Muscular Strength and Endurance

Tom Seabourne, Ph.D.
Muscle Physiology

- Muscles consist of many *muscle fibers* (*cells*) connected in bundles
- Muscle fibers are made up of *myofibrils*
- Strength training increases the number of myofibrils and the size of muscle fibers = *hypertrophy*
- Inactivity reverses the process = *atrophy*
Muscular System

Anterior view

- Temporalis
- Masseter
- Sternocleidomastoid
- Trapezius
- Biceps brachii
- Deltoid
- [Pectoralis minor]
- [Pectoralis major]
- Biceps brachii
- Brachialis
- Brachioradialis
- External oblique
- [Transverse abdominis]
- Rectus abdominis
- [Iliopsoas]
- Adductor longus
- Sartorius
- Rectus femoris
- [Vastus intermedius]
- Vastus lateralis
- Vastus medialis
- Patella
- Gastrocnemius (calf)
- Tibialis anterior
- Soleus
Muscular System

- Brachioradialis
- Biceps brachii
- Splenius capitis [Splenius cervicis]
- Trapezius
- Deltoid
- Teres minor
- Triceps brachii
- Rhomboid
- Latissimus dorsi [Erector spinae]
- External oblique [Internal oblique]
- Teres major
- Gluteus maximus (buttock)
- Biceps femoris
- Semimembranosus
- Semitendinosus
- Flexor carpi radialis
- Flexor carpi ulnaris
- Quadratus lumborum
- Hamstrings
- Gastrocnemius (calf)
- Tendo calcaneus (Achilles tendon)

Posterior view
Skeletal Muscle Tissue
Muscle Fibers

- **Slow-twitch fibers**
  - Fatigue resistant
  - Don’t contract as rapidly and forcefully as fast-twitch fibers
  - Rely primarily on oxidative energy system

- **Fast-twitch fibers**
  - Contract rapidly and forcefully
  - Fatigue more quickly than slow-twitch fibers
  - Rely more on nonoxidative energy system
Motor Units

- Motor units (nerves connected to muscle fibers) are recruited to exert force
Physiological Effects of Strength Training

- Increased muscle mass and size of muscle fibers
- Increased utilization and coordination of motor units
- Increased strength of tendons, ligaments, and bones
- Increased storage of fuel in and blood supply to muscles
- Improvements in blood fat levels and biochemical processes
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
- Prevention and management of chronic disease
Assessing Muscular Strength and Endurance

Muscular strength assessed by determining repetition maximum (1 RM), the maximum resistance that can be lifted once.

Muscular endurance assessed by counting the maximum number of repetitions of a muscular contraction.
Types of Strength Training Exercises

- Static (isometric) exercise = muscle contraction without a change in the length of the muscle
- Dynamic (isotonic) exercise = muscle contraction with a change in the length of the muscle
  - Concentric contraction = muscle applies force as it shortens
  - Eccentric contraction = muscle applies force as it lengthens
Types of Dynamic Exercise

- **Variable resistance** = changing load to provide maximal resistance throughout a joint’s range of motion
- **Eccentric loading** = placing load on a muscle as it lengthens
- **Plyometrics** = sudden eccentric loading and stretching followed by a concentric contraction
- **Speed loading** = moving a load as rapidly as possible
- **Isokinetic exercise** = exerting force at a constant speed against an equal force
Creating a Successful Weight Training Program

Choosing equipment: Weight machines versus free weights

- Resistance is provided by both types
- Exercise machines
  - Safer, convenient, and easy to use
- Free weights
  - Require more care, balance, and coordination
  - Strength transfers to daily activities
Applying the FITT Principle

- **F**requency = days per week
- **I**ntensity = amount of resistance
- **T**ime = number of repetitions and sets
- **T**ype = strength training exercises for all major muscle groups
Frequency of Exercise

American College of Sports Medicine recommends 2-3 days per week
- Allow 1 full day of rest between workouts
Intensity of Exercise: Amount of Resistance

- Choose resistance based on your current fitness level and goals
  - To build strength
    - Lift heavy weights (80% of 1 RM)
    - Perform a low number of repetitions
  - To build endurance
    - Lift lighter weights (40-60% of 1 RM)
    - Perform a high number of repetitions
  - For a general fitness program
    - Lift moderate weights (70% of 1 RM)
    - Moderate number of repetitions
Time of Exercise: Repetitions and Sets

- To build strength and endurance, do enough repetitions to fatigue the muscles.
- The heavier the weight, the fewer the repetitions (1-5) to fatigue = a program to build strength.
- The lighter the weight, the higher the number of repetitions (15-20) to fatigue = a program to build endurance.
- To build both strength and endurance, try to do 8-12 repetitions of most exercises.
Training for Strength versus Training for Endurance

Training results in a large gain in strength but little or no gain in endurance.

Training results in moderate gains in both strength and endurance.

Training results in a large gain in endurance but little or no gain in strength.
Time of Exercise: Repetitions and Sets

- Set = a group of repetitions followed by a rest period
- For general fitness, 1 set of each exercise is sufficient
- Doing more than one set will increase strength development
- Rest between sets
Type of Exercise

For a general fitness program:

- 8–10 different exercises
- Work all major muscle groups
- Balance between agonist and antagonist muscle groups
- Do exercises for large-muscle groups and multiple joints before exercises for small-muscle groups or single joints
Warm Up and Cool Down

- Warm up prior to each weight training session with a general warm-up and a warm-up for the exercises you will perform.
- Cool down after weight training, relax for 5-10 minutes, lower your heart rate.
**FITT Principle for Strength Training**

<table>
<thead>
<tr>
<th>Warm-up 5–10 minutes</th>
<th>Strength training exercises for major muscle groups (8–10 exercises)</th>
<th>Cool-down 5–10 minutes</th>
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<td><strong>Sample program</strong></td>
<td><strong>Exercise</strong></td>
<td><strong>Muscle group developed</strong></td>
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<td>Bench press</td>
<td>Chest, shoulders, triceps</td>
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<td>Pull-ups</td>
<td>Lats, biceps</td>
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<td>Shoulder press</td>
<td>Shoulders, trapezius, triceps</td>
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<td>Upright rowing</td>
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<td>Spine extensions</td>
<td>Low- and mid-back spine extensors</td>
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<td>Side bridges</td>
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**Frequency:** 2–3 days per week

**Intensity/Resistance:** Weights heavy enough to cause muscle fatigue when exercises are performed with good form for the selected number of repetitions

**Time:** Repetitions: 8–12 of each exercise (10–15 with a lower weight for people over age 50–60); **Sets:** 1 (doing more than 1 set per exercise may result in faster and greater strength gains)

**Type of activity:** 8–10 strength training exercises that focus on major muscle groups
Making Progress

- To start: Choose a weight with which you can do 8–12 repetitions with good form
- To progress: Add resistance when you can do more than 12 repetitions
- Maintain good form at all times
- Track your progress
# Sample Workout Card

## Workout Card for Sara Lopez

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More Advanced Strength Training Programs

- Performing more sets of a smaller number of repetitions with a heavier weight
- Cycle training (periodization) by varying type and amount of exercise
- Consult a coach certified by the National Strength and Conditioning Association
Weight Training Safety

- Use proper lifting techniques
- Use spotters and collars with free weights
- Be alert for injuries