Section 10: General Principles of Exercise Prescription

ACSM Guidelines: Chapter 7

HPHE 4450
Dr. Cheatham

General Principles

• Designed to meet individual health and physical fitness goals
• Based on application of scientific evidence
• Intended as guidelines for apparently healthy adults
• Components to be addressed include:
  – cardiovascular (aerobic) fitness,
  – muscular strength and endurance,
  – flexibility,
  – body composition,
  – neuromuscular fitness (balance, agility),
  – bone health
General Principles

• When determining exercise programming, consider:
  – individual’s goals,
  – physical ability,
  – health status, and
  – available equipment

The “Art” of Exercise Prescription

• Physiologic and perceptual responses to acute exercise vary among individuals and within an individual performing different types of exercise. There is a need to titrate the intensity and duration of exercise and monitor HR, BP, RPE, and, where appropriate, ECG responses to achieve a safe and effective exercise stimulus.
• Adaptations to exercise training vary in terms of magnitude and rate of development. Progress should be monitored by checking HR and RPE responses to allow fine-tuning of the exercise stimulus.
• Desired outcomes based on individual need(s) may be achieved with exercise programs that vary considerably in structure, so one should address individual interests, abilities, and limitations in the design of the program.

“The art of exercise prescription is the successful integration of exercise science with behavioral techniques that result in long-term program compliance and attainment of the individual’s goals.”
Components of the Training Session

BOX 7.1 Components of the Exercise Training Session

- Warm-up: At least 5 to 10 minutes of light (<40% VO₂R) to moderate (40%<60% VO₂R) intensity cardiovascular and muscular endurance activities
- Conditioning: 20 to 60 minutes of aerobic, resistance, neuromuscular, and/or sport activities (exercise bouts of 10 minutes are acceptable if the individual accumulates at least 20 to 60 min · d⁻¹ of daily exercise)
- Cool-down: At least 5 to 10 minutes of low- (<40% VO₂R) to moderate- (40%<60% VO₂R) intensity cardiovascular and muscular endurance activities
- Stretching: At least 10 minutes of stretching exercises performed after the warm-up or cool-down phase


Components of the Training Session

FIGURE 7.1 Format of a typical aerobic exercise session illustrating the warm-up, endurance, and cool-down phases along with a representative heart rate response. At the conclusion of warm-up, heart rate approached the lower limit of the target zone for training, corresponding to 70% to 85% of the peak heart rate reserve achieved during maximal exercise testing.
**Conditioning Phase – FITT Principle**

- FITT Principle
  - F = Frequency
  - I = Intensity
  - T = Time (duration)
  - T = Type (mode)

**Conditioning Phase – Frequency**

- Function of frequency, intensity, and duration
- Dose-response relationship
- Minimum/maximum necessary related to health/fitness goals
- Any/some exercise preferable to physical inactivity
Conditioning Phase – Frequency

**TABLE 7.1. GENERAL EXERCISE RECOMMENDATIONS FOR HEALTHY ADULTS**

<table>
<thead>
<tr>
<th>WEEKLY FREQUENCY (d·wk⁻¹ devoted to an exercise program)</th>
<th>DO THESE TYPES OF EXERCISES</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least 5 d·wk⁻¹</td>
<td>Moderate intensity (40% to &lt;60% VO₂R) aerobic (cardiovascular endurance) activities, weight-bearing exercise, flexibility exercise</td>
</tr>
<tr>
<td>At least 3 d·wk⁻¹</td>
<td>Vigorous intensity (≥60% VO₂R) aerobic activities, weight-bearing exercise, flexibility exercise</td>
</tr>
<tr>
<td>3–5 d·wk⁻¹</td>
<td>A combination of moderate- and vigorous-intensity aerobic activities, weight-bearing exercise, flexibility exercise</td>
</tr>
<tr>
<td>2–3 d·wk⁻¹</td>
<td>Muscular strength and endurance, resistance exercise, calisthenics, balance and agility exercise</td>
</tr>
</tbody>
</table>

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**Conditioning Phase – Frequency**

Moderate-intensity aerobic exercise done at least 5 d·wk⁻¹, vigorous-intensity aerobic exercise done at least 3 d·wk⁻¹, or a weekly combination of 3 to 5 d·wk⁻¹ of moderate- and vigorous-intensity exercise is recommended for the majority of adults to achieve and maintain health/fitness benefits.
**Conditioning Phase – Intensity**

- An increasing intensity yields a positive continuum of health/fitness benefits.
- Moderate intensity (an intensity that noticeably increases HR and breathing) is recommended as minimum to achieve health/fitness benefits.
- Vigorous intensity (substantial increases in HR and breathing)
- A combination of moderate and vigorous intensity (an intensity results in substantial increases in HR and breathing) is ideal to achieve health/fitness benefits in most adults.

### TABLE 1.2. CLASSIFICATION OF PHYSICAL ACTIVITY INTENSITY

<table>
<thead>
<tr>
<th>INTENSITY</th>
<th>RELATIVE INTENSITY</th>
<th>ABSOLUTE INTENSITY RANGES (METs) ACROSS FITNESS LEVELS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VO₂ max (%)</td>
<td>MAXIMAL HR (%)</td>
</tr>
<tr>
<td>Very light</td>
<td>&lt;20</td>
<td>&lt;50</td>
</tr>
<tr>
<td>Light</td>
<td>20–39</td>
<td>50–63</td>
</tr>
<tr>
<td>Moderate</td>
<td>40–59</td>
<td>64–76</td>
</tr>
<tr>
<td>Hard (vigorous)</td>
<td>60–84</td>
<td>77–93</td>
</tr>
<tr>
<td>Very hard</td>
<td>≥85</td>
<td>≥94</td>
</tr>
<tr>
<td>Maximal</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

METs, metabolic equivalent units (1 MET = 3.5 mL · kg⁻¹ · min⁻¹); VO₂ max, oxygen uptake reserve; HR rate reserve; HR, heart rate.


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**Conditioning Phase – Intensity**

- Moderate Exercise:
  - 40 to < 60% VO₂R or HRR
- Vigorous Exercise:
  - ≥ 60% VO₂R or HRR

- Make sure to adjust the ranges appropriately if basing exercise intensity from HRₘₐₓ or VO₂ₘₐₓ
  - Use Table 1.2 (ACSM Guidelines)

**Conditioning Phase – Intensity**

- Methods to quantify exercise intensity
  - Heart Rate Reserve (HRR)
  - VO₂ Reserve (VO₂R) [Preferred Methods]
  - Percentage of maximum HR
  - Percentage of VO₂ₘₐₓ
  - Absolute energy expenditure (kcal·min⁻¹)
  - Metabolic equivalents (METS)
  - RPE
  - Talk test, affective valence
Conditioning Phase – Intensity

Notes on maximal HR:
- In absence of GXT, prediction of HR_{max} may be necessary to prescribe intensity of exercise.
- Historically, use of “220 – age” has been used for males and females
  - Underestimates HR_{max} for both genders <40 yrs
  - Overestimates HR_{max} for both genders >40 yrs
- More accurate predictor:
  - HR_{max} = 206.9 - (0.67 x age)

Summary of Methods for Prescribing Exercise Intensity Using Heart Rate (HR), Oxygen Uptake (VO_{2}), and Metabolic Equivalents (METs)

- HR reserve (HRR) method: Target HR (THR) = [(HR_{max} - HR_{rest}) \times % \text{ intensity desired}] + HR_{rest}
- VO_{2} reserve (VO_{2}R) method: Target VO_{2}R^{\#} = [(VO_{2\text{max}} - VO_{2\text{rest}}) \times % \text{ intensity desired}] + VO_{2\text{rest}}
- Peak HR method: Target HR = HR_{\text{max}}^{b} \times % \text{ intensity desired}
- Peak VO_{2} method: Target VO_{2}^{\#} = VO_{2\text{max}}^{\#} \times % \text{ intensity desired}
- Peak MET \times (% \text{ MET}) method: Target MET^{\#} = [(VO_{2\text{max}}^{\#})/3.5 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}]^{\#} \times % \text{ intensity desired}

^{a} \text{Activities at the target VO}_{2} \text{ and MET can be determined using a compendium of physical activity (8,9) or metabolic calculations (6) (Table 7.2).}

^{b} \text{HR}_{\text{max}} \text{ is estimated by 220 – age or some other prediction equation.}

^{\#} \text{VO}_{2\text{max}} \text{ is estimated by maximal or submaximal exercise testing.}

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So, now the big question is:
- How do you translate a determined HR range or VO₂ range into actual exercise settings?
  - i.e. workload on a cycle ergometer or speed and grade on a treadmill?

Translating a HR range into exercise setting:
- Direct Method
- Trial and Error
**Conditioning Phase – Intensity**

- Translating a VO$_2$ range into exercise settings

**TABLE 7.2. METABOLIC CALCULATIONS FOR THE ESTIMATION OF ENERGY EXPENDITURE [VO$_2$ (mL·kg$^{-1}$·min$^{-1}$)] DURING COMMON PHYSICAL ACTIVITIES**

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>RESTING COMPONENT</th>
<th>HORIZONTAL COMPONENT</th>
<th>VERTICAL COMPONENT/ RESISTANCE COMPONENT</th>
<th>LIMITATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>3.5</td>
<td>0.1 × speed$^a$</td>
<td>1.8 × speed$^a$ × grade$^a$</td>
<td>Most accurate for speeds of 1.9-3.7 mph (30-100 m·min$^{-1}$)</td>
</tr>
<tr>
<td>Running</td>
<td>3.5</td>
<td>0.2 × speed$^a$</td>
<td>0.9 × speed$^a$ × grade$^a$</td>
<td>Most accurate for speeds &gt;5 mph (134 m·min$^{-1}$)</td>
</tr>
<tr>
<td>Stepping</td>
<td>3.5</td>
<td>0.2 × steps per min</td>
<td>1.33 × (1.8 × step height$^a$ × steps per min)</td>
<td>Most accurate for stepping rates of 12-30 steps per min</td>
</tr>
</tbody>
</table>

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**Conditioning Phase – Intensity**

Heart Rate Reserve (HRR) Method

Available test data:
- HR$_{max}$: 70 beats·min$^{-1}$
- HR$_{rest}$: 180 beats·min$^{-1}$

Desired exercise intensity range: 50%-60%

Formula: Target Heart Rate (THR) = [(HR$_{max}$ – HR$_{rest}$) × % intensity] + HR$_{rest}$

1) Calculation of HRR:
   - HRR = (HR$_{max}$ – HR$_{rest}$)
   - HRR = (180 beats·min$^{-1}$ – 70 beats·min$^{-1}$) = 110 beats·min$^{-1}$

2) Determination of exercise intensity as %HRR:
   - Convert desired %HRR into a decimal by dividing by 100
   - Desired intensity × HRR
   - %HRR = 0.5 × 110 beats·min$^{-1}$ = 55 beats·min$^{-1}$
   - %HRR = 0.6 × 110 beats·min$^{-1}$ = 66 beats·min$^{-1}$

3) Determine THR range:
   - THR = (%HRR) + HR$_{rest}$
   - To determine lower limit of THR range:
     - THR = 55 beats·min$^{-1}$ + 70 beats·min$^{-1}$ = 125 beats·min$^{-1}$
   - To determine upper limit of THR range:
     - THR = 66 beats·min$^{-1}$ + 70 beats·min$^{-1}$ = 136 beats·min$^{-1}$
   - THR range: 125 beats·min$^{-1}$ to 136 beats·min$^{-1}$
**Conditioning Phase – Intensity**

### VO2 Reserve (VO2R) Method

**Available test data:**
- VO2max: 30 mL·kg⁻¹·min⁻¹
- VO2max: 3.5 mL·kg⁻¹·min⁻¹

**Desired exercise intensity range:** 50%-60%

**Formula:** Target VO2 = [ (VO2max - VO2min) × % intensity ] / VO2max

1) **Calculation of VO2R**

- VO2R = VO2max - VO2min
- VO2R = 30 mL·kg⁻¹·min⁻¹ - 3.5 mL·kg⁻¹·min⁻¹
- VO2R = 26.5 mL·kg⁻¹·min⁻¹

2) **Determination of exercise intensity as % VO2R**

Convert desired intensity (W/OER) into a decimal by dividing by 100

W/OER = desired intensity / VO2R

3) **Determine target VO2R range**

(W/OER) × VO2R

- To determine the lower target VO2 range:
  - Target VO2 = 15.9 mL·kg⁻¹·min⁻¹
- To determine upper target VO2 range:
  - Target VO2 = 19.4 mL·kg⁻¹·min⁻¹

**%HRmax (Measured or Estimated) Method**

**Available data:**
- A man 45 yr of age

**Desired exercise intensity:** 70%-80%

**Formula:** THR = HRmax × desired %

Calculate estimated HRmax (if measured HRmax not available):

HRmax = 220 - age

HRmax = 220 - 45 = 175 beats · min⁻¹

1) **Determine THR range:**

- THR = Desired % × HRmax
- Convert desired %HRmax into a decimal by dividing by 100
- Determine lower limit of THR range:
  - THR = 175 beats · min⁻¹ × 0.70 = 123 beats · min⁻¹
- Determine upper limit of THR range:
  - THR = 175 beats · min⁻¹ × 0.80 = 140 beats · min⁻¹

THR range: 123 beats · min⁻¹ to 140 beats · min⁻¹
• Ratings of Perceived Exertion
  – Used as an adjunct to the HR methods.
  – Usually, an RPE between 12 and 16 ("somewhat hard to hard) is associated with physiological adaptations.
  – RPE should not be used as a sole guideline for determining exercise intensity.
**Conditioning Phase – Intensity**

- Conclusions
  - The appropriate exercise intensity is:
    - One that is safe
    - One that is compatible with a long-term active lifestyle
    - One that achieved the desired caloric output given the time constraints of the exercise session.

**Conditioning Phase – Time (Duration)**

- Prescribed as a measure of either:
  - amount of time physical activity is performed, or
  - total caloric expenditure.
- May be continuous or intermittent
  - If intermittent, bout of exercise should not be less than 10 minutes.
**Conditioning Phase – Time (Duration)**

- Recommended minimum is $1,000 \text{kcal} \cdot \text{wk}^{-1}$
  - $150 \text{ min} \cdot \text{wk}^{-1} (~30 \text{ min} \cdot \text{d}^{-1})$
- Pedometer steps useful assessment of quantity
  - 3,000 to 4,000 steps per day
- Maximum safe quantity of exercise not known

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**Conditioning Phase – Time (Duration)**

- The following is recommended for most adults:
  - At least 30 minutes on $\geq 5 \text{ d} \cdot \text{wk}^{-1}$ at moderate intensity to total at least 150 min-wk$^{-1}$
  - At least 20-25 minutes on $\geq 3 \text{ d} \cdot \text{wk}^{-1}$ at vigorous intensity to total at least 75 min-wk$^{-1}$
  - At least 20 to 30 minutes on 3 to 5 d-wk$^{-1}$ of moderate and vigorous intensity
- To promote/maintain weight loss:
  - 50 to 60 min-d$^{-1}$ daily exercise to total 300 minutes moderate, 150 minutes vigorous or an equivalent combination
**Conditioning Phase – Time (Duration)**

- Intermittent exercise is an effective alternate to continuous exercise.
- Total caloric expenditure or step counts may be used as alternate measures of duration.
- Minimum caloric expenditure of 1,000 kcal·wk⁻¹ of physical activity and at least 3,000 to 4,000 steps per day are recommended.

**Conditioning Phase – Type (Mode)**

- Exercise should be:
  - rhythmic,
  - aerobic type, and
  - large muscle groups.
- Physiologic adaptations are specific to the type of exercise performed.
**Conditioning Phase – Type (Mode)**

- Rhythmic, aerobic exercise of at least moderate intensity, involving large muscle groups, and requiring little skill to perform is recommended for all adults to improve health/fitness.
- Other exercise and sports requiring skill to perform or at higher levels of fitness are recommended only for individuals possessing adequate skill and fitness to perform that activity.

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**TABLE 7.3. AEROBIC (CARDIOVASCULAR ENDURANCE) EXERCISES TO IMPROVE PHYSICAL FITNESS**

<table>
<thead>
<tr>
<th>EXERCISE GROUP</th>
<th>EXERCISE DESCRIPTION</th>
<th>RECOMMENDED FOR</th>
<th>EXAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Endurance activities requiring minimal skill or physical fitness to perform</td>
<td>All adults</td>
<td>Walking, leisurely cycling, aqua-aerobics, slow dancing</td>
</tr>
<tr>
<td>B</td>
<td>Vigorous-intensity endurance activities requiring minimal skill</td>
<td>Adults with a regular exercise program and/or at least average physical fitness</td>
<td>Jogging, running, rowing, aerobics, spinning, elliptical exercise, stepping exercise, fast dancing</td>
</tr>
<tr>
<td>C</td>
<td>Endurance activities requiring skill to perform</td>
<td>Adults with acquired skill and/or at least average physical fitness levels</td>
<td>Swimming, cross country skiing, skating</td>
</tr>
<tr>
<td>D</td>
<td>Recreational sports</td>
<td>Adults with a regular exercise program and at least average physical fitness</td>
<td>Racquet sports, basketball, soccer, downhill skiing, hiking</td>
</tr>
</tbody>
</table>


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**FITT Principles Applied**

**Progression**

- Dependent on individual’s health status, exercise tolerance, and exercise program goals
- Any component of FITT may be increased
  - Initially, gradual increase in duration (5–10 minutes) every 1 to 2 weeks over first 4 to 6 weeks is reasonable.
  - After 1 month or more, frequency and intensity may be gradually adjusted until recommended quality and quantity of exercise are met.
- Following adjustments, monitor individual for adverse effects (adjust downward if not well tolerated).
Muscular Fitness

• Essential component of exercise training program
• May be weight lifting or other devices
• Should improve strength, endurance, and power
• Goals of health-related resistance program
  – Maintain fitness to perform activities of daily living
  – Manage, attenuate, or prevent chronic diseases
• Very important with increasing age

Muscular Fitness

• Major muscle groups:
  – Chest
  – Shoulders
  – Upper and lower back
  – Abdomen
  – Hips
  – Legs
• Smaller muscle groups:
  – Arms (biceps, triceps)
Muscular Fitness – Frequency

• Train each major muscle group 2-3 d·wk\(^{-1}\) with at least 48 hours separating the exercise training sessions for the same muscle group.
• All muscle groups may be trained in the same session (whole-body) or split among sessions
  – Example:
    • Lower-Body
      – Mondays and Thursdays
    • Upper-Body
      – Tuesdays and Fridays
  • Note: This “split” results in 4 d·wk\(^{-1}\) but each session is a shorter duration, so OK.

Muscular Fitness – Types of Resistance Exercises

• Resistance training should include multijoint or compound exercises
• Single-joint exercises can also be included
  – Bicep curls, triceps extensions, quadriceps extensions, leg curls, calf raises
• To avoid muscle imbalances, train opposing (agonists and antagonists) muscle groups
Muscular Fitness – Volume (Sets/Reps/Weight)

• Each muscle group should be trained for a total of 2 to 4 sets
  – Same exercise or combination of exercises affecting same muscle group
    • Example: Pectoral Muscles
      – 4 sets of bench press OR
      – 2 sets of bench press + 2 sets of dips
  – 2 to 3 minutes of rest between sets

Muscular Fitness – Volume (Sets/Reps/Weight)

• RT intensity and # of reps with each set are inversely related
• To improve muscular strength, mass, and, to some extent endurance:
  – 8 to 12 reps/set
  – 60 to 80% 1-RM
  – With multiple sets, number of reps in initial sets should be around 12 and decline to 8 for the last set
  – Each set should be performed to muscular fatigue but NOT failure
**Muscular Fitness – Volume (Sets/Reps/Weight)**

- If goal is to primarily improve muscular endurance:
  - Fewer sets (1 to 2)
  - More reps (15 to 25)
  - Lower weight (no more than 50% 1-RM)
  - Shorter rest periods between sets

- Older and very deconditioned persons:
  - 1 or more sets
  - 10 to 15 reps
  - 60 to 70% 1-RM (moderate intensity)

**Muscular Fitness – Progression/Maintenance**

- Progression
  - Most common approach = increase resistance
  - OR, increase # of sets or days per week

- Maintenance
  - Progressive overload not required
  - Frequency may be reduced to 1 d·wk\(^{-1}\) as long as intensity is held constant

- Very good summary in Box 7.3 (Guidelines) p. 172
Flexibility

- Recommended for inclusion in exercise training for all adults
- Improves range of motion and/or counters loss of range of motion with aging
- Scientific evidence regarding stretching and performance, injury prevention, and reduction of muscle soreness not conclusive

**BOX 7.4 Summary of Key Points about Stretching**

- Stretching exercise is most effective when the muscles are warm.
- Stretching should be performed before and/or after the conditioning phase.
- Stretching following exercise may be preferable for sports for which muscular strength, power, and endurance are important for performance.
- Stretching may not prevent injury.
- Stretching should be performed at least 2–3 d·wk⁻¹.
- Static, dynamic or ballistic, proprioceptive neuromuscular facilitation (PNF), and dynamic range of motion techniques improve flexibility.
- Stretching exercises should involve the major muscle tendon groups of the body.
- ≥4 repetitions per muscle group is recommended.
- Ballistic stretching may be considered particularly for persons whose sports activities involve ballistic movements.
- Static stretches should be held for 15 to 60 seconds.
- A 6-second contraction followed by a 10- to 30-second assisted stretch is recommended for PNF techniques.

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**Exercise Program Supervision**

TABLE 7.5. GENERAL GUIDELINES FOR EXERCISE PROGRAM SUPERVISION

<table>
<thead>
<tr>
<th>Health status</th>
<th>Level of Supervision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low risk</td>
<td>Unsupervised</td>
</tr>
<tr>
<td>Moderate risk</td>
<td>Professionally supervised</td>
</tr>
<tr>
<td>High risk</td>
<td>Clinically supervised</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Functional capacity</th>
<th>Level of Supervision</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;7 METs</td>
<td>Unsupervised</td>
</tr>
<tr>
<td>&gt;7 METs</td>
<td>Professionally supervised</td>
</tr>
<tr>
<td>&lt;7 METs</td>
<td>Clinically supervised</td>
</tr>
</tbody>
</table>

MET, metabolic equivalent.

Supervision:
- Professional supervision refers to a health fitness professional possessing a combination of academic training and certification equivalent to the ACSM Certified Health Fitness Specialist or higher.
- Clinical supervision refers to a health fitness professional possessing a combination of advanced college training and certification equivalent to the ACSM Registered Clinical Exercise Physiologist and ACSM Certified Clinical Exercise Specialist or higher.

Risk status:
- Low risk: Asymptomatic men and women who have ≤1 risk factor from Table 2.3.
- Moderate risk: Asymptomatic men and women who have ≥2 risk factors from Table 2.3.
- High risk: Individuals who have one or more signs and symptoms listed in Table 2.2 or known cardiovascular, pulmonary, or metabolic disease.

Stable disease refers to stable CVD, well-controlled metabolic or pulmonary disease, and other stable chronic diseases for which professional supervision is adequate to ensure safety.


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**Exercise Adherence**

**BOX 7.5  Practical Recommendations to Enhance Exercise Adherence**

- Obtain healthcare provider support of the exercise program.
- Clarify individual needs to establish the motive for exercise.
- Identify individualized, attainable goals and objectives for exercise.
- Identify safe, convenient, and well-maintained facilities for exercise.
- Identify social support for exercise.
- Identify environmental supports and reminders for exercise.
- Identify motivational exercise outcomes for self-monitoring of exercise progress and achievements, such as exercise logs and step counters.


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