chapter

13

Administration, Scoring, and Interpretation of Selected Tests
Chapter Objectives

• Discern the best ways to measure selected parameters related to athletic performance.
• Administer field tests appropriately.
• Evaluate and analyze test data and make normative comparisons.
• Understand appropriate statistics.
• Combine the results of selected tests to generate an athletic profile.
Measuring Parameters of Athletic Performance

• **Maximum Muscular Strength (Low-Speed Strength)**
  – Related to the force a muscle or muscle group can exert in one maximal effort

• **Anaerobic or Maximum Muscular Power (High-Speed Strength)**
  – Related to the ability of muscle tissue to exert high force while contracting at a high speed (also called *maximal anaerobic muscular power* or *anaerobic power*).
Key Points

- Most maximal muscular strength tests use relatively slow movement speeds and therefore reflect low-speed strength.
- Conversely, assessment of high-speed muscular strength can involve measuring the 1RM of explosive resistance training exercises or activities.
- The Phosphagen (ATP-CP) system is the primary energy system used for both low-speed and high-speed muscular strength tests.
Measuring Parameters of Athletic Performance

• **Anaerobic Capacity**
  – Maximal rate of energy production by the combined phosphagen and glycolytic (lactate) energy systems for moderate duration activities

• **Local Muscular Endurance**
  – Ability of certain muscles or muscle groups to perform repeated contractions against a submaximal resistance
Measuring Parameters of Athletic Performance

• **Aerobic Capacity**
  - Maximum rate at which an athlete can produce energy through oxidation of energy resources (carbohydrates, fats, and proteins) – oxidative (aerobic) system is the primary energy system employed
  - Usually expressed as the maximum volume of oxygen consumed per kilogram of body weight per minute (i.e., \( \text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \)); also called max *aerobic power* or \( \text{VO}_{2} \text{ max} \).
Measuring Parameters of Athletic Performance

• Agility
  – Ability to stop, start, and change the direction of the whole body rapidly and in a controlled manner in response to a sport-specific stimulus

• Speed
  – Movement distance per unit time, typically quantified as the time taken to cover a fixed distance.
Measuring Parameters of Athletic Performance

• **Flexibility**
  – Range of motion about a body joint

• **Balance and stability**
  – Balance: The ability to maintain static and dynamic equilibrium
  – Stability: The ability to return to a desired position following a disturbance to the system
Measuring Parameters of Athletic Performance

• **Body Composition**
  – Relative proportions by weight of fat and lean tissue

• **Anthropometry**
  – The science of measurement applied to the human body
  – Generally includes measurements of height, weight, and selected body girths
Measuring Parameters of Athletic Performance

• Testing Conditions
  – To maximize the reliability of tests, conditions should be as similar as possible for all athletes tested and from test to retest of the same athlete.
  – Temperature and humidity, surface, and type of equipment should be consistent.
  – Athletes should not be tested when fatigued, or when glycogen depleted or overly full from a meal. They should arrive for testing normally hydrated and with standard nutrition (no supplements).
  – Warm-up for the tests should be standardized.
Performance Tests
1 RM Squat
Maximum Lower Extremity Strength
(Low-Speed Strength)

• General technique principles for the squat are described in chapter 15 (Resistance Training).
• Detailed 1RM methods are described in chapter 17 (Program Design for Resistance Training).
See strength norms across sports in Tables 13.1-13.4
1 RM Bench Press
Maximum Upper Extremity Pressing (Pushing) Strength - (Low-Speed Strength)

- General technique principles for the bench press are described in chapter 15 (Resistance Training).
- Detailed 1RM methods are described in chapter 17 (Program Design for Resistance Training).

See strength norms across sports in Tables 13.1-13.4
1 RM Bench Pull
Maximum Upper Extremity Pulling Strength - (Low-Speed Strength)

See strength norms across sports in Tables 13.1-13.4
1 RM Power Clean
Maximum Total Body Anaerobic Power
(High-Speed Strength)

- General technique principles for the power clean are described in chapter 15 (Resistance Training).
- Detailed 1RM methods are described in chapter 17 (Program Design for Resistance Training).
See power clean norms across sports in Tables 13.1-13.4
See Tables 13-1 to 13-4 for complete set of age & sex 1 RM squat, bench press, & power clean norms for various sports.

<table>
<thead>
<tr>
<th>Sports</th>
<th>1RM bench press</th>
<th>1RM back squat</th>
<th>1RM power clean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lb</td>
<td>kg</td>
<td>lb</td>
</tr>
<tr>
<td>NCAA Division I college football players:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offensive linemen</td>
<td>385</td>
<td>175</td>
<td>531</td>
</tr>
<tr>
<td>Defensive linemen</td>
<td>377</td>
<td>171</td>
<td>502</td>
</tr>
<tr>
<td>Linebackers</td>
<td>358</td>
<td>163</td>
<td>476</td>
</tr>
<tr>
<td>Offensive backs</td>
<td>335</td>
<td>152</td>
<td>471</td>
</tr>
<tr>
<td>Tight ends</td>
<td>333</td>
<td>151</td>
<td>464</td>
</tr>
<tr>
<td>Defensive backs</td>
<td>307</td>
<td>140</td>
<td>415</td>
</tr>
<tr>
<td>Wide receivers</td>
<td>280</td>
<td>127</td>
<td>390</td>
</tr>
<tr>
<td>Quarterbacks</td>
<td>277</td>
<td>126</td>
<td>379</td>
</tr>
<tr>
<td>College baseball players (men)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>College basketball players (men)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>College track (women)</td>
<td>103</td>
<td>47</td>
<td>150</td>
</tr>
<tr>
<td>College basketball players (women)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCAA Division II college basketball players (women):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guards</td>
<td>95</td>
<td>43</td>
<td>165</td>
</tr>
<tr>
<td>Forwards</td>
<td>105</td>
<td>48</td>
<td>185</td>
</tr>
<tr>
<td>Centers</td>
<td>105</td>
<td>48</td>
<td>220</td>
</tr>
<tr>
<td>College volleyball players (women)</td>
<td>104</td>
<td>47</td>
<td>165</td>
</tr>
</tbody>
</table>

*The values listed are either means or 50th percentiles (medians). Also, the two sets of data reported for men’s and women’s basketball are based on multiple different samples.
Vertical Jump Using Wall and Chalk (Anaerobic Power) - (High-Speed Strength)

- Tester rubs chalk on the athlete’s dominant hand.
- Athlete stands about 6 inches from the wall and places a mark on the wall with the dominant arm as high as possible while keeping both feet flat on the floor.
- Athlete then performs a countermovement jump and places a second chalk mark as high as possible on the wall.
Vertical Jump (Anaerobic Power)
(High-Speed Strength)

• (a) Starting position and (b) maximum height of the vertical jump, using a commercial Vertec device

Average jump heights are 12-16 inch for collegiate women’s soccer and 18-21 inch for collegiate women’s volleyball and basketball (age and gender norms shown in Table 13.21)
Reactive Strength Index (Anaerobic Power)

(a) Starting position of the drop jump test to measure reactive strength index
(b) Contact on mat
(c) Maximum height of the jump

(High-Speed Strength)
Standing Long Jump (Anaerobic Power)  
(High-Speed Strength)

- Athlete stands with toes just behind the starting line and performs a counter-movement jump as far forward as possible

- Athlete must land on the feet in order for the jump to be scored

- Distance is measured from the back edge of the athlete’s rearmost heel

Average long jumps are 9 ft, 2 inch for elite males and 8 ft, 2 inch for elite females, and for 15-16 year olds its 5ft, 9 inch for males and 4 ft, 9 inch for females (age and gender norms shown in Tables 13.5-13.7).
The athlete sprints toward the stairs from a standing start 20 feet (6 m) from the base of the stairs and then up the staircase three steps at a time.

Power in watts is calculated as the athlete’s weight \( w \) in newtons times height \( h \) in meters from the third step to the ninth step divided by the measured time interval \( t \) in seconds; \( P \) (watts) = \( w \times h \) / \( t \). Average values for young men are 1400-1800 W and for young women are 1100 – 1500 W (age and gender norms in Table 13.8).
The athletes sprint to the line 25 yards (22.86 m) away, then immediately sprint back to the first line. Six such round trips are made as fast as possible without stopping.

The average of two trials is recorded to the nearest second. Average times are 57 sec for men's National soccer team & 67 sec for collegiate volleyball team (age & gender norms in Table 13.9)
T-Test (Agility)

- The test begins with the athlete standing at point A. The athlete:
  - Sprints to point B and touches the base of the cone with the right hand.
  - Shuffles left & touches base of cone C with the left hand.
  - Shuffles right & touches base of cone D with the right hand.
  - Shuffles left & touches base of cone B with the left hand.
  - Runs backward past point A.
  - Keep head in neutral position with eyes always looking straight ahead.

Average times are 9-10 sec in collegiate men athletes and 10-11 sec in collegiate women athletes (age & gender norms shown in Table 13.21)
Hexagon Test (Agility)

- The athlete double-leg hops from the center of the hexagon over each side and back to the center, starting with the side directly in front of the athlete, in a continuous clockwise sequence until all six sides are covered three times (for a total of 18 jumps).

Average times for collegiate athletes are approx. 12 sec for men and approx. 13 sec for women (age & gender norms shown in Table 13.21).
Pro Agility Test (Agility)

- The athlete sprints 5 yards (4.6 m) to the line on the left, then changes direction and sprints 10 yards (9.1 m) to the line on the right, then again changes direction and sprints 5 yards (4.6 m) to the center line.
- For age & sex norms for various sports, see Table 12.18.

Average times are 4.9-5.1 sec in collegiate women athletes and 4.4-4.5 sec in collegiate men athletes (age & gender norms in Tables 13.21 & 13.22)
Straight-Line Sprint Tests (Speed)

- Have the athlete warm up and dynamically stretch for several minutes.
- Allow at least two practice runs at submaximal speed.
- The athlete assumes a starting position using a three- or four-point stance.
- On an auditory signal, the athlete sprints the specified distance (eg, 10, 20, 30 or 40 yards) at maximal speed.
- The best split times of two trials are recorded to the nearest 0.1 second.
- Allow at least 2 minutes of active recovery or rest between trials.

Mean times across various distances & sports are shown in Table 13.23
<table>
<thead>
<tr>
<th>Sport/position</th>
<th>Vertical jump in.</th>
<th>Vertical jump cm</th>
<th>Pro Agility T-test s</th>
<th>40-ya sprint s</th>
<th>Hexagon test s</th>
<th>300-ya shuttle s</th>
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<tbody>
<tr>
<td>NCAA Division I college football split ends, strong safeties, offensive and defensive backs</td>
<td>31.5</td>
<td>80</td>
<td>4.3</td>
<td>4.6-4.7</td>
<td></td>
<td>&lt;59</td>
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<tr>
<td>NCAA Division I college football wide receivers and outside linebackers</td>
<td>31</td>
<td>79</td>
<td>4.3</td>
<td>4.6-4.7</td>
<td></td>
<td>&lt;59</td>
</tr>
<tr>
<td>NCAA Division I college football linebackers, tight ends, safeties</td>
<td>29.5</td>
<td>75</td>
<td>4.4</td>
<td>4.8-4.9</td>
<td></td>
<td>&lt;61</td>
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<tr>
<td>NCAA Division I college football quarterbacks</td>
<td>28</td>
<td>71</td>
<td>4.6</td>
<td>4.9-5.1</td>
<td></td>
<td>&lt;65</td>
</tr>
<tr>
<td>NCAA Division I college football defensive tackles</td>
<td>27</td>
<td>69</td>
<td>4.7</td>
<td>5.1</td>
<td></td>
<td>&lt;65</td>
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<tr>
<td>NCAA Division I college football offensive guards</td>
<td>25-26</td>
<td>64-66</td>
<td>5.4</td>
<td></td>
<td></td>
<td>&lt;65</td>
</tr>
<tr>
<td>NCAA Division I college football offensive tackles</td>
<td>28</td>
<td>71</td>
<td>4.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCAA Division I college basketball players (men)</td>
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<tr>
<td>College basketball players (men)</td>
<td>27-29</td>
<td>69-74</td>
<td>8.9</td>
<td>5.0</td>
<td>12.3</td>
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<tr>
<td>Competitive college athletes (men)</td>
<td>25-25.5</td>
<td>64-65</td>
<td>10.0</td>
<td>5.0</td>
<td>12.3</td>
<td></td>
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<tr>
<td>Recreational college athletes (men)</td>
<td>24</td>
<td>61</td>
<td>10.5</td>
<td>5.0</td>
<td>12.3</td>
<td></td>
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<tr>
<td>High school football backs and receivers</td>
<td>24</td>
<td>61</td>
<td>10.5</td>
<td>5.0</td>
<td>12.3</td>
<td></td>
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<tr>
<td>College baseball players (men)</td>
<td>23</td>
<td>58</td>
<td>4.5</td>
<td>9.2</td>
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<td></td>
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<tr>
<td>College tennis players (men)</td>
<td>23</td>
<td>58</td>
<td>4.5</td>
<td>9.4</td>
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<td></td>
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<tr>
<td>College soccer players (women)</td>
<td>16</td>
<td>41</td>
<td>4.9</td>
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<tr>
<td>College basketball players (women)</td>
<td>21</td>
<td>53</td>
<td>5.0</td>
<td>9.9</td>
<td></td>
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<tr>
<td>College volleyball players (women)</td>
<td>21</td>
<td>53</td>
<td>5.0</td>
<td>10.7</td>
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<td></td>
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<tr>
<td>Competitive college athletes (women)</td>
<td>16-19</td>
<td>(41-48)</td>
<td>10.8</td>
<td>5.5-6.0</td>
<td>12.9</td>
<td></td>
</tr>
</tbody>
</table>
Curl-Up (Trunk Muscular Endurance)

- **Curl-up:**
  - (a) beginning position
  - (b) end position

- Set a metronome to 40 beats per minute and have the individual do slow, controlled curl-ups to lift the shoulder blades off the mat in time with the metronome as fingers slide forward 4 inches. The upper back must touch the floor before each curl-up.

- The athlete performs as many curl-ups as possible without pausing, to a maximum of 75.

Average number of curl-ups are 27-31 for young men and 21-27 for young women (age and gender norms shown in Table 13.10)
Army Style Push-Up (for males)
Upper Extremity Muscular Endurance

• Push-up according to Army standard:
  – (a) beginning position
  – (b) end position

• For the Army standard, as many repetitions as possible are done within a timed 2-minute period.

Average number of push-ups are 17-22 for young men (age and gender norms shown in Table 13.11)
ACSM Style Push-Up (for females)
Upper Extremity Muscular Endurance

• Push-up according to ACSM standard for females:
  – (a) beginning position
  – (b) end position

• For the ACSM standard, as many repetitions as possible are done continuously until failure.

Average number of push-ups are 13-15 for young women (age and gender norms shown in Table 13.11)
YMCA Bench Press Test
Upper Extremity Muscular Endurance

• Resistance is set at 80 pounds for males and 35 pounds for females.
• Set metronome cadence at 60 beats per minute to establish a rate of 30 repetitions per minute (one beat up, one beat down).
• This test is performed until the athlete can no longer perform repetitions with the metronome.

Average number of bench press are 22-26 for young men and 20-21 for young women (age and gender norms shown in Table 13.13)
Yo-Yo Intermittent Recovery Test (Aerobic Capacity)

- 20 m test course with markers 2 m apart at each end of the course & 5 m distance behind start line.
- At 1st audio signal, athletes run forward towards turning line and arrives before 2nd audio signal.
- At 2nd signal athletes run back to the starting line, arriving before next signal.
- Athletes jog toward the 5 m mark after the start line and return to start line to wait for next audio signal to start again.
- Each audio signals come quicker forcing athletes to increase run speed.
- Test is terminated when athlete cannot maintain required pace for two trials.

Average distance are 2000-2400 m and 1200-1300 m, respectively, for the mens and women’s National soccer team (norms in Table 13.20).
Tests to Calculate VO$_2$ Max (Aerobic Capacity)

- **Max Protocols**
  - Treadmill Running (eg, Bruce protocol), 12 min run, 1.5 mile run, cycling, etc...

- **Submax Protocols** (using HR and Appropriate Regression Equations)
  - Step-test, treadmill, cycling

Average 1.5 mile run times for young men and women are 12 min and 14 min, respectively. Average 12 min run distances for young men and women are 1.53 miles and 1.37 miles, respectively. Age and gender norms shown in Tables 13.14 – 13.19.
Maximal Aerobic Speed (MAS) Test (Aerobic Capacity)

• Marker cones are placed at 25 m intervals around the running track.

• Initial speed of test is set between 8-12 km/h (~5-7.5 mi/h), depending on athlete’s fitness level, and increased by 1 km/h (~0.6 mi/h) every 2 minutes until the athlete cannot maintain the speed.

• If audio signal from MAS test software is not available, a whistle can be used between cones (eg, at a 10 km/h pace the whistle would blow every 9 sec from cone to cone; and every 6 sec at a 15 km/h pace, and so forth)

• The last speed maintained for at least 2 minutes is considered the speed associated with VO₂max, estimated by multiplying 3.5 by MAS (in km/h).

• The test is terminated if the athlete fails to reach the next cone on two consecutive occasions in the required time.

• The speed at the last completed stage is increased by 0.5 km/h if the athlete is able to run a half stage.

Alternatively, MAS can be calculated by having the athlete run around a 400 track as fast as possible for 1.5-2 km and record distance & time. For example, is an athlete ran 1500 m in 4min 55sec (295sec) then his MAS would be 1500m/295secs = 5.08m/sec = 18.31 km/h = 11.36 mi/h. Therefore, his estimated VO₂max = 3.5*18.31 km/h = 64.1 mL·kg⁻¹·min⁻¹
Maximum 1.5 Mile Run (Aerobic Capacity)

- A subject runs as fast as possible for 1.5 miles and the time at completion is recorded. \( \text{VO}_2 \text{ max} \) is estimated by using the following ACSM equation:

\[
\text{VO}_2 \text{ max} \ (\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}) = 3.5 + \frac{483}{(\text{time in min})}
\]
Maximum 12 Minute Run (Cooper, 1968) (Aerobic Capacity)

- For the 12 min run test, a subject runs as fast as possible for 12 min and records the distance traveled in meters or miles.
- Using 115 asymptomatic US Air Force male officers with an age range between 17-52 years old (mean = 22 years old), Cooper (1968) developed the following generalized regression equations (R = 0.90) for the 12 min run protocol to estimate VO2 max:

\[
\text{VO}_2 \text{ max (ml·kg}^{-1}·\text{min}^{-1}) = \frac{(\text{Distance (m)} - 504.9)}{44.73}
\]

or

\[
\text{VO}_2 \text{ max (ml·kg}^{-1}·\text{min}^{-1}) = \frac{(\text{Distance (miles)} - 0.3138)}{0.0278}
\]
Maximum Treadmill Test (Bruce et al, 1973) (Aerobic Capacity)

- The conventional Bruce protocol involves performing up to six 3 min stages (stages 1-6) with speeds and grades as follows:
  - Stage 1: 1.7 mi/h at 10%; Stage 2: 2.5 mi/h at 12%; Stage 3: 3.4 mi/h at 14%; Stage 4: 4.2 mi/h at 16%; Stage 5: 5.0 mi/h at 18%; Stage 6: 5.5 mi/h at 20%.
- When maximal exertion is achieved and the subject is unable to continue, the time completed in minutes is recorded.
- Foster et al. (1984) developed the following generalized regression equation \( R = 0.98; \text{SEE} = 3.35 \text{ ml.kg}^{-1}\text{min}^{-1} \) for the conventional Bruce protocol (stages 1-6) to order to estimate VO2 max for symptomatic and asymptomatic active and sedentary males:
  \[ \text{VO}_2 \text{ max} (\text{ml.kg}^{-1}\text{min}^{-1}) = 14.76 - 1.379*\text{Time (min)} + 0.451*\text{Time}^2 - 0.012*\text{Time}^3 \]
- Pollock et al. (1982) developed the following generalized regression equation \( R = 0.91; \text{SEE} = 2.7 \text{ ml.kg}^{-1}\text{min}^{-1} \) for the conventional Bruce protocol (stages 1-6) to order to estimate VO2 max for asymptomatic active and sedentary females:
  \[ \text{VO}_2 \text{ max} (\text{ml.kg}^{-1}\text{min}^{-1}) = 4.38*\text{Time (min)} - 3.9 \]
### Table 13.18

<table>
<thead>
<tr>
<th>Classification</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Extremely high</strong></td>
<td>70+</td>
<td>60+</td>
</tr>
<tr>
<td><strong>Very high</strong></td>
<td>63-69</td>
<td>54-59</td>
</tr>
<tr>
<td><strong>High</strong></td>
<td>57-62</td>
<td>49-53</td>
</tr>
<tr>
<td><strong>Above average</strong></td>
<td>52-56</td>
<td>44-48</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>44-51</td>
<td>35-43</td>
</tr>
</tbody>
</table>

**Sport**

- Cross-country skiing
- Middle-distance running
- Long-distance running
- Bicycling
- Rowing
- Race walking
- Soccer
- Middle-distance swimming
- Canoe racing
- Handball
- Racquetball
- Speed skating
- Figure skating
- Downhill skiing
- Wrestling
- Basketball
- Ballet dancing
- Football (offensive/defensive backs)
- Gymnastics
- Hockey
- Horse racing (jockey)
- Sprint swimming
- Tennis
- Sprint running
- Jumping
- Baseball/softball
- Football (linemen, quarterbacks)
- Shot put
- Discus throw
- Olympic-style weightlifting
- Bodybuilding

Data from Nieman 1995 (39).
Sit-and-Reach Test (Flexibility)

• **Sit-and-reach:**
  - *(a)* starting position
    - The white tape is positioned even with the heels and perpendicular to the yard stick at the 15 inch mark
  - *(b)* final position

Average distances for the sit-and-reach are 17 inches for young men and 19 inches for young women (age & gender norms in Tables 13.14 – 13.17). Note: a 17 inch distance implies the finger tips move 2 inches beyond the heels (17 inch – 15 inch = 2 inch)
Overhead Squat (Flexibility)

- **Body position**
  - (a) Starting position
    - Grip wooden dowel twice shoulder width, feet ~ shoulder width, & feet turned slightly out
  - (b) Squat position
    - Squat down until crease of hip is below top of knees keeping heels on ground and trunk slightly forward and parallel with tibia

- **A minimum of 5 repetitions should be performed**

- **Assessment is qualitative**
  - Pass or Fail
Balance Error Scoring System (BESS) (Balance and Stability)

- Three stance positions performed for 20 sec holds each with eyes closed – first perform on firm surface as shown
  - a) Double-leg stance with feet together
  - b) Single-leg stance on nondominant leg with contralateral leg flexed 90°
  - c) Tandem stance with dominant foot in front of nondominant foot
Balance Error Scoring System (BESS) (Balance and Stability)

- Three stance positions performed for 20 sec holds each with eyes closed – then perform on soft surface as shown
  - d) Double-leg stance with feet together
  - e) Single-leg stance on nondominant leg with contralateral leg flexed 90°
  - f) Tandem stance with dominant foot in front of nondominant foot
Balance Error Scoring System (BESS) (Balance and Stability)

- **Errors include the following:**
  - Opening eyes
  - Lifting hands from hips
  - Touchdown of nonstance foot
  - Step, hop, or other movement of the stance foot/feet
  - Lifting forefoot or heel
  - Moving hip into more than 30° of hip flexion or abduction
  - Remaining out of position for more than 5 seconds
  - Errors from all 6 positions are summed into single score

Average error score is 10.4 for young men and 11.9 for young women (age and gender norms shown in Table 13.24).
Star Excursion Balance Test (SEBT) (Balance and Stability)

Athlete stands in the center of a grid with eight lines (120 cm) extending out at 45° increments.

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Star Excursion Balance Test (SEBT) (Balance and Stability)

Athlete maintains a single-leg stance facing a chosen direction while reaching with the contralateral leg as far as possible for each taped line, touching the farthest point possible, and then returning to the bilateral position. For each of the 8 positions the stance leg remains stationary facing the same direction. 3 trials are performed for each condition and reach distances measured & averaged.
Star Excursion Balance Test (SEBT) (Balance and Stability)

- The distance from the center of the star to the touch position is measured.
- Starting direction & support leg chosen randomly, and each leg is tested.
- 15 sec rest is allowed between each of the reaches.
- Trials are discarded if the athlete
  – Does not touch the line
  – Lifts stance foot from the center grid
  – Loses balance
  – Does not maintain start and return positions for 1 second
Star Excursion Balance Test (SEBT) (Balance and Stability)

• Athletes should be given a minimum of four practice trials before being tested.

• It has been suggested that testing the anteromedial, medial, posteromedial, and posterolateral positions are sufficient for most situations (ie, specificity of sports movements).

• Differences between left and right sides are compared
Girth Measurements
Anthropometry

• Common sites for girth measurements
  – Chest
  – Upper arm
  – Forearm
  – Waist
  – Hips
  – Thigh
  – Calf
Body mass index (BMI)

Body Composition

- BMI can be used as an initial screening tool to identify potential weight issues in individuals and assess if a person is underweight, normal weight, overweight, or obese.
- Is a measure of total body mass — cannot distinguish between fat, muscle, or bone mass, although it can be used to estimate body fat in the average person but NOT athletes, who have a more lean body mass and less fat mass than the average person.
- To calculate BMI, use one of the following equations:
  - Weight (kg) / Height (m²)
  - [Weight (pounds) / Height (inches)²] × 703
TABLE 4.2. Predicted Body Fat Percentage Based on Body Mass Index (BMI) for African American and White Adults

<table>
<thead>
<tr>
<th>BMI (kg · m⁻²)</th>
<th>Health Risk</th>
<th>20–39 yr</th>
<th>40–59 yr</th>
<th>60–79 yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;18.5</td>
<td>Elevated</td>
<td>&lt;8%</td>
<td>&lt;11%</td>
<td>&lt;13%</td>
</tr>
<tr>
<td>18.6–24.9</td>
<td>Average</td>
<td>8%–19%</td>
<td>11%–21%</td>
<td>13%–24%</td>
</tr>
<tr>
<td>25.0–29.9</td>
<td>Elevated</td>
<td>20%–24%</td>
<td>22%–27%</td>
<td>25%–29%</td>
</tr>
<tr>
<td>&gt;30</td>
<td>High</td>
<td>≥25%</td>
<td>≥28%</td>
<td>≥30%</td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;18.5</td>
<td>Elevated</td>
<td>&lt;21%</td>
<td>&lt;23%</td>
<td>&lt;24%</td>
</tr>
<tr>
<td>18.6–24.9</td>
<td>Average</td>
<td>21%–32%</td>
<td>23%–33%</td>
<td>24%–35%</td>
</tr>
<tr>
<td>25.0–29.9</td>
<td>Elevated</td>
<td>33%–38%</td>
<td>34%–39%</td>
<td>36%–41%</td>
</tr>
<tr>
<td>&gt;30</td>
<td>High</td>
<td>≥39%</td>
<td>≥40%</td>
<td>≥42%</td>
</tr>
</tbody>
</table>

Note: Standard error of estimate is ±5% for predicting percent body fat from BMI (based on a four compartment estimate of body fat percentage).

Reprinted with permission from (41).

Skinfold Measurements to Assess % Body Fat (Body Composition)

- Body composition determined from skinfold thickness measurements correlates well ($r = 0.70–0.90$) with body composition determined by hydrodensitometry.
- The principle behind skinfold measurements is that the amount of subcutaneous fat is proportional to the total amount of body fat.
- It is assumed that close to one-third (or up to one-half) of the total fat is located subcutaneously.
- Regression equations used to convert sum of skinfolds to percent body fat should consider these variables for greatest accuracy (typically accurate within $\pm 3.5\%$ of actual body fat).
Standardized Description of Skinfold Sites and Procedures

Procedures

• All measurements should be made on the right side of the body with the subject standing upright
• Caliper should be placed directly on the skin surface, 1 cm away from the thumb and finger, perpendicular to the skinfold, and halfway between the crest and the base of the fold
• Pinch should be maintained while reading the caliper
• Wait 1–2 s (not longer) before reading caliper
• Take duplicate measures at each site and retest if duplicate measurements are not within 1–2 mm
• Rotate through measurement sites or allow time for skin to regain normal texture and thickness
Standardized Description of Skinfold Sites and Procedures

SKINFOLD SITE

Chest: Diagonal fold; one-half the distance between the anterior axillary line and the nipple (men), or one-third of the distance between the anterior axillary line and the nipple (women)

Thigh: Vertical fold; on the anterior midline of the thigh, midway between the proximal border of the patella and the inguinal crease (hip)

Abdominal: Vertical fold; 2 cm to the right side of the umbilicus

Triceps: Vertical fold; on the posterior midline of the upper arm, halfway between the acromion and olecranon processes, with the arm held freely to the side of the body
Skinfold Measurements to Assess % Body Fat

Body Composition

- Common sites for skinfold measurements
  - Chest
  - Thigh
  - Abdomen
  - Triceps
Suprailiac: Diagonal fold; in line with the natural angle of the iliac crest taken in the anterior axillary line immediately superior to the iliac crest

Midaxillary: Vertical fold; on the midaxillary line at the level of the xiphoid process of the sternum. An alternate method is a horizontal fold taken at the level of the xiphoid/sternal border in the midaxillary line

Subscapular: Diagonal fold (at a 45-degree angle); 1–2 cm below the inferior angle of the scapula
Skinfold Measurements to Assess % Body Fat

Body Composition

- Common sites for skinfold measurements
  - Suprailium
  - Midaxilla
  - Subscapula
## Skinfold Measurements to Assess % Body Fat Body Composition

### 7-Site (Chest, Thigh, Abdominal, Triceps, Suprailium, Midaxilla, Subscapula) Body Fat (BF) Percentage Calculation for Male and Female using the Jackson-Pollock Method

<table>
<thead>
<tr>
<th></th>
<th>Formula</th>
<th>Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>BF% = 495/(1.112 - (0.00043499<em>s) + (0.00000055</em>s<em>s) - (0.00028826</em>a)) − 450</td>
<td>s = sum of 7 skinfold mm, a = age</td>
</tr>
<tr>
<td>Female</td>
<td>BF% = 495/(1.097 - (0.00046971<em>s) + (0.00000056</em>s<em>s) - (0.00012828</em>a)) − 450</td>
<td></td>
</tr>
</tbody>
</table>
### Skinfold Measurements to Assess % Body Fat Body Composition

3-Site (Chest, Thigh, Abdominal for Males and Triceps, Suprailium, Thigh for Females) Body Fat (BF) Percentage Calculation using the Jackson-Pollock Method

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
</table>
| BF%      | \[
|          | \[
|          | \[
|          | \[
|          | \[
|          | \[
|          | \[
|          | \[
| Variables| s = sum of 3 skinfold mm, a = age                                  | s = sum of 3 skinfold mm, a = age                                  |
## Percent Body Fat Descriptive Data for Athletes in Various Sports

<table>
<thead>
<tr>
<th>Classification</th>
<th>Typical Percent Body Fat</th>
<th>Sport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely lean</td>
<td></td>
<td>Gymnastics</td>
</tr>
<tr>
<td>Males: &lt;7%</td>
<td></td>
<td>Bodybuilding (at contest)</td>
</tr>
<tr>
<td>Females: &lt;15%</td>
<td></td>
<td>Wrestling (at contest)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cross-country</td>
</tr>
<tr>
<td>Very lean</td>
<td>8-10%</td>
<td>Men's basketball (guards, forwards)</td>
</tr>
<tr>
<td>Males:</td>
<td></td>
<td>Racquetball</td>
</tr>
<tr>
<td>Females: 16-18%</td>
<td></td>
<td>Rowing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soccer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Track-and-field decathlon (men)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Track-and-field heptathlon (women)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Men's basketball (centers)</td>
</tr>
<tr>
<td>Leaner than average</td>
<td>11-13%</td>
<td>Men's baseball</td>
</tr>
<tr>
<td>Males:</td>
<td></td>
<td>Canoeing</td>
</tr>
<tr>
<td>Females: 19-20%</td>
<td></td>
<td>Downhill skiing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Speed skating</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Olympic-style weightlifting</td>
</tr>
<tr>
<td>Average</td>
<td>14-17%</td>
<td>Women's basketball</td>
</tr>
<tr>
<td>Males:</td>
<td></td>
<td>Football quarterbacks, kickers, linebackers</td>
</tr>
<tr>
<td>Females: 21-25%</td>
<td></td>
<td>Hockey</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Horse racing (jockey)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tennis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Discus throw</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volleyball</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Women's softball</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Powerlifting</td>
</tr>
<tr>
<td>Fatter than average</td>
<td>18-22%</td>
<td>Football (linemen)</td>
</tr>
<tr>
<td>Males:</td>
<td></td>
<td>Shot put</td>
</tr>
<tr>
<td>Females: 26-30%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data from Nieman 1995 (39).
Statistical Evaluation of Test Data

• Types of Statistics
  – Descriptive Statistics
    • Central Tendency
      – mean: The average of the scores.
      – median: The middlemost score when a set of scores is arranged in order of magnitude.
      – mode: The score that occurs with the greatest frequency.
Statistical Evaluation of Test Data

• Types of Statistics
  – Descriptive Statistics
    • Variability
      – range: The interval from the lowest to the highest score.
      – standard deviation: A measure of the variability of a set of scores about the mean.
    • Percentile Rank
      – The percentage of test takers scoring below an individual
“Normally distributed” scores form the bell-shaped curve. Two-thirds of the population will fall within 1 SD of the mean, and 95% of the population will fall within 2 SD of the mean.

Standard deviation is most useful when scores are normally distributed.
Statistical Evaluation of Test Data

• Types of Statistics
  – Inferential Statistics
    • Allows one to draw general conclusions about a population from information collected in a population sample.
    • Population sample must be representative. For example, one might infer that the means and SD’s of 200 basketball players from 10 different Division I basketball programs represents the ability of Division I basketball players nationwide.
    • A relatively small sample may limit the ability to use inferential stats.
Statistical Evaluation of Test Data

• Types of Statistics
  – Magnitude statistics
    • Allow for interpretation of the clinical significance of fitness testing
    • Minimum Detectable Change (Smallest worthwhile change): the ability of a test to detect the smallest practically important change in performance
    • Effect size: a statistic used for calculating group performance following a training program or comparing between groups of athletes
Statistical Evaluation of Test Data

• Developing an Athletic Profile
  – Select tests that will measure the specific parameters most closely related to the characteristics of the sport or sports in question.
  – Choose valid and reliable tests to measure these parameters, and arrange the testing battery in an appropriate order with sufficient rest between tests to promote test reliability.
  – Administer the test battery to as many athletes as possible.
  – Calculate percentile ranks to present a visual profile.
  – Evaluate the athlete based on percentile rank within the group and against the individual’s best performances over previous years, if possible.
Statistical Evaluation of Test Data

• Developing an athletic profile
  – Compare to normative data where appropriate. Develop own norms when standardized procedures are used.
  – Conduct repeat testing (e.g., before and after training program) and use the results to present a visual profile with figures.
  – Identify the strengths and weaknesses of the athletes and design the training program with these in mind.