high intensities are used to increase strength and power.
Understanding Strength: Specificity of training

- **Periodization** or variation:
  - Keeps program challenging
  - Enhances strength development
  - Prevents *overtraining*
  - Three types of periodization
    1. Classical periodization for maximum strength gains
    2. Reverse periodization for muscular endurance
    3. Undulating periodization cycles through strength, hypertrophy, power and endurance cycles

**Principles of strength training**

1. Frequency
2. Resistance
3. Sets
4. Mode

*Key factor in successful training is individualization of the program*

**Two modes of strength training**

- **Isometric Training**
  - Muscle contraction that produces little or no movement
- **Dynamic Training**
  - Muscle contraction with movement
  - Strength is gained through full *range of motion* exercises
  - Two action phases
    1. Concentric/Positive resistance – muscle shortens
    2. Eccentric/Negative resistance – muscle lengths
Dynamic training equipment and techniques

- **Free weights**
  - Barbells and dumbbells

- **Fixed-resistance**
  - Exercise in which constant resistance is moved through a joint’s full range of motion
  - Equipment may include barbells, dumbbells and machines using constant resistance

- **Variable-resistance machines**
  - Special machines equipped with mechanical devices that provide differing amount of resistance throughout the range of motion

- **Isokinetic training**
  - Speed of muscle contraction is kept constant because the equipment provides an accommodation resistance to match the user’s maximal force through the range of motion

Principles Involved in Strength Training

**Free Weights**

- Require that the individual balance the resistance through the entire lifting motion.
- Are cheaper, allow variety of use, can be transported more easily, require balancing by using stabilizing muscles, and fit all exercisers.

**Weight machines**

- Are safer, provide some exercises not possible with free weights, can program variable resistance, isolate muscles better, require less time to select weight, can limit range of motion for rehabilitation, and require less skill than free weights
Resistance should change throughout training

- General recommendation: resistance of 80% of 1 RM
- To avoid having to regularly determine 1 RM, use progressive resistance training
  - Perform 8 – 12 repetitions of each exercise
  - When more than 12 repetitions can be performed, increase weight by 5-10 pounds
- When learning technique, use resistance of 50% of 1 RM

Principles Involved in Strength Training

- Sets
  - Number of repetitions performed for a given exercise
    - 1 to 3 sets for the starting exerciser
  - Recovery time
    - Needed to replenish ATP-CP system
    - Usually 3 minutes for strength training.
    - About 2 minutes for health-fitness training
- Circuit training
  - Alternating exercises by performing them in a sequence of three to six or more exercises

Frequency of strength training

- After maximum strength workout, rest interval of 48-72 hours is recommended
  - If soreness lasts 2-3 days, reduce sets during next workout
- Total body workout 2-3 days per week
  - Can you lift weights more than 3 days per week?
- Eight consecutive weeks of training are needed to see significant strength gains
**General Strength Training Guidelines**

- **Mode:** Select 8 to 10 dynamic strength-training exercises that involve the body's major muscle groups and include opposing muscle groups (chest and upper back, abdomen and lower back, front and back of the legs).
- **Resistance:** Sufficient resistance to perform 8 to 12 repetitions maximum for muscular strength and 15 to 25 repetitions to near fatigue for muscular endurance. Older adults and injury prone individuals should use 10 to 15 repetitions with moderate resistance (50% to 60% of their 1 RM).
- **Sets:** 2 to 4 sets per exercise with 2 to 3 minutes recovery between sets for optimal strength development. Less than 2 minutes per set if exercises are alternated that require different muscle groups (chest and upper back) or between muscular endurance sets.
- **Frequency:** 2 to 3 days per week on nonconsecutive days. More frequent training can be done if different muscle groups are exercised on different days. (Allow at least 48 hours between strength-training sessions of the same muscle group.)

**Guidelines for Various Strength-Training Programs**

<table>
<thead>
<tr>
<th>Strength-Training Program</th>
<th>Resistance</th>
<th>Rest Between Sets</th>
<th>Frequency (workouts per week)**</th>
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</thead>
<tbody>
<tr>
<td>General fitness</td>
<td>B-12 reps max</td>
<td>2-4</td>
<td>2-3</td>
</tr>
<tr>
<td>Muscular endurance</td>
<td>15-25 reps max</td>
<td>2-4</td>
<td>1-2 min</td>
</tr>
<tr>
<td>Maximal strength</td>
<td>1-6 reps max</td>
<td>2-5</td>
<td>3 min</td>
</tr>
<tr>
<td>Body building</td>
<td>B-20 reps near max</td>
<td>3-8</td>
<td>up to 1 min</td>
</tr>
</tbody>
</table>

**Plyometrics increase speed and explosiveness**

- *Defined:* explosive jump training, incorporating speed and strength training to enhance explosiveness
- *Objective:* produce greatest amount of force in shortest amount of time
- Basic strength is needed before beginning plyometric exercises
- Risk of injury is higher than other modes of strength training
Strength Training Exercises

- Strength training without weights (Exercises 1–14).
- Strength training with weights (Exercises 15–37).
  - Exercises 15–27 are recommended for a complete workout.
  - Exercises 28–37 are supplemental or can substitute for certain exercises numbered 15–27.
- Stability ball exercises (Exercises 38–46)
  - Can be used to complement your workout.

Changing exercises should be done to continue to challenge the muscles
- Can vary range of motion
- Create difficulty of exercise
- Avoiding monotony of doing the same exercises over and over and over...

Major Muscles of the Human Body
Dietary guidelines for strength development

- Increase daily protein intake from 0.8 g/kg body weight to 1.5 grams/kg of body weight per day
- Increase caloric intake by 500 calories/day to maximize muscle gain
- Pre- and post-exercise snacks enhance muscle gain
  - Snacks should be a combination (4:1 ratio) of carbohydrate and protein
  - Pre-exercise snack 30-60 minutes prior to exercise
  - Post-exercise snack immediately after training and an hour later

Core strength training

- The "core" of the body includes the trunk (spine) and pelvis.
- Core muscles include muscles of the abdomen, hip, and spine.
- Many of the major muscle groups of the legs, shoulder, and arms attach to the core.
- A major objective of core strength training is to exercise the abdominal and lower back muscles in unison.

Pilates exercises also develop the core

- Pilates exercises develop pelvic stability and abdominal control; exercises are coupled with focused breathing patterns
  - Originally developed in the 1920s by Joseph Pilates
- Exercises are performed on a mat or with specialized equipment
- Objective: improve muscle tone and length
Stability Exercise Balls and Elastic-Band Resistive Exercise

- Stability exercise balls
  - Exercises are designed to develop abdominal, hip, chest, and spinal muscles by addressing core stabilization while the exerciser maintains a balanced position over the ball
  - Emphasis is placed on correct movement and maintenance of proper alignment
  - Primary objective is core strength and stability

Elastic-band resistive exercise

- Elastic bands and tubing can be used as constant-resistance training

  - Advantages
    - Low-cost
    - Versatility – multiple body parts, all angles and directions
    - Travel friendly
    - Beginners and strength-trained can use effectively

Sample Elastic-Band Resistive Exercises
Exercise Safety Guidelines

Planning considerations
• Involve all major muscles groups in training
• Include core exercises
• Never lift weights alone

Before your exercise session
• Warm-up with aerobic activity for 5-7 minutes and a light stretch

Exercise Safety Guidelines

During your exercise session
• Use proper lifting technique and maintain balance
• Exercise large muscle groups first
• Exercise opposing muscle groups
• Breathe naturally – avoid holding breath
• Be careful when fatigued or performing sets to fatigue
• Stop training if you experience pain or discomfort

After your exercise session
• Stretch
• Allow adequate recovery time between sessions