Chapter 19: Cardiorespiratory and Health-Related Physical Fitness Assessments

• To educate participants about their current level of health-related physical fitness
• To use data from fitness assessments to individualize exercise programs
• To evaluate an exercise program’s effectiveness
• To inspire individuals to take action to improve their health-related physical fitness
• To improve a participant’s risk stratification status
**Box 19-1 Benefits of Regular Physical Activity and/or Exercise**

*Improvement in Cardiovascular and Respiratory Function*
- Increased maximal oxygen uptake due to both central and peripheral adaptations
- Lower minute ventilation at a given submaximal intensity
- Lower myocardial oxygen cost for a given absolute submaximal intensity
- Lower heart rate and blood pressure at a given submaximal intensity
- Increased capillary density in skeletal muscle
- Increased exercise threshold for the accumulation of lactate in the blood
- Increased exercise threshold for the onset of disease signs or symptoms (e.g., angina pectoris, ischemic ST-segment depression, claudication)

*Decreased Mortality and Morbidity*
- Primary prevention (i.e., interventions to prevent an acute cardiac event)
- Activity and/or fitness levels are associated with lower death rates from coronary artery disease
- Higher activity and/or fitness levels are associated with lower incidence rates for combined cardiovascular diseases, coronary artery disease, cancer of the colon, and type 2 diabetes
- Secondary prevention (i.e., interventions after a cardiac event [to prevent another])
- Based on meta-analyses (pooled data across studies), cardiovascular and all-cause mortality are reduced in post-myocardial infarction patients who participate in cardiac rehabilitation exercise training, especially as a component of multifactorial risk factor reduction
- Randomized controlled trials of cardiac rehabilitation exercise training involving postmyocardial infarction patients do not support a reduction in the rate of nonfatal reinfarction

*Reduction in Coronary Artery Disease Risk Factors*
- Reduced resting systolic/diastolic pressures
- Increased serum high-density lipoprotein cholesterol and decreased serum triglycerides
- Reduced total body fat, reduced intra-abdominal fat
- Reduced insulin needs, improved glucose tolerance

*Other Postulated Benefits*
- Decreased anxiety and depression
- Enhanced feelings of well-being
- Enhanced performance of work, recreational, and sport activities
<table>
<thead>
<tr>
<th>Cardiorespiratory Fitness:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Field Tests: i.e., Step Tests, 1.5 Mile Walk/Run, One Mile Walk Test</td>
</tr>
<tr>
<td>• Submaximal Tests: i.e., YMCA Submaximal Cycle Test &amp; Astrand-Ryhmig Cycle Test</td>
</tr>
<tr>
<td>• Maximal Tests: Graded Exercise Test</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Body Composition:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Height/Weight &amp; Body Mass Index</td>
</tr>
<tr>
<td>• Circumferences &amp; Waist-to-Hip Ratio</td>
</tr>
<tr>
<td>• Skinfolds</td>
</tr>
<tr>
<td>• Bioelectrical Impedance</td>
</tr>
<tr>
<td>• Underwater Weighing Flexibility:</td>
</tr>
<tr>
<td>• Sit and Reach Test</td>
</tr>
<tr>
<td>• Modified Sit and Reach Test</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Muscular Strength:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Hand Grip Test</td>
</tr>
<tr>
<td>• One RM (repetition maximum)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Muscular Endurance:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sit-ups</td>
</tr>
<tr>
<td>• Curl-ups</td>
</tr>
<tr>
<td>• Pushups</td>
</tr>
<tr>
<td>• YMCA Bench Press Test</td>
</tr>
</tbody>
</table>
Basic principles and guidelines surrounding health-related fitness testing

- The ideal approach to identifying an individual’s physical fitness is to assess each component of health-related physical fitness separately, and then compare the individual’s assessment data with normative data for each component.

- The following should be considered:
  
  - Ease of test administration (How easy is it for the patient to perform the test?)
  
  - Can the test administrator and the patient interact during the test?
  
  - Ease of normative data comparison (How applicable and well-developed are the normative standards for any given mode of testing?)
  
  - Economic issues, such as the cost of the test, equipment, and personnel
  
  - Validity and reliability of test results
  
  - Patient needs, preferences, current fitness level, and risk stratification
The primary reasons for conducting a preactivity screening include:

- Identification of medical contraindications (reasons not to test) to performing specific health-related fitness assessments
- Identification of those patients who should receive a medical evaluation before participating in specific health-related fitness assessments
- Identification of those patients who should be medically supervised during health-related fitness assessments
- Identification of any other health/medical concerns or conditions that may alter testing format (i.e., diabetes mellitus, orthopedic injuries, readiness for exercise, etc.)
• The following should be considered prior to performing a preactivity screening:
  – Pretest instructions
  – Test environment
    • Should consider temperature, noise level, privacy, and equipment
  – Test order
    • Testing order should include resting measurements of HR, BP, height, weight, and body composition, followed by tests of cardiorespiratory endurance, muscular fitness, and flexibility
  – Risk stratification
    • Important to help guide parameters of the exercise prescription
BOX 19-2  GUIDELINES FOR PREACTIVITY SCREENING

- Consult a physician before participating in health-related physical fitness assessment or any exercise program:
  - If you are a man 45 or older, or a woman 55 or older
  - If you are planning to perform vigorous physical activity
  - If you are new to exercise and/or not accustomed to exercise
  - If you are in doubt about your health status
- Conduct a medical history/health habits questionnaire including but not limited to:
  - Family history
  - History of various diseases and illnesses, including cardiovascular disease
  - Surgical history
- Past and present health behaviors/habits (such as a history of cigarette smoking and physical inactivity)
- Current use of various drugs and/or medications
- Specific history of any signs or symptoms suggesting cardiovascular disease or any other chronic disease
- Physical Activity Readiness Questionnaire (PAR-Q; a minimal standard for entry into a moderate-intensity exercise program that was developed as a simpler alternative to the health habits questionnaire and designed to prevent patients from participating in physical activities that may be too strenuous for them; see the ACSM/AHA form in GETP8 Figure 2.2)
- Medical/health examination


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**Low Risk**
Younger individuals* who are asymptomatic and meet no more than one risk factor threshold from Box 19-7

**Moderate Risk**
Older individuals (men ≥ 45 years of age; woman ≥ 55 years of age) or those who meet the threshold for two or more risk factors from Box 19-7

**High Risk**
Individuals with one or more signs/symptoms listed in Box 19-8 or known cardiovascular,† pulmonary,‡ or metabolic§ disease

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*Men < 45 years of age; women < 55 years of age.
†Cardiac, peripheral vascular, or cerebrovascular disease.
‡Chronic obstructive pulmonary disease, asthma, interstitial lung disease, or cystic fibrosis.
§Diabetes mellitus (types 1 and 2), thyroid disorders, renal or liver disease.
### BOX 19-7  
**CORONARY ARTERY DISEASE RISK FACTOR THRESHOLDS FOR USE WITH ACSM RISK STRATIFICATION**

<table>
<thead>
<tr>
<th><strong>SPOtIVE RISK FACTORS</strong></th>
<th><strong>DEFINING CRITERIA</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Family history</td>
<td>Myocardial infarction, coronary revascularization, or sudden death before 55 years of age in father or other male first-degree relative, or before 65 years of age in mother or other female first-degree relative.</td>
</tr>
<tr>
<td>2. Cigarette smoking</td>
<td>Current cigarette smoker or those who quit within the previous 6 months.</td>
</tr>
<tr>
<td>3. Hypertension</td>
<td>Systolic blood pressure $\geq 140$ mmHg or diastolic $\geq 90$ mmHg, confirmed by measurements on at least two separate occasions, or antihypertensive medication.</td>
</tr>
<tr>
<td>4. Dyslipidemia</td>
<td>Low-density lipoprotein (LDL) cholesterol $&gt;130$ mg·dL$^{-1}$ (3.4 mmol·L$^{-1}$) or high-density lipoprotein (HDL) cholesterol $&lt;40$ mg·dL$^{-1}$ (1.03 mmol·L$^{-1}$), or on lipid-lowering medication. If total serum cholesterol is all that is available use $&gt;200$ mg·dL$^{-1}$ (5-2 mmol·L$^{-1}$) rather than LDL $&gt;130$ mg·dL$^{-1}$.</td>
</tr>
<tr>
<td>5. Impaired fasting glucose</td>
<td>Fasting blood glucose $\geq 100$ mg·dL$^{-1}$ (5.6 mmol·L$^{-1}$) confirmed by measurements on at least two separate occasions.</td>
</tr>
</tbody>
</table>
| 6. Obesity               | Body mass index $>30$ kg·m$^{-2}$  
  or  
  Waist girth $>102$ cm for men and $>88$ cm for women or Waist/hip ratio $\geq 0.95$ for men and $\geq 0.86$ for women. |
| 7. Sedentary lifestyle   | Persons not participating in a regular exercise program or not meeting the minimal physical activity recommendations from the U. S. Surgeon General's Report. |

### Negative Risk Factors

<table>
<thead>
<tr>
<th><strong>Defining Criteria</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. High serum HDL cholesterol $&gt;60$ mg·dL$^{-1}$ (1.6 mmol·L$^{-1}$)</td>
</tr>
</tbody>
</table>
BOX 19-8 MAJOR SIGNS OR SYMPTOMS SUGGESTIVE OF CARDIOVASCULAR AND PULMONARY DISEASE*

- Pain, discomfort (or other anginal equivalents) in the chest, neck, jaw, arms, or other areas that may be due to ischemia
- Shortness of breath at rest or with mild exertion
- Dizziness or syncope
- Orthopnea or paroxysmal nocturnal dyspnea
- Ankle edema
- Palpitations or tachycardia
- Intermittent claudication
- Known heart murmur
- Unusual fatigue or shortness of breath with usual activities

*These symptoms must be interpreted in the clinical context in which they appear because they are not all specific for cardiovascular, pulmonary, or metabolic disease.

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<table>
<thead>
<tr>
<th></th>
<th>LOW RISK</th>
<th>MODERATE RISK</th>
<th>HIGH RISK</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate exercise†</td>
<td>Not necessary‡</td>
<td>Not necessary</td>
<td>Recommended</td>
</tr>
<tr>
<td>Vigorous exercise§</td>
<td>Not necessary</td>
<td>Recommended</td>
<td>Recommended</td>
</tr>
<tr>
<td>B.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Submaximal test</td>
<td>Not necessary</td>
<td>Not necessary</td>
<td>Recommended</td>
</tr>
<tr>
<td>Maximal test</td>
<td>Not necessary</td>
<td>Recommended††</td>
<td>Recommended</td>
</tr>
</tbody>
</table>

*Within the past year.

†Moderate exercise is defined as activities that are approximately 3 to 6 METs or the equivalent of brisk walking at 3 to 4 mph for most healthy adults (13). Nevertheless, a pace of 3 to 4 mph might be considered to be “hard” to “very hard” by some sedentary, older persons. Moderate exercise may alternatively be defined as an intensity well within the individual’s capacity, one that can be comfortably sustained for a prolonged period of time (~45 min), which has a gradual initiation and progression, and is generally noncompetitive. If an individual’s exercise capacity is known, relative moderate exercise may be defined by the range 40 to 60% maximal oxygen uptake.

‡The designation of “Not necessary” reflects the notion that a medical examination, exercise test, and physician supervision of exercise testing would not be essential in the preparticipation screening; however, they should not be viewed as inappropriate.

§Vigorous exercise is defined as activities of 16 METs. Vigorous exercise may alternatively be defined as exercise intense enough to represent a substantial cardiorespiratory challenge. If an individual’s exercise capacity is known, vigorous exercise may be defined as an intensity of 60% maximal oxygen uptake.

††When physician supervision of exercise testing is “Recommended,” the physician should be in close proximity and readily available should there be an emergent need.
Should consider which cardiorespiratory parameters are to be assessed at rest before exercise:

- **Heart rate**
  - Easy to determine
- **Stoke volume**
  - Requires specialized equipment
- **Cardiac output**
  - Requires specialized equipment
- **Resting blood pressure**
  - Easy to determine
An important component of fitness with many methods of determination, which are reviewed in detail in Chapter 17.

Consider the method based on information needed, ease of performance, and cost to the participant.

Below are the most common methods of body composition assessment:

- **Anthropometric methods**
- **Body mass index**
- **Circumferences**
- **Waist-to-hip ratio**
- **Skinfold measurement**
- **Bioelectrical impedance analysis**
- **Densitometry**
- **Hydrodensiometry (underwater weighing)**
- **Plethysmography**

Body composition norms

- A range of 10% to 22% for men and 20% to 32% for women is considered satisfactory for normal health.
### TABLE 19-1. RATINGS OF THE VALIDITY AND OBJECTIVITY OF BODY COMPOSITION METHODS

<table>
<thead>
<tr>
<th>METHOD</th>
<th>PRECISION</th>
<th>OBJECTIVITY</th>
<th>ACCURACY</th>
<th>VALID EQUATIONS</th>
<th>OVERALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass index</td>
<td>1</td>
<td>1</td>
<td>4, 5</td>
<td>4, 5</td>
<td>4</td>
</tr>
<tr>
<td>Near infrared interactance</td>
<td>1</td>
<td>1, 2</td>
<td>4</td>
<td>4</td>
<td>3.5</td>
</tr>
<tr>
<td>Skinfolds</td>
<td>2</td>
<td>2, 3</td>
<td>2, 3</td>
<td>2, 3</td>
<td>2.5</td>
</tr>
<tr>
<td>Bioelectric impedance</td>
<td>2</td>
<td>2</td>
<td>2, 3</td>
<td>2, 3</td>
<td>2.5</td>
</tr>
<tr>
<td>Circumferences</td>
<td>2</td>
<td>2</td>
<td>2, 3</td>
<td>2, 4</td>
<td>3.0</td>
</tr>
</tbody>
</table>

1, excellent; 2, very good; 3, good; 4, fair; 5, unacceptable.

Precision is reliability within investigators; objectivity is reliability between investigators; accuracy refers to comparison with a criterion method; valid equations are cross-validated.
BOX 19-10  GENERALIZED SKINFOLD EQUATIONS

MEN

• **Seven-Site Formula** (chest, midaxillary, triceps, subscapular, abdomen, suprailiac, thigh)
  Body density = 1.112 − 0.00043499 (sum of seven skinfolds)
  + 0.00000055 (sum of seven skinfolds)²
  − 0.00028826 (age) [SEE 0.008 or ~3.5% fat]

• **Three-Site Formula** (chest, abdomen, thigh)
  Body density = 1.10938 − 0.0008267 (sum of three skinfolds)
  + 0.0000016 (sum of three skinfolds)²
  − 0.0002574 (age) [SEE 0.008 or ~3.4% fat]

• **Three-Site Formula** (chest, triceps, subscapular)
  Body density = 1.1125025 − 0.0013125 (sum of three skinfolds)
  + 0.0000055 (sum of three skinfolds)²
  − 0.000244 (age) [SEE 0.008 or ~3.6% fat]

WOMEN

• **Seven-Site Formula** (chest, midaxillary, triceps, subscapular, abdomen, suprailiac, thigh)
  Body density = 1.097 − 0.00046971 (sum of seven skinfolds)
  + 0.00000056 (sum of seven skinfolds)²
  − 0.00012828 (age) [SEE 0.008 or ~3.8% fat]

• **Three-Site Formula** (triceps, suprailiac, thigh)
  Body density = 1.099421 − 0.0009929 (sum of three skinfolds)
  + 0.0000023 (sum of three skinfolds)²
  − 0.0001392 (age) [SEE 0.009 or ~3.9% fat]

• **Three-Site Formula** (triceps, suprailiac, abdominal)
  Body density = 1.089733 − 0.0009245 (sum of three skinfolds)
  + 0.0000025 (sum of three skinfolds)²
  − 0.0000979 (age) [SEE 0.009 or ~3.9% fat]

Cardiorespiratory Fitness (CRF)

- Determined by one’s ability to perform dynamic exercise at moderate to high intensities, using large muscle groups, for prolonged periods

- Reasons for measuring CRF
  - A low level of CRF is associated with a markedly increased cardiovascular and all-cause mortality.
  - Increasing CRF results in a reduction in all-cause mortality.
  - High levels of CRF are related to increased levels of habitual physical activity, which in turn is correlated with significant health benefits.
  - Provides information that can be used to determine the intensity, duration, and mode of exercise recommended as part of an exercise program
  - Can serve as motivation to the patient as reason for continuing with a regular exercise program
Cardiorespiratory Fitness (CRF)

- How CRF is measured and expressed: maximal oxygen uptake (VO$_{2\text{max}}$)
  - Many options available
  - Can directly measure VO$_2$ via gas exchange or estimate CRF
  - Need to consider
    - Length of the test
    - Willingness of the participant
    - Cost of the test to administer
    - What the personnel need is (i.e., qualifications)
    - What equipment and facilities are needed for the test
    - Whether physician supervision is needed
    - Whether there are any safety concerns
    - Needs to be met to preserve accuracy of the data being collected
**BOX 19-11 CONTRAINDICATIONS TO EXERCISE TESTING**

**ABSOLUTE**
- A recent significant change in the resting ECG suggesting significant ischemia, recent myocardial infarction (within 2 days), or other acute cardiac event
- Unstable angina
- Uncontrolled cardiac dysrhythmias causing symptoms or hemodynamic compromise
- Symptomatic severe aortic stenosis
- Uncontrolled symptomatic heart failure
- Acute pulmonary embolus or pulmonary infarction
- Acute myocarditis or pericarditis
- Suspected or known dissecting aneurysm
- Acute systemic infection, accompanied by fever, body aches, or swollen lymph glands

**RELATIVE**
- Left main coronary stenosis
- Moderate stenotic valvular heart disease
- Electrolyte abnormalities (e.g., hypokalemia, hypomagnesemia)
- Severe arterial hypertension (i.e., systolic BP of 200 mm Hg and/or a diastolic BP of 110 mm Hg) at rest
- Tachydysrhythmia or bradydysrhythmia
- Hypertrophic cardiomyopathy and other forms of outflow tract obstruction
- Neuromuscular, musculoskeletal, or rheumatoid disorders that are exacerbated by exercise
- High-degree atrioventricular block
- Ventricular aneurysm
- Uncontrolled metabolic disease (e.g., diabetes, thyrotoxicosis, or myxedema)
- Chronic infectious disease (e.g., mononucleosis, hepatitis, AIDS)
- Mental or physical impairment leading to inability to exercise adequately

*Relative contraindications can be superseded if benefits outweigh risks of exercise. In some instances, these individuals can be exercised with caution and/or using low-level end points, especially if they are asymptomatic at rest.*

1. Obtain resting heart rate and BP immediately before exercise in the exercise posture.
2. The client should be familiarized with the ergometer. If using a cycle ergometer, properly position the client on the ergometer (i.e., upright posture, five-degree bend in the knee at maximal leg extension, hands in proper position on handlebars).
3. The exercise test should begin with a two- to three-minute warm-up to acquaint the client with the cycle ergometer and prepare him or her for the exercise intensity in the first stage of the test.
4. A specific protocol should consist of 2- or 3-minute stages with appropriate increments in work rate.
5. Heart rate should be monitored at least two times during each stage, near the end of the second and third minutes of each stage. If heart rate $>110$ beats $\cdot$ min$^{-1}$, steady-state heart rate (i.e., two heart rates within 5 beats $\cdot$ min$^{-1}$) should be reached before the workload is increased.
6. Blood pressure should be monitored in the last minute of each stage and repeated (verified) in the event of a hypotensive or hypertensive response.
7. Perceived exertion and additional rating scales should be monitored near the end of the last minute of each stage using either the 6-20 or 0-10 scale (Table 4.8 of GETP8).
8. Client appearance and symptoms should be monitored and recorded regularly.
9. The test should be terminated when the subject reaches 70% heart rate reserve (85% of age-predicted maximal heart rate), fails to conform to the exercise test protocol, experiences adverse signs or symptoms, requests to stop, or experiences an emergency situation.
10. An appropriate cool-down/recovery period should be initiated consisting of either:
   a. Continued exercise at a work rate equivalent to that of the first stage of the exercise test protocol or lower; or
   b. A passive cool-down if the subject experiences signs of discomfort or an emergency situation occurs.
11. All physiologic observations (e.g., heart rate, BP, signs and symptoms) should be continued for at least 5 minutes of recovery unless abnormal responses occur, which would warrant a longer posttest surveillance period. Continue low-level exercise until heart rate and BP stabilize, but not necessarily until they reach pre-exercise levels.
Maximal versus submaximal exercise testing

- Consider the pros and cons of each type of testing
  - Maximal provides the best assessment of safety of exercise and disease presence.
  - Maximal provides best data (e.g., true peak HR) for ExRx purposes.
  - Submaximal takes less time to perform, is less expensive, and does not require physician supervision.
  - Submaximal may be safer for those with established disease.

Pretest instructions for CRF assessment

- Common instructions:
  - Abstain from eating at least 4 hours before testing (although patients who experience hypoglycemia may be advised to have a light, healthy snack of protein and carbohydrate combination 2 to 3 hours before the test, and all patients should be encouraged to eat something light and well-balanced in the 12 hours preceding the 4-hour pretest fast).
  - Abstain from strenuous exercise for at least 24 hours before the test.
  - Abstain from consuming caffeine-containing products for a minimum of 12 to 24 hours before the test.
  - Abstain from using products containing nicotine for at least 3 hours and from consuming alcohol for at least 24 hours before the test.
• Test mode for measuring CRF: procedures and protocols for step tests, field tests, submaximal exercise tests, and maximal exercise tests
  
  - See next several slides for details of the following:
    
    • Step tests
    
    • Field tests for the prediction of CRF
The Queens College Step Test is also known as the McArdle Step Test.

1. The step test requires that the individual step up and down on a standardized step height of 16.25 in (41.25 cm) for 3 minutes. (Many gymnasium bleachers have a riser height of 16.25 in.)
2. The men step at a rate (cadence) of 24 per minute, whereas the women step at a rate of 22 per minute. This cadence should be closely monitored and set with the use of an electronic metronome. A 24 per minute cadence means that the complete cycle of step up with one leg, step up with the other, step down with the first leg, and finally step down with the last leg is performed 24 times in a minute (up one leg, up the other leg, down the first leg, down the other leg). Commonly we set the metronome at a cadence of four times the step rate, in this case 96 beats per minute for men, to coordinate each leg’s movement with a beat of the metronome. The women’s step rate would be 88 beats per minute. Although it may be possible to test more than one patient at a time, depending on equipment, it would be difficult to test men and women together.

3. After the 3 minutes are up, the patient stops and palpates the pulse or has the pulse taken (at the radial site, preferably) while standing within the first 5 seconds. A 15-second pulse count is then taken. Multiply this pulse count by 4 to determine heart rate (HR) in beats per minute (bpm). The recovery HR should occur between 5 and 20 seconds of immediate recovery from the end of the step test.

The subject’s $\dot{V}O_{2max}$ in mL $\cdot$ kg$^{-1}$ $\cdot$ min$^{-1}$ is determined from the recovery HR by the following formulas:

For men:

$$\dot{V}O_{2max} (\text{mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}) = 111.33 - (0.42 \cdot \text{HR})$$

For women:

$$\dot{V}O_{2max} (\text{mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}) = 65.81 - (0.1847 \cdot \text{HR})$$

HR = recovery HR (bpm)

For example:
If a man finished the test with a recovery HR of 144 bpm (36 beats in 15 seconds), then:

$$\dot{V}O_{2max} (\text{mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}) = 111.33 - (0.42 \cdot 144) = 50.85 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$$
BOX 19-14  1.5-MILE RUN AND 12-MINUTE WALK/RUN TEST PROCEDURES

1.5-MILE RUN TEST
This test is contraindicated for unconditioned beginners, individuals with symptoms of heart disease, and those with known heart disease or risk factors for heart disease. Your patient should be able to jog for 15 minutes continuously to complete this test and obtain a reasonable prediction of their aerobic capacity.

1. Ensure that the area for performing the test measures out to be 1.5 miles in distance. A standard quarter-mile track would be ideal (6 laps = 1.5 miles).
2. Inform the patient of the purposes of the test and the need to pace over the 1.5-mile distance. Effective pacing and the subject’s motivation are key variables in the outcome of the test.
3. Have the patient start the test; start a stopwatch to coincide with the start. Give your patient feedback on time to help them with pacing.
4. Record the total time to complete the test and use the formula below to predict cardiorespiratory fitness in mL·kg$^{-1}$·min$^{-1}$

For men and women:

\[ \text{VO}_{2\text{max}} \ (\text{mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}) = 3.5 + 483/\text{Time} \]

\[ \text{Time} = \text{time to complete 1.5 miles in nearest hundredth of a minute} \]

For example:

If time to complete 1.5 miles was 11:12 (11 minutes and 12 seconds), then the time used in the formula would be 11.2 (12/60 = 0.2).

\[ \text{VO}_{2\text{max}} \ (\text{mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}) = 3.5 + 483/11.2 \]

\[ = 46.6 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \]

12-MINUTE WALK/RUN TEST PROCEDURES
A popular variation of the 1.5-mile run test is the 12-minute walk/run test popularized by Dr. Ken Cooper of the Aerobics Institute in Dallas, Texas. This test requires the patient to cover the maximum distance in 12 minutes by either walking, running, or using a combination of walking and running. The distance covered in 12 minutes needs to be measured and expressed in meters.

The prediction of aerobic capacity from the 12-minute walk/run test is:

\[ \text{VO}_{2\text{max}} \ (\text{mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}) = (\text{distance in meters} - 504.9)/44.73 \]
This test may be useful for those who are unable to run because of a low fitness level and/or injury. The patient should be able to walk briskly (get their exercise heart rate [HR] above 120 bpm) for 1 mile to complete this test.

1. The 1-mile walk test requires that the subject walk 1 mile as fast as possible around a measured course. The patient must not break into a run! Walking can be defined as having contact with the ground at all times (running involves an airborne phase). The time to walk this 1 mile is measured and recorded.

2. Immediately at the end of the 1-mile walk, the patient counts the recovery HR or pulse for 15 seconds and multiplies by 4 to determine a 1-minute recovery HR (bpm). In another version of the test, HR is measured in the final minute of the 1-mile walk (during the last quarter mile).

The formula for VO2max, mL·kg⁻¹·min⁻¹ is sex specific (i.e., the constant of 6.315 is added to the formula for men only).

\[
\text{VO2max (mL·kg}^{-1}·\text{min}^{-1}) = 132.853 - (0.1692 \cdot \text{WT}) - (0.3877 \cdot \text{AGE}) + (6.315, \text{for men}) - (3.2649 \cdot \text{TIME}) - (0.1565 \cdot \text{HR})
\]

WT = weight in kilograms
AGE = in years
TIME = time for 1 mile in nearest hundredth of a minute (e.g., 15:42 = 15.7)
HR = recovery HR in bpm

This formula was derived on apparently healthy individuals ranging in age from 30 to 69 years of age.

For example:
32-year-old male; 68 kg (150 lbs)
1 mile = 10:35 (10.58); HR = 136

\[
\text{VO2max (mL·kg}^{-1}·\text{min}^{-1}) = 132.853 - (0.1692 \cdot 68) - (0.3877 \cdot 32) + (6.315) - (3.2649 \cdot 10.58) - (0.1565 \cdot 136) = 59.4 \text{ mL·kg}^{-1}·\text{min}^{-1}
\]
• Submaximal exercise tests for the prediction of CRF

• Submaximal exercise testing can be a valid and reliable method for predicting CRF when done in a laboratory setting.

  – Assumptions of submaximal prediction of CRF

    • A linear (straight line) relationship exists between VO₂ and HR within the range of 110 to 150 bpm. It is at this point that SV has reached a plateau (approximately 40%–50% of max), and the HR and oxygen consumption track linearly.

    • Maximum HR (HRₘₐₓ), which must be predicted for submaximal ergometer testing, can be estimated or predicted as a function of age (HRₘₐₓ = 220 – age).

    • Steady-state heart rate (HRₚₛ) can be achieved in 3 to 4 minutes at a constant, submaximal work output.

    • A cadence of 50 revolutions per minute (rpm) is typically considered comfortable and mechanically efficient in most individuals.

    • The HR at two separate work outputs can be plotted as the HR – VO₂ relationship and extrapolated to the estimated HRₘₐₓ.

  – Sources of error in submaximal prediction

  – Submaximal protocols for predicting CRF
1. The exercise test should begin with a 2- to 3-min warm-up to acquaint the client with the cycle ergometer and prepare him or her for the exercise intensity in the first stage of the test.

2. The specific protocol consists of 3-min stages with appropriate increments in work rate.

3. The client should be properly positioned on the cycle ergometer (i.e., upright posture, 5° bend in the knee at maximal leg extension, hands in proper position on handlebars).

4. Heart rate should be monitored at least two times during each stage, near the end of the second and third minutes of each stage. If heart rate $> 110$ beats·min$^{-1}$, steady state heart rate (i.e., two heart rates within 6 beats·min$^{-1}$) should be reached before the work rate is increased.

5. Blood pressure should be monitored in the later portion of each stage and repeated (verified) in the event of a hypotensive or hypertensive response.

6. Perceived exertion should be monitored near the end of each stage using either the 6–20 or the 0–10 scale.

7. Client appearance and symptoms should be monitored regularly.

8. The test should be terminated when the subject reaches $85\%$ of age-predicted maximal heart rate (70% of heart rate reserve), fails to conform to the exercise test protocol, experiences adverse signs or symptoms, requests to stop, or experiences an emergency situation.

9. An appropriate cool-down/recovery period should be initiated consisting of either:
   a. continued pedaling at a work rate equivalent to that of the first stage of the exercise test protocol or lower; or,
   b. a passive cool-down if the subject experiences signs of discomfort or an emergency situation occurs.

10. All physiologic observations (e.g., heart rate, blood pressure, signs and symptoms) should be continued for at least 4-min of recovery unless abnormal responses occur, which would warrant a longer posttest surveillance period.
BOX 19-17  GENERAL INDICATIONS FOR STOPPING AN EXERCISE TEST IN LOW-RISK ADULTS* (ABSOLUTE AND RELATIVE)

**ABSOLUTE INDICATIONS**
- Drop in systolic blood pressure of $>10$ mm Hg from baseline* blood pressure despite an increase in workload when accompanied by other evidence of ischemia
- Moderately severe angina (defined as 3 on standard scale)
- Increasing nervous system symptoms (e.g., ataxia, dizziness, or near syncope)
- Signs of poor perfusion (cyanosis or pallor)
- Technical difficulties monitoring the ECG or systolic blood pressure
- Subject’s desire to stop
- Sustained ventricular tachycardia
- ST elevation (+1.0 mm) in leads without diagnostic Q-waves (other than V₁ or aVR)

**RELATIVE INDICATIONS**
- Drop in systolic blood pressure of $>10$ mm Hg from baseline* blood pressure despite an increase in workload in the absence of other evidence of ischemia
- ST or QRS changes such as excessive ST depression $\geq 2$ mm horizontal or downsloping ST-segment depression) or marked axis shift
- Arrhythmias other than sustained ventricular tachycardia, including multifocal PVCs, triplets of PVCs, supraventricular tachycardia, heart block, or bradyarrhythmias
- Fatigue, shortness of breath, wheezing, leg cramps, or claudication
- Development of bundle-branch block or intraventricular conduction delay that cannot be distinguished from ventricular tachycardia
- Increasing chest pain
- Hypertensive response (systolic blood pressure of $>250$ mm Hg and/or a diastolic blood pressure of $>115$ mm Hg).

ECG, electrocardiogram; PVC, premature ventricular contraction.

*Baseline refers to a measurement obtained immediately before the test and in the same posture as the test is being performed.

In summary, the patient performs a multistage protocol based on the response to the first stage. The total test may last from 6 to 12 minutes.

1. Explain the test to your patient. Be sure you have adequately screened your patient via a Health History Questionnaire and/or a PAR-Q and performed ACSM risk stratification. Note: Physician supervision is not necessary with submaximal testing in low- and moderate-risk adults. More information on this can be found in ACSM’s GETP8.

2. In addition, you should have already ensured that your patient has followed some basic pretest instructions for this submaximal test: wearing comfortable clothing; having plenty of fluids beforehand; avoiding alcohol, tobacco, and caffeine within 3 hours of the test; avoiding strenuous exercise on the day of the test; and having adequate sleep the night before the test.

3. Explain informed consent. The safety of this test is reported as >300,000 tests performed without a major complication. Informed consent was important. It is very important that you understand that he or she is free to stop the test at any time, but he or she is also responsible for informing you of any and all symptoms that might develop.

4. You should also discuss with your patient the concept of your general preparedness to handle any emergencies. The details of general preparedness include the testing environment and emergency plan/procedures. Also, an explanation of the rating of perceived exertion (RPE) scale is warranted at this time (Table 4.7 of GETP8). An example of some verbal directions you could read to your patient before asking him or her to use the RPE scale to give a general rating is: “Rate your feelings that are caused by exercise using this scale. The feelings should be general, about your whole body. We will ask you to select one number that most accurately corresponds to your perception of your total body feeling. You can use the verbal qualifiers to help you select your RPE number. There is no right or wrong answer. Use any number that you think is appropriate.”

5. Take the baseline or resting measures of heart rate and blood pressure with your patient seated. If necessary, these seated measurements can be performed on the cycle ergometer.

6. Adjust seat height. The knee should be flexed at approximately 5 to 10 degrees in the pedal-down position with the toes on the pedals. Another way to check seat height is to have your patient place the heels on the pedals; with the heels on the pedals, the leg should be straight in the pedal-down position. Also, you can align the seat height with your patient’s greater trochanter, or hip, with your patient standing next to the cycle. Most important is for your patient to be comfortable with the seat height. Have your patient turn the pedals to test for the seat height appropriateness. While pedaling, your patient should be comfortable, and there should be no rocking of the hips (you can check on hip rocking by viewing your patient from behind). Also, be sure your patient maintains an upright posture (by adjusting the handlebars, if necessary) and does not grip the handlebars too tight.

7. START THE TEST. Have your patient freewheel, without any resistance (0 kg), at the pedaling cadence of 50 rpm. A brief period of approximately 2 to 3 minutes should suffice for this freewheeling period. Remember, some subjects may have a difficult time with freewheeling. Maintaining 50 rpm throughout the test is essential. The rpm may vary between about 48 and 52 rpm; any more variance than this may invalidate the test.

8. Set the first work output according to YMCA protocol. The first work output, for everyone, is 150 kp · min⁻¹ (50 rpm · 0.5 kp). The YMCA protocol is found in Boxes 19-19 and 19-20.
1. Start the clock/timer. It may be best to think of timing each stage (e.g., 3 minutes) rather than the entire test time. Therefore, you may wish to set the time at the end of each stage. In reality, timing of this test is the most difficult part for individuals to learn. Suggested timing sequence for each stage of the test are included below.

2. Measure the heart rate (HR) after 2 minutes into the first work rate or stage. Count HR for at least 10 to 15 seconds. Some suggest a 30-second count for more accuracy, but it may be impractical to spend a full 30 seconds of each minute counting the HR. The use of an HR monitor may be helpful; however, it should only be used as a teaching aid to check your results by palpation. Record the HR on the test form.

3. Measure and record the blood pressure (BP) one time during each stage; usually after having completed the 2-minute HR of that stage. ACSM’s GETP8 for test termination and BP is applicable.
   - BP >250/115 mm Hg
   - Significant drop (>10 mm Hg) in systolic blood pressure or a failure to rise with an increase in exercise intensity

4. Ask your patient for the RPE for that stage. Choose either the 6-20 scale or the 0-11 scale. These scales were discussed earlier. Be sure to monitor your patient for general appearance and any symptoms that may develop.

5. Take another HR after the BP and RPE measurements, around 3 minutes into the stage. Record the HR on the appropriate testing data form.

   Compare minute 2 HR to minute 3 HR during each stage:
   A. If there is a difference of within 5 bpm, consider that work rate or stage finished. Steady state conditions apply.
   B. If there is a difference of >5 bpm, continue on for another minute (i.e., minute 4 of that stage) and check HR again. Do not change to the next stage until you have a steady-state heart rate HRSS (difference within 5 bpm). If you fail to have your patient achieve an HRSS for a stage, then you may have to discontinue the test and plan to test again on another day. It has been noted that up to 10% of individuals who are tested with this protocol are unable to obtain HRSS in a stage.

In summary:
- HRSS (within 5 bpm): Go to step 7
- No HRSS (>5 bpm) achieved: Continue stage until HRSS

6. Regularly check the work output of the cycle ergometer using the pendulum resistance scale on the side of the ergometer and the rpm of your patient. For the resistance, do not use the scale on the top front panel of the cycle ergometer for measurement. Adjust the work output if necessary. Regularly check your patient’s rpm and correct if necessary.

7. After completing the first stage of 150 kp·m·min⁻¹ compare your patient’s HRSS to the protocol sheet. Adjust resistance appropriately for the second stage based on HR response to first stage. This is a multistage test; the patient will perform at least two stages.
   - You need to obtain HRSS from a stage (within 6 bpm).
   - The test requires completion of at least two separate stages with HRSS at each stage.
   - Consider for the test results the third minute HR as the HRSS, if it is a steady state (for plotting or calculations) for that stage.
   - These two stages must have HRs between 110 bpm and 85% of age-predicted maximum heart rate (APMHR) to be used in the plotting and calculation of VO2max.

8. Allow your patient to cool down after the last stage of the protocol is complete. Have your patient continue to pedal at 50 rpm, and adjust the resistance down to 0.5 to 1 kp for 3 minutes of cool-down or recovery. Take your patient’s HR and BP at the end of the 3-minute active recovery period. Next, allow him or her to sit quietly in a chair for 2 to 3 minutes to continue the recovery process. Be sure to check the HR and BP before allowing them to leave the lab. It is hoped that the HR and BP will approach the resting measures.
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00–0:45</td>
<td>Monitor your client’s work output (cadence and resistance)</td>
</tr>
<tr>
<td>0:45–1:00</td>
<td>Pulse count for 15 seconds (for practice)</td>
</tr>
<tr>
<td>1:00–1:45</td>
<td>Monitor your client’s work output (cadence and resistance)</td>
</tr>
<tr>
<td>1:45–2:00</td>
<td>Pulse count for 15 seconds (2 min HR)</td>
</tr>
<tr>
<td>2:00–2:30</td>
<td>Stage BP check</td>
</tr>
<tr>
<td>2:30–2:45</td>
<td>Stage RPE check</td>
</tr>
<tr>
<td>2:45–3:00</td>
<td>Pulse count for 15 seconds (3 min HR)</td>
</tr>
</tbody>
</table>
In summary, the patient performs a 6-minute submaximal exercise session on the cycle ergometer. Thus, this is typically a single-stage test. The heart rate (HR) response to this session will determine the maximal aerobic capacity by plotting the HR response to this one stage on a nomogram.

The calibration of the cycle ergometer is the same as in the YMCA protocol:

1. Explain the test to your patient: same as in the YMCA protocol.
2. Explain informed consent: same as in the YMCA protocol.
3. You should also discuss with your patient the concept of general preparation to handle any emergencies: same as in the YMCA protocol.
4. Take the baseline or resting measures of HR and blood pressure (BP) with your patient seated: same as in the YMCA protocol.
5. Adjust seat height: same as in the YMCA protocol.
6. START THE TEST. Have your patient freewheel, without any resistance (0 kg), at the pedaling cadence of 50 rpm. Maintaining 50 rpm throughout the test is essential.
7. Set the first stage’s work output according to protocol table 19-3.
8. Start the clock/timer.
9. Measure the HR after each minute starting at minute 2. Count the HR for 10 to 15 seconds. You may wish to use a heart rate monitor, only as a teaching tool. Record the HR on the test form.
10. Measure and record the blood pressure after the 3-minute HR; ACSM guidelines for test termination and BP are applicable.
11. The fifth and sixth minute HR will be used in the test determination of VO\textsubscript{2max} as long as there is not more than a 6-beat difference between the two HRs.

The following applies for steady-state heart rate (HR\textsubscript{SS}):

If there is a difference of ≤6 bpm, then consider the test finished.

If there is a difference of >6 bpm, then continue for another minute and check HR again.

12. Regularly check the work output of the cycle ergometer using the pendulum resistance scale on the side of the ergometer and the rpm of subject. For the resistance, do not use the scale on the top front panel for measurement. Adjust the work output if necessary.

13. Regularly check your patient’s rpm and correct if necessary.

The Astrand protocol requires the following for test completion:

You need to obtain HR\textsubscript{SS} from the test with the fifth and sixth minute HR (within 6 bpm).

For the best (most accurate) prediction of VO\textsubscript{2max}, the HR should be between 125 and 170 bpm.

If the HR response to the initial work rate is not above 125 bpm after 6 minutes, then the test is continued for another 6-minute interval by increasing the work rate by 300 kg·m·min\textsuperscript{-1} (0.5 kp).

The HR at the fifth and sixth minutes, if acceptable to the criteria above, is averaged for the nomogram method.

14. Allow your patient to cool down after the protocol is complete. Have your patient continue to pedal at 50 rpm, and adjust the resistance down to 0.5 to 1 kp for 3 minutes of cool-down or recovery. Take your patient’s HR and BP at the end of the 3-minute active recovery period. Next, allow your patient to sit quietly in a chair for 2 to 3 minutes to continue the recovery process. Be sure to check your patient’s HR and BP before allowing your patient to leave the lab. It is hoped that the HR and BP will approach the resting measures.
This protocol table is designed as a guide. The protocol is designed to elicit an HR of between 125–170 bpm by 6 minutes. You can adjust the work output as necessary during the test (usually after the first 6 minutes) to achieve an HR in or near this range in your subject.

<table>
<thead>
<tr>
<th>INDIVIDUAL</th>
<th>WORK OUTPUT (kp·m·min⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td></td>
</tr>
<tr>
<td>Unconditioned</td>
<td>300–600</td>
</tr>
<tr>
<td>Conditioned</td>
<td>600–900</td>
</tr>
<tr>
<td>Women</td>
<td></td>
</tr>
<tr>
<td>Unconditioned</td>
<td>300–450</td>
</tr>
<tr>
<td>Conditioned</td>
<td>450–600</td>
</tr>
<tr>
<td>Poorly Conditioned or Older</td>
<td>300</td>
</tr>
<tr>
<td>Individuals</td>
<td></td>
</tr>
</tbody>
</table>
Figure 19-2. Modified Åstrand-Ryhming Nomogram
Maximal exercise testing (GXT)

- The maximal GXT has four primary purposes:
  - Screening for the presence of disease
  - Diagnosis of a disease when symptoms are present
  - Prognosis of the patient relative to the patient’s coronary artery disease and/or other disease history
  - Guiding the management of an individual, including for use as an exercise prescription

Who should have a maximal GXT?

- Those with a moderate to high disease risk
- Older or diseased individuals wishing to perform higher intensity exercise
- Those with symptoms suggestive of disease
• Personnel needs for conducting the maximal GXT
  – *Allied health personnel (i.e., exercise physiologists or nurses) who have been adequately trained can safely perform maximal exercise testing.*
  – *Physician should be nearby or in the room, depending on the person being tested.*

• Protocols for maximal exercise testing
  – Should be adjusted for:
    • *Purpose of the test*
    • *Mode of exercise*
    • *Population being tested*
• Measurements taken during exercise testing
  – Common variables measured during maximal exercise testing include HR, BP, RPE, ECG, and subjective measurements of signs or symptoms related to coronary ischemia.
  – Direct measurements of ventilatory responses and expired gases can also be measured during maximal exercise testing.

• Test termination criteria
  – Should test to symptom-limited maximum for best test predictive value and information for exercise prescription
BOX 19-22 SEQUENCE OF MEASURES FOR HR, BP, RPE, AND ELECTROCARDIOGRAM (ECG) DURING EXERCISE TESTING

Pre-Test
1. 12-lead ECG in supine and exercise postures
2. Blood pressure measurements in the supine position and exercise posture

Exercise*
1. 12-lead ECG recorded during last 15 seconds of every stage and at peak exercise (3-lead ECG observed.Recorded every minute on monitor)
2. Blood pressure measurements should be obtained during the last minute of each stage†
3. Rating scales: RPE at the end of each stage, other scales if applicable

Post-Test
1. 12-lead ECG immediately after exercise, then every 1 to 2 minutes for at least 5 minutes to allow any exercise-induced changes to return to baseline
2. Blood pressure measurements should be obtained immediately after exercise, then every 1 to 2 minutes until stabilized near baseline level.
3. Symptomatic ratings should be obtained using appropriate scales as long as symptoms persist after exercise

*In addition, these referenced variables should be assessed and recorded whenever adverse symptoms or abnormal ECG changes occur.
†Note: An unchanged or decreasing systolic blood pressure with increasing workloads should be retaken (i.e., verified immediately)
**BOX 19-23  INDICATIONS FOR TERMINATING EXERCISE TESTING**

**Absolute**
- Drop in systolic blood pressure of 210 mmHg from baseline blood pressure despite an increase in workload, when accompanied by other evidence of ischemia
- Moderate to severe angina
- Increasing nervous system symptoms (e.g., ataxia, dizziness, or near syncope)
- Signs of poor perfusion (cyanosis or pallor)
- Technical difficulties monitoring the ECG or systolic blood pressure
- Subject’s desire to stop
- Sustained ventricular tachycardia
- ST elevation (≥1.0 mm) in leads without diagnostic Q-waves (other than V₁ or aVR)

**Relative**
- Drop in systolic blood pressure of ≥10 mmHg from baseline blood pressure despite an increase in workload, in the absence of other evidence of ischemia
- ST or QRS changes such as excessive ST depression (>2 mm horizontal or downsloping ST-segment depression) or marked axis shift
- Arrhythmias other than sustained ventricular tachycardia, including multifocal PVCs, triplets of PVCs, supraventricular tachycardia, heart block, or brady-arrhythmias
- Fatigue, shortness of breath, wheezing, leg cramps, or claudication
- Development of bundle-branch block or intraventricular conduction delay that cannot be distinguished from ventricular tachycardia
- Increasing chest pain
- Hypertensive response†


†Systolic blood pressure of more than 250 mmHg and/or a diastolic blood pressure of more than 115 mmHg.

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• Muscular fitness integrates muscular strength, muscular endurance, and flexibility.

• Muscle strength
  – Muscular strength is defined as the maximal force (expressed in newtons, kilograms, or pounds) that can be generated by a specific muscle or muscle group.
  – Can evaluate statically or dynamically
  – Common techniques/protocols for measuring muscular strength include the one repetition maximum (1-RM) bench press test, the 1-RM leg press test, and isokinetic testing.
**TABLE 19-4. NORMS FOR UPPER BODY STRENGTH**

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<thead>
<tr>
<th>PERCENTILE</th>
<th>20-29</th>
<th>30-39</th>
<th>40-49</th>
<th>50-59</th>
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</tr>
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<tbody>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>.37</td>
<td>.33</td>
</tr>
</tbody>
</table>

*One repetition maximum bench press, with bench press weight ratio = weight pushed/body weight ratio.*

†Data provided by the Institute for Aerobics Research, Dallas, TX (1994). Adapted from ACSM's Guidelines for Exercise Testing and Prescription. 8th ed., 2009. Study population for the data set was predominantly white and college educated. A Universal dynamic variable resistance (DVR) machine was used to measure the 1-RM. The following may be used as descriptors for the percentile rankings: well above average (90), above average (70), average (50); below average (30), and well below average (10).
**TABLE 19-5. NORMS FOR LEG STRENGTH**

<table>
<thead>
<tr>
<th>PERCENTILE</th>
<th>20–29</th>
<th>30–39</th>
<th>40–49</th>
<th>50–59</th>
<th>60+</th>
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<td><strong>Men</strong></td>
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<td></td>
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<td></td>
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<tr>
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<td><strong>Women</strong></td>
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<td>90</td>
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<td>.93</td>
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<td>1.15</td>
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<td>1.00</td>
<td>.94</td>
<td>.78</td>
<td>.72</td>
</tr>
</tbody>
</table>

*One repetition maximum leg press with leg press weight ratio = weight pushed body weight.

†Data provided by the Institute for Aerobics Research, Dallas, TX (1994). Adapted from ACSM’s Guidelines for Exercise Testing and Prescription, 8th ed, 2009 Study population for the data set was predominantly white and college educated. A Universal dynamic variable resistance (DVR) machine was used to measure the I-RM. The following may be used as descriptors for the percentile rankings: well above average (90), above average (70), average (50); below average (30), and well below average (10).
1. The subject should warm up by completing several submaximal repetitions (at 40%–60% of perceived maximum).
2. Select an initial weight that is within the subject’s perceived capacity (~50%–70% of capacity).
3. With the subject keeping his/her back on the bench, both feet on the floor, and hands shoulder width apart with palms up on the bar, determine the 1RM (or any multiple RM) within four trials with rest periods of 3 to 5 minutes between trials (a spotter should be present for all lifts and assists the subject with liftoff.) The subject starts the lift with the bar in the up position with arms fully extended, then lowers the bar to the chest and pushes it back up until the arms are locked. Be sure to encourage regular breathing and avoid breath holding during exertion.
4. Following a 1-minute rest with light stretching, the subject does three to five repetitions at 60% to 80% of perceived maximum.
5. Further lifts should include the addition of a small amount of weight, and a 1RM lift is attempted. This continues until the subject cannot lift the desired weight. The goal is to find the 1RM in three to five maximal efforts. The greatest amount of weight lifted is considered the 1RM.
6. For the determination of the amount of weight lifted compared with the individual’s body weight (for norms comparison purposes), divide the maximum weight lifted in pounds by the subject’s weight in pounds.

Note: The above procedure can also be used for the 1RM leg press.

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**BOX 19-25**

PUSH-UP AND CURL-UP (CRUNCH) TEST PROCEDURES FOR MEASUREMENT OF MUSCULAR ENDURANCE*

**Push-up**

1. The push-up test is administered with male subjects starting in the standard “down” position (hands pointing forward and under the shoulder, back straight, head up, using the toes as the pivotal point) and female subjects in the modified “knee push-up” position (legs together, lower leg in contact with mat with ankles plantar-flexed, back straight, hands shoulder width apart, head up, using the knees as the pivotal point).
2. The subject must raise the body by straightening the elbows and return to the “down” position, until the chin touches the mat. The stomach should not touch the mat.
3. For both men and women, the subject’s back must be straight at all times and the subject must push up to a straight arm position.
4. The maximal number of push-ups performed consecutively without rest is counted as the score.
5. The test is stopped when the client strains forcibly or is unable to maintain the appropriate technique within two repetitions.

**Curl-Up (Crunch)**

1. Individual assumes a supine position on a mat with the knees at 90 degrees. The arms are at the side, palms facing down with the middle fingers touching a piece of masking tape. A second piece of masking tape is placed 10 cm apart. Shoes remain on during the test.
2. A metronome is set to 50 beats/min and the individual does slow, controlled curl-ups to lift the shoulder blades off the mat (trunk makes a 30-degree angle with the mat) in time with the metronome at a rate of 25 per minute. The test is done for 1 minute. The low back should be flattened before curling up.
3. Individual performs as many curl-ups as possible without pausing, to a maximum of 25.


1 Alternatives include: 1) having the hands held across the chest, with the head activating a counter when the trunk reaches a 30-degree position and placing the hands on the thighs and curling up until the hands reach the knee caps. Elevation of the trunk 30 degrees is the important aspect of the movement.

2 An alternative includes doing as many curl-ups as possible in 1 minute.
### Table 19-6. Fitness Categories by Age Groups and Gender for Partial Curl-Up*

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<tr>
<th></th>
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<th>40–49</th>
<th>50–59</th>
<th>60–69</th>
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</thead>
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<td><strong>M</strong></td>
<td><strong>F</strong></td>
<td><strong>M</strong></td>
</tr>
<tr>
<td>Very good</td>
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<td>24</td>
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<tr>
<td>Needs improvement</td>
<td>16</td>
<td>14</td>
<td>14</td>
<td>9</td>
<td>12</td>
</tr>
</tbody>
</table>


### Table 19-7. Fitness Categories by Age Groups and Gender for Push-Ups*

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<th>30–39</th>
<th>40–49</th>
<th>50–59</th>
<th>60–69</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td><strong>M</strong></td>
<td><strong>F</strong></td>
<td><strong>M</strong></td>
<td><strong>F</strong></td>
<td><strong>M</strong></td>
</tr>
<tr>
<td>Excellent</td>
<td>36</td>
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</table>


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BOX 19-26  YMCA BENCH PRESS TEST

1. Use a 35-pound barbell setup for women or an 80-pound barbell setup for men.
2. Set the metronome to 60 beats per minute; the subject’s lifting cadence will be 30 lifts or reps per minute.
3. Have the subject lie back down on the bench with both feet on the floor.
4. A spotter should hand the barbell to the subject and be available throughout the test to grasp the barbell when necessary.
5. The subject will start with the weight in the down position (weight resting on chest) and with elbows flexed. Hands should grip the bar at shoulder width with palms up.
6. The subject will press the weight and lower the weight at the cadence of 30 repetitions per minute. Each repetition must consist of full movement of the barbell from elbows flexed with the barbell resting on the chest to arms fully extended. The cadence of 30 repetitions per minute must be maintained.
7. The subject completes the test for the maximum number of repetitions before fatigue or breaking of the lifting cadence. Compare the subject’s maximum number of reps with the norms.

From: ACSM's Health-Related Physical Fitness Assessment Manual, 2nd ed.
# Table 19-8. Endurance Bench-Press Test—Total Lifts

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<th>AGE (yrs)</th>
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<th>36–45</th>
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<td>M</td>
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<tr>
<td>Below average</td>
<td>20–22</td>
<td>16–18</td>
<td>21–24</td>
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<tr>
<td>Poor</td>
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</tr>
<tr>
<td>Very poor</td>
<td>0–10</td>
<td>0–6</td>
<td>0–9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>56–65</th>
<th>&gt;65</th>
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</thead>
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<td>M</td>
</tr>
<tr>
<td>Excellent</td>
<td>21–25</td>
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<td>17–21</td>
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<td>Average</td>
<td>16–20</td>
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<td>0–2</td>
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</tbody>
</table>

*Note: Women use a 35-pound bar; men, 80 pounds. Maximum repetitions in time to metronome at 30 lifts per minute.*

*Source: Adapted from YMCA. Y's Way to Fitness, 4th ed., 1998. Reprinted with permission from the YMCA of the USA.*
• Muscle endurance
  - The ability of a muscle group to repeatedly perform muscular contractions over a period that is sufficient to cause muscular fatigue, or the ability to maintain a percentage of maximal voluntary contraction (MVC) for an extended period
  - Common assessments for muscular endurance include the YMCA Bench Press Test, push-up test, and the partial curl-up (crunch) test.

• Special considerations
  - Older adults
    • Beneficial to evaluate functional ability and to design a training program
    • Consider using senior-specific testing procedures
Coronary-prone clients

- Safe and effective for improving muscular fitness, preventing/managing certain chronic medical conditions, modifying coronary risk factors, and enhancing psychosocial well-being in those with and without cardiovascular disease.

- Those cardiac patients deemed low risk (e.g., persons without resting or exercise-induced evidence of myocardial ischemia, severe left ventricular dysfunction, or complex ventricular dysrhythmias, and with normal or near-normal CRF) can perform moderate- to high-intensity (e.g., 40%–80% 1-RM) resistance testing and training safely.

  - Blood pressure does not rise excessively and therefore is not considered problematic during assessment or training.

Children and adolescents

- Developing muscular fitness in youth develops proper posture, reduces injury risk, enhances body composition, and improves motor performance skills.

- Push-up and abdominal curl-up tests are common assessments.

- Teaching proper technique and safety and having an adult at all testing are requirements for youth testing.
• Flexibility
  – Defined as the functional ability of a joint to move through its full range of motion (ROM)
  – The goal is to move through the ROM without deficit or pain.
  – Flexibility depends on the distensibility of the joint capsule, adequate warm-up, muscle viscosity, and the compliance of ligaments and tendons.
  – Sit and reach assessment is very common and often used to reflect overall flexibility.
**BOX 19-27 TRUNK FLEXION (SIT-AND-REACH) TEST PROCEDURES**

**Pretest:** Participant should perform a short warm-up prior to this test and include some stretches (e.g., modified hurdler’s stretch). It is also recommended that the participant refrain from fast, jerky movements, which may increase the possibility of an injury. The participant’s shoes should be removed.

1. For the Canadian trunk forward flexion test, the client sits without shoes and the soles of the feet flat against the flexometer (sit-and-reach box) at the 26-cm mark. Inner edges of the soles are placed within 2 cm of the measuring scale. For the YMCA sit and reach test, a yardstick is placed on the floor and tape is placed across it at a right angle to the 15-inch mark. The participant sits with the yardstick between the legs, with legs extended at right angles to the taped line on the floor. Heels of the feet should touch the edge of the taped line and be about 10 to 12 inches apart. (Note the zero point at the foot/box interface and use the appropriate norms.)

2. The participant should slowly reach forward with both hands as far as possible, holding this position approximately 2 seconds. Be sure that the participant keeps the hands parallel and does not lead with one hand. Fingertips can be overlapped and should be in contact with the measuring portion or yard-stick of the sit-and-reach box.

3. The score is the most distant point (in centimeters or inches) reached with the fingertips. The best of two trials should be recorded. To assist with the best attempt, the participant should exhale and drop the head between the arms when reaching. Testers should ensure that the knees of the participant stay extended; however, the participant’s knees should not be pressed down. The participant should breathe normally during the test and should not hold his or her breath at any time.

Norms for the Canadian test are presented in Table 19-9. Note that these norms use a sit-and-reach box in which the “zero” point is set at the 26-cm mark. If you are using a box in which the zero point is set at 23 cm (e.g., Fitnessgram), subtract 3 cm from each value in this table. The norms for the YMCA test are presented in Table 19-10.

1. Before administering the sit-and-reach test, offer the individual the opportunity to do some stretching exercises and light to moderate aerobic exercise (5-10 minutes) to warm up the muscles. Inquire whether the subject has any back problems before administering the protocol. If the subject has a back problem or a history of back problems.

2. Make sure they have an adequate aerobic and muscular warm-up.

3. Have them take a few practice tries before the actual measure and inquire if it bothers the back, or skip the test.

4. A yardstick is placed on the floor and tape is placed across it at a right angle to the 15-inch mark.

5. The subject sits with the yardstick between the legs and the legs extended at right angles to the taped line on the floor. Heels of the feet should touch the edge of the taped line and be about 10 to 12 inches apart.

6. Table 19-9 Contains the YMCA Sit-and-Reach Test norm data.
### TABLE 19-9. FITNESS CATEGORIES BY AGE GROUPS AND GENDER FOR TRUNK FORWARD FLEXION USING A SIT-AND-REACH BOX (cm)*,†

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</tr>
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</tbody>
</table>


†Note: These norms are based on a sit-and-reach box in which the “zero” point is set at 26 cm. When using a box in which the zero point is set at 23 cm, subtract 3 cm from each value in this table.

### TABLE 19-10. PERCENTILES BY AGE GROUPS AND GENDER FOR YMCA SIT-AND-REACH TEST (Inches)*

<table>
<thead>
<tr>
<th>PERCENTILE</th>
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* Based on data from YMCA of the USA (reference 18). The following may be used as descriptors for the percentile rankings: well above average (90), above average (70), average (50), below average (30), and well below average (10)