Plyometric Training

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Chapter Objectives

• Explain the physiology of plyometric exercise.
• Identify the phases of the stretch-shortening cycle.
• Identify components of a plyometric training program.
• Design a safe and effective plyometric training program.
• Recommend proper equipment for plyometric exercise.
• Teach correct technique for plyometric exercises.
Section Outline

- Plyometric Mechanics and Physiology
  - Mechanical Model of Plyometric Exercise
  - Neurophysiological Model of Plyometric Exercise
  - Stretch-Shortening Cycle
Plyometric Mechanics and Physiology

• Mechanical Model of Plyometric Exercise
  – Elastic energy in tendons and muscles is increased with a rapid stretch (as in an eccentric muscle action) and then briefly stored.
  – If a concentric muscle action follows immediately, the stored energy is released, contributing to the total force production.
Mechanical Model

• **Figure 16.1 (next slide)**
  – Mechanical model of skeletal muscle function
    • The series elastic component (SEC), when stretched, stores elastic energy that increases the force produced.
    • The contractile component (CC) (i.e., actin, myosin, and cross-bridges) is the primary source of muscle force during concentric muscle action.
    • The parallel elastic component (PEC) (i.e., epimysium, perimysium, endomysium, and sarcolemma) exerts a passive force with unstimulated muscle stretch.
Figure 16.1

Plyometric Mechanics and Physiology

• **Neurophysiological Model of Plyometric Exercise**
  – This model involves *potentiation* (change in the force–velocity characteristics of the muscle’s contractile components caused by stretch) of the concentric muscle action by use of the stretch reflex.
  – *Stretch reflex* is the body’s involuntary response to an external stimulus that stretches the muscles.
Stretch Reflex

• **Figure 16.2 (next slide)**
  – When muscle spindles are stimulated, the stretch reflex is stimulated, sending input to the spinal cord via Type Ia nerve fibers.
  – After synapsing with the alpha motor neurons in the spinal cord, impulses travel to the agonist extrafusal fibers, causing a reflexive muscle action.
Adapted, by permission, from Wilk et al., 1993.
Plyometric Mechanics and Physiology

- **Stretch-Shortening Cycle**
  - The stretch-shortening cycle (SSC) employs both the energy storage of the SEC and stimulation of the stretch reflex to facilitate maximal increase in muscle recruitment over a minimal amount of time.
  - There are three phases: eccentric, amortization, and concentric.
  - A fast rate of musculotendinous stretch is vital to muscle recruitment and activity resulting from the SSC.
<table>
<thead>
<tr>
<th>Phase</th>
<th>Action</th>
<th>Physiological event</th>
</tr>
</thead>
<tbody>
<tr>
<td>I—Eccentric</td>
<td>Stretch of the agonist muscle</td>
<td>▪ Elastic energy is stored in the series elastic component.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Muscle spindles are stimulated.</td>
</tr>
<tr>
<td>II—Amortization</td>
<td>Pause between phases I and III</td>
<td>▪ Type Ia afferent nerves synapse with alpha motor neurons.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Alpha motor neurons transmit signals to agonist muscle group.</td>
</tr>
<tr>
<td>III—Concentric</td>
<td>Shortening of agonist muscle fibers</td>
<td>▪ Elastic energy is released from the series elastic component.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Alpha motor neurons stimulate the agonist muscle group.</td>
</tr>
</tbody>
</table>
Stretch-Shortening Cycle

• Figure 16.3 (next slide)
  – The long jump and stretch-shortening cycle
    • (a) The eccentric phase begins at touchdown and continues until the movement ends.
    • (b) The amortization phase is the transition from eccentric to concentric phases; it is quick and without movement.
    • (c) The concentric phase follows the amortization phase and comprises the entire push-off time, until the athlete’s foot leaves the surface.
Key Point

- The stretch-shortening cycle combines mechanical and neurophysiological mechanisms and is the basis of plyometric exercise. A rapid eccentric muscle action stimulates the stretch reflex and storage of elastic energy, which increase the force produced during the subsequent concentric action.
Section Outline

• Plyometric Program Design
  – Mode
    • Lower Body Plyometrics
    • Upper Body Plyometrics
    • Trunk Plyometrics
  – Intensity
  – Frequency
  – Recovery
  – Volume
  – Program Length
  – Progression
  – Warm-Up
Plyometric Program Design

• **Mode**
  – Lower Body Plyometrics
    • These are appropriate for virtually any athlete and any sport.
    • Direction of movement varies by sport, but many sports require athletes to produce maximal vertical or lateral movement in a short amount of time.
    • There are a wide variety of lower body drills with various intensity levels and directional movements.
## TABLE 16.2
Lower Body Plyometric Drills

<table>
<thead>
<tr>
<th>Type of drill</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jumps in place</td>
<td>These drills involve jumping and landing in the same spot. Jumps in place emphasize the vertical component of jumping and are performed repeatedly, without rest between jumps; the time between jumps is the stretch-shortening cycle’s amortization phase. Examples of jumps in place include the squat jump and tuck jump.</td>
</tr>
<tr>
<td>Standing jumps</td>
<td>These emphasize either horizontal or vertical components. Standing jumps are maximal efforts with recovery between repetitions. The vertical jump and jumps over barriers are examples of standing jumps.</td>
</tr>
<tr>
<td>Multiple hops and jumps</td>
<td>Multiple hops and jumps involve repeated movement and may be viewed as a combination of jumps in place and standing jumps. One example of a multiple jump is the zigzag hop.</td>
</tr>
<tr>
<td>Bounds</td>
<td>Bounding drills involve exaggerated movements with greater horizontal speed than other drills. Volume for bounding is typically measured by distance but may be measured by the number of repetitions performed. Bounding drills normally cover distances greater than 98 feet (30 m) and may include single- and double-leg bounds in addition to the alternate-leg bounds illustrated in this chapter.</td>
</tr>
<tr>
<td>Box drills</td>
<td>These drills increase the intensity of multiple hops and jumps by using a box. The box may be used to jump on or off. The height of the box depends on the size of the athlete, the landing surface, and the goals of the program. Box drills may involve one, both, or alternating legs.</td>
</tr>
<tr>
<td>Depth jumps</td>
<td>Depth jumps use gravity and the athlete’s weight to increase exercise intensity. The athlete assumes a position on a box, steps off, lands, and immediately jumps vertically, horizontally, or to another box. The height of the box depends on the size of the athlete, the landing surface, and the goals of the program. Depth jumps may involve one or both legs.</td>
</tr>
</tbody>
</table>

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Plyometric Program Design

- **Mode**
  - Upper Body Plyometrics
    - Drills include medicine ball throws, catches, and several types of push-ups.
Plyometric Program Design

• Mode
  – Trunk Plyometrics
    • Exercises for the trunk may be performed “plyometrically” provided that movement modifications are made.
    • Specifically, the exercise movements must be shorter and quicker to allow stimulation and use of the stretch reflex.
Medicine Ball Sit-Up

• **Figure 16.4 (next slide)**
  – The slide shows a medicine ball sit-up.
  – The large range of motion and time needed to complete this exercise negate abdominal muscle potentiation by the stretch reflex.
Plyometric Sit-Up

• **Figure 16.5 (next slide)**
  – The slide shows a plyometric sit-up.
  – The relatively small range of motion and quick movement in this exercise may increase abdominal muscle activity through use of the stretch reflex.
Plyometric Program Design

• **Intensity**
  - Plyometric intensity refers to the amount of stress placed on muscles, connective tissues, and joints.
  - It is controlled primarily by the type of plyometric drill.
  - Generally, as intensity increases, volume should decrease.
### TABLE 16.3
Factors Affecting the Intensity of Lower Body Plyometric Drills

<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Points of contact</td>
<td>The ground reaction force during single-leg lower body plyometric drills places more stress on an extremity’s muscles, connective tissues, and joints than during double-leg plyometric drills.</td>
</tr>
<tr>
<td>Speed</td>
<td>Greater speed increases the intensity of the drill.</td>
</tr>
<tr>
<td>Height of the drill</td>
<td>The higher the body’s center of gravity, the greater the force on landing.</td>
</tr>
<tr>
<td>Body weight</td>
<td>The greater the athlete’s body weight, the more stress is placed on muscles, connective tissues, and joints. External weight (in the form of weight vests, ankle weights, and wrist weights) can be added to the body to increase a drill’s intensity.</td>
</tr>
</tbody>
</table>

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Plyometric Program Design

• Frequency
  – Forty-eight to 72 hours between plyometric sessions is a typical recovery time guideline for prescribing plyometrics.
  – Using these typical recovery times, athletes commonly perform two to four plyometric sessions per week.
Plyometric Program Design

• Recovery
  – Recovery for depth jumps may consist of 5 to 10 seconds of rest between repetitions and 2 to 3 minutes between sets.
  – The time between sets is determined by a proper work-to-rest ratio (i.e., 1:5 to 1:10) and is specific to the volume and type of drill being performed.
  – Drills should not be thought of as cardiorespiratory conditioning exercises but as power training.
  – Furthermore, drills for a given body area should not be performed two days in succession.
Plyometric Program Design

• Volume
  – For lower body drills, plyometric volume is expressed as contacts per workout (or in distance for bounding drills).
  – For upper body drills, plyometric volume is expressed as the number of throws or catches per workout.
  – Recommended lower body volumes vary for athletes with different levels of experience.
# Table 16.4

## Appropriate Plyometric Volumes

<table>
<thead>
<tr>
<th>Plyometric experience</th>
<th>Beginning volume*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginner (no experience)</td>
<td>80 to 100</td>
</tr>
<tr>
<td>Intermediate (some experience)</td>
<td>100 to 120</td>
</tr>
<tr>
<td>Advanced (considerable experience)</td>
<td>120 to 140</td>
</tr>
</tbody>
</table>

*Volume is given in contacts per session.

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Plyometric Program Design

• Program Length
  – Currently, most programs range from 6 to 10 weeks; however, vertical jump height improves as quickly as four weeks after the start of a plyometric training program.
Plyometric Program Design

• Progression
  – Plyometrics is a form of resistance training and thus must follow the principles of *progressive overload* (the systematic increase in training frequency, volume, and intensity in various combinations).
• **Warm-Up**
  – Plyometric exercise sessions must begin with a general warm-up, stretching, and a specific warm-up.
  – The specific warm-up should consist of low-intensity, dynamic movements.
  – Table 16.5 lists specific warm-up drills.
### Table 16.5

**Plyometric Warm-Up Drills**

<table>
<thead>
<tr>
<th>Drill</th>
<th>Explanation</th>
</tr>
</thead>
</table>
| Marching| Mimics running movements  
Emphasizes posture and movement technique  
Enhances proper lower body movements for running |
| Jogging | Prepares for impact and high-intensity plyometric drills  
- Toe jogging—not allowing heel to touch the ground (emphasizes quick reaction)  
- Straight-leg jogging—not allowing or minimizing leg flexion in preparation for impact of plyometric drills  
- “Butt-kickers”—flexing knee to allow heel to touch the buttocks |
| Skipping| Exaggerated form of reciprocal upper and lower extremity movements  
Emphasis on quick takeoff and landing, mimics plyometric activities |
| Footwork| Drills that target changes of direction  
Preparation for changes of direction during plyometric drills  
Examples: shuttle, shuffle, pattern, and stride drills |
| Lunging | Based on the forward step lunge exercise (see pp. 354-355)  
May be multidirectional (e.g., forward, side, backward) |
Section Outline

• Age Considerations
  – Adolescents
  – Masters
Age Considerations

• Adolescents
  – Consider both physical and emotional maturity.
  – The primary goal is to develop neuromuscular control and anaerobic skills that will carry over into adult athletic participation.
  – Gradually progress from simple to complex.
  – The recovery time between workouts should be a minimum of two to three days.
Key Point

- Under proper supervision and with an appropriate program, prepubescent and adolescent children may perform plyometric exercises. Depth jumps and high-intensity lower body plyometrics are contraindicated for this population.
Age Considerations

- **Masters**
  - The plyometric program should include no more than five low- to moderate-intensity exercises.
  - The volume should be lower, that is, should include fewer total foot contacts than a standard plyometric training program.
  - The recovery time between plyometric workouts should be three to four days.
• Prepubescent children should not perform depth jumps and other high-intensity lower body drills. Adolescents usually can safely participate in plyometric training depending on their ability to follow directions. Masters athletes can do plyometrics, as long as modifications are made for orthopedic conditions and joint degeneration.
Section Outline

• Plyometrics and Other Forms of Exercise
  – Plyometric Exercise and Resistance Training
  – Plyometric and Aerobic Exercise
Plyometrics and Other Forms of Exercise

• Plyometric Exercise and Resistance Training
  – Combine lower body resistance training with upper body plyometrics, and upper body resistance training with lower body plyometrics.
  – Performing heavy resistance training and plyometric exercises on the same day is generally not recommended.
  – Some advanced athletes may benefit from complex training, which combines intense resistance training with plyometric exercises.
### TABLE 16.6

Sample Schedule for Integrating Resistance Training and Plyometrics

<table>
<thead>
<tr>
<th>Day</th>
<th>Resistance training</th>
<th>Plyometrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>High-intensity upper body</td>
<td>Low-intensity lower body</td>
</tr>
<tr>
<td>Tuesday</td>
<td>Low-intensity lower body</td>
<td>High-intensity upper body</td>
</tr>
<tr>
<td>Thursday</td>
<td>Low-intensity upper body</td>
<td>High-intensity lower body</td>
</tr>
<tr>
<td>Friday</td>
<td>High-intensity lower body</td>
<td>Low-intensity upper body</td>
</tr>
</tbody>
</table>

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Plyometrics and Other Forms of Exercise

• Plyometric and Aerobic Exercise
  – Because aerobic exercise may have a negative effect on power production, it is advisable to perform plyometric exercise before aerobic endurance training.
Section Outline

• Safety Considerations
  – Pretraining Evaluation of the Athlete
    • Technique
    • Strength
    • Speed
    • Balance
    • Physical Characteristics

(continued)
Section Outline (continued)

• Safety Considerations
  – Equipment and Facilities
    • Landing Surface
    • Training Area
    • Equipment
    • Proper Footwear
    • Supervision
    • Depth Jumping
Safety Considerations

• Pretraining Evaluation of the Athlete
  – Technique
    • Before adding any drill, the strength and conditioning professional must demonstrate proper technique to the athlete.
    • Proper landing technique is essential to prevent injury and improve performance in lower body plyometrics.
Proper Plyometric Landing Position

• **Figure 16.6 (next slide)**
  – The shoulders are in line with the knees, which helps to place the center of gravity over the body’s base of support.
Safety Considerations

• Pretraining Evaluation of the Athlete
  – Strength
    • For lower body plyometrics, the athlete’s 1RM squat should be at least 1.5 times his or her body weight.
    • For upper body plyometrics, the bench press 1RM should be at least 1.0 times the body weight for larger athletes (those weighing over 220 pounds, or 100 kg) and at least 1.5 times the body weight for smaller athletes (those weighing less than 220 pounds).
    • An alternative measure of prerequisite upper body strength is the ability to perform five clap push-ups in a row.
Safety Considerations

• Pretraining Evaluation of the Athlete
  – Speed
    • For lower body plyometrics, the athlete should be able to perform five repetitions of the squat with 60% body weight in 5 seconds or less.
    • To satisfy the speed requirement for upper body plyometrics, the athlete should be able to perform five repetitions of the bench press with 60% body weight in 5 seconds or less.
Safety Considerations

• Pretraining Evaluation of the Athlete
  – Balance
    • Three balance tests are provided in table 16.7, listed in order of difficulty.
    • Each test position must be held for 30 seconds. Tests should be performed on the same surface used for drills.
    • An athlete beginning plyometric training for the first time must stand on one leg for 30 seconds without falling.
    • An athlete beginning an advanced plyometric program must maintain a single-leg half squat for 30 seconds without falling.
<table>
<thead>
<tr>
<th>Test</th>
<th>Variations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standing</td>
<td>Double leg</td>
</tr>
<tr>
<td></td>
<td>Single leg</td>
</tr>
<tr>
<td>Quarter squat</td>
<td>Double leg</td>
</tr>
<tr>
<td></td>
<td>Single leg</td>
</tr>
<tr>
<td>Half squat</td>
<td>Double leg</td>
</tr>
<tr>
<td></td>
<td>Single leg</td>
</tr>
</tbody>
</table>

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Safety Considerations

• Pretraining Evaluation of the Athlete
  – Physical Characteristics
    • Athletes who weigh more than 220 pounds (100 kg) may be at an increased risk for injury when performing plyometric exercises.
    • Further, athletes weighing over 220 pounds should not perform depth jumps from heights greater than 18 inches (46 cm).
Safety Considerations

• Equipment and Facilities
  – Landing Surface
    • To prevent injuries, the landing surface used for lower body plyometrics must possess adequate shock-absorbing properties.
    • A grass field, suspended floor, or rubber mat is a good surface choice.
Safety Considerations

• Equipment and Facilities
  – Training Area
    • The amount of space needed depends on the drill.
    • Most bounding and running drills require at least 30 m (33 yards) of straightaway, though some drills may require a straightaway of 100 m (109 yards).
    • For most standing, box, and depth jumps, only a minimal surface area is needed, but the ceiling height must be 3 to 4 m (9.8-13.1 feet) in order to be adequate.
Safety Considerations

• Equipment and Facilities
  – Equipment
    • Boxes used for box jumps and depth jumps must be sturdy and should have a nonslip top.
    • Boxes should range in height from 6 to 42 inches (15 to 107 cm).
    • Boxes should have landing surfaces of at least 18 by 24 inches (46 by 61 cm).
Safety Considerations

• Equipment and Facilities
  – Proper Footwear
    • Participants must use footwear with ankle and arch support; lateral stability; and a wide, nonslip sole.
  – Supervision
    • Closely monitor athletes to ensure proper technique.
Safety Considerations

• Equipment and Facilities
  – Depth Jumping
    • The recommended height for depth jumps ranges from 16 to 42 inches (41 to 107 cm), with 30 to 32 inches (76 to 81 cm) being the norm.
    • Depth jumps for athletes who weigh over 220 pounds (100 kg) should be 18 inches (46 cm) or less.
Safety Considerations

• What Are the Steps for Implementing a Plyometric Program?
  – Evaluate the athlete.
  – Ensure that facilities and equipment are safe.
  – Establish sport-specific goals.
  – Determine program design variables.
  – Teach the athlete proper technique.
  – Properly progress the program.