Fulfill [noun] – to make full; to put into effect; to meet the requirements of; to bring to an end; to measure up to; to convert into reality

**Reactive Neuromuscular Training**

**Plyometrics in Rehabilitation**

- What is plyometric exercise?
- Biomechanical & physiological principles
- Program development
- Guidelines for plyometrics
- Integrating plyometrics into rehab

**Readings**

- Chapter 11

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**What is Plyometric Exercise?**

Quick, powerful movement involving pre-stretching or countermovement that activates the stretch shortening cycle (SSC) of muscle and increases motor-unit recruitment. 


Proposed Mechanisms

1. Heighten excitability of nervous system
   - Pre-stimulation enhances motor neuron pool excitability
     - Potentiated reflex response
   - Increased recruitment of motor units
   - Greater central input to the motor neuron
   - Increased MU synchronization
   - Decrease in presynaptic inhibition


Proposed Mechanisms

2. Post-activation potentiation (PAP)
   - Phosphorylation of the myosin light chain
     - MLC → MLCK → ATP availability
     - Activity-dependent potentiation
     - Increases myofilaments Ca²⁺ sensitivity


• Increase in sarcoplasmic Ca²⁺
• Activates MLC kinase
• MLC kinase is responsible for making more ATP
• Actin-myosin interaction more sensitive to Ca²⁺

Mechanical Characteristics

Three components

1. Contractile component (CC)
2. Series elastic component (SEC)
3. Parallel elastic component (PEC)

- SEC lengthens and contributes to overall force output
- Force output = CC + SEC
- Transition moment involving
- Force production through sliding filament theory
- Force transferred externally through SEC


If a muscle is lengthened while loaded (eccentric action) prior to shortening (concentric action), it will produce greater force:

- storage and release of elastic energy (spring action)
- Requires very short transition time between eccentric and concentric - amortisation phase

**Muscle-tendon component**

**Neurophysiological Mechanism**

Stretch shortening cycle affects sensory response of receptors (muscle spindles; golgi tendon organs):

- Facilitates greater contraction force
  - excitatory threshold of the GTOs increased
  - less likely to send signals to limit force production
The stretch-shortening cycle combines mechanical & neurophysiological mechanisms & is the basis of plyometric exercise. A rapid eccentric muscle action stimulates the stretch reflex & storage of elastic energy, which increases the force produced during the subsequent concentric action.

Neuromuscular coordination

1. Speed of muscular contraction limited by neuromuscular efficiency
   • Body operates within a set speed range
2. Plyometric training results in improved neuromuscular efficiency

Program Development

- Complex movements → break down into basic movement patterns
- Establish adequate base
  - Increased strength will allow for increased force production
    - Prepare body to accept increasingly larger loads
    - Nervous system more readily reacts
    - Fine tune neuromuscular system

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Plyometric Prerequisites: Assessing athlete readiness

1. Identify potential contraindications prior to initiation of program
   - Evaluation and functional tests
2. Require sound mechanics (lower and upper body)
   - Testing allows evaluation of base strength
     - Ensure appropriate stability and mobility
     - Eccentric strength is critical

Plyometric Prerequisites: Assessing athlete readiness

2. Lower-body: squats
   - 5 reps @ 60% BW < 5s
3. Upper-body: bench press
   - 5 reps @ 60% BW < 5s
4. Lower-body: squats (1RM)
   - Male: 1.5 x BW; Female: 1.0 - 1.2 x BW
5. Upper-body: bench press (1RM)
   - Male: 1.0 x BW athletes > 100kg; 1.5 x BW athletes < 100kg
   - Female: 0.75 - 1.0 x BW
   - Alternative: 5 clap push-ups in a row

Plyometric Prerequisites: Assessing athlete readiness

4. Divided into 2 categories
   1. Static stability
      - Ability to stabilise and control body
      - Centres on single leg strength and stability
      - Postural stability
   2. Dynamic stability
      - Ability to stabilise and control body during movement
      - Assess eccentric abilities
      - Stabilization jumping

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Plyometric Prerequisites:
Assessing athlete readiness

- Static Stability Testing
  - One-leg standing for 30 s (eyes open & closed)
    - Assess ability to stabilise & control body
    - Look for deviations in triple extension of support leg
  1. One-leg stance - 30 s
    - Eye open
    - Eyes closed
  2. One-leg ¼ squat - 30 s
    - Eye open
    - Eyes closed
  3. One-leg ½ squat - 30 s
    - Eye open
    - Eyes closed

- Dynamic Stability Testing
  - Lateral cross-over
    - Assess dynamic stabilisation of lumbo-pelvic-hip complex
    - Look for excessively long amortization phases (slow switch) ECC to CON actions

Plyometric Prerequisites:
Assessing athlete readiness

5. Assess ability to produce explosive coordinated movement
   - Vertical or single leg jumping
   - Medicine ball toss

   **Vertical or single-leg jumping for distance**
   - SJ: dominant leg score / non-dominant leg score x 100
   - Passing score 85% (symmetry)

6. Requires general and specific flexibility
   - Lower body
   - Upper body
8-factors in plyometric program design

1. Heavier athlete = greater training demand

2. Horizontal movement is less stressful than vertical

3. Increasing speed = greater training demand

4. Altered by activity performed (double → single leg)
   Progress from simple to complex
   Addition of external weight or increasing height = greater training demand

5. Plyometrics should not be trained more than 3 x wk preseason phase and not more than 2 x wk in season
   ✓ Recommend 48-72 hours between sessions
   ✓ Intensity dependent

6. 1:3 or 1:4 ratio (minimum) → 1:5 or 1:6

7. Number of years athlete has been formal training
   Younger ages; training demand should be kept low

8. Varies inversely with intensity of exercise
   ✓ Beginner = 75-100 (low intensity)
   ✓ Advanced = 200-250 (low to moderate intensity)

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Table 1. Foot or Hand Contacts per Session

<table>
<thead>
<tr>
<th>Level</th>
<th>Low Intensity</th>
<th>Med. Intensity</th>
<th>High Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginner</td>
<td>10</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>Intermediate</td>
<td>100</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Advanced</td>
<td>140</td>
<td>120</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 2. Work and Rest Periods

<table>
<thead>
<tr>
<th>Work Time</th>
<th>Rest between reps</th>
<th>Rest between sets</th>
<th>Rest between exercises</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-8 s</td>
<td>5-30 s</td>
<td>1-2 min</td>
<td>None</td>
</tr>
<tr>
<td>≤ 3 s</td>
<td>None</td>
<td>2-3 min</td>
<td>None</td>
</tr>
<tr>
<td>3-8 s</td>
<td>None</td>
<td>2-8 min</td>
<td>None</td>
</tr>
<tr>
<td>10-20 s</td>
<td>None</td>
<td>3-5 min</td>
<td>6-10 min</td>
</tr>
</tbody>
</table>

Table 3. Sample Beginner Lower Body Plyometrics Program

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Sets</th>
<th>Reps</th>
<th>Total Contacts</th>
<th>Rest Between Jumps</th>
<th>Rest Between Sets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single response vertical jumps</td>
<td>3</td>
<td>30</td>
<td>35</td>
<td>3 minutes</td>
<td></td>
</tr>
<tr>
<td>Single leg jumps</td>
<td>3</td>
<td>24</td>
<td>24</td>
<td>No rest</td>
<td>3 minutes</td>
</tr>
<tr>
<td>Row jumps onto box</td>
<td>3</td>
<td>24</td>
<td>55</td>
<td>3 minutes</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>78</td>
<td>98</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

EHR315 Injury Prevention and Rehab
Week 9 - The role of plyometric exercise in rehabilitation

**Plyometric progression model**


1. In-place jumping
2. Standing jumps
3. Multiple-response jumps and hops
4. In-depth jumping and box drills
5. Bounding
6. High-stress sport-specific drills


**Chu’s Plyometric Categories**

- In-place jumping
- Standing jumps
- Multiple-response jumps and hops
- In-depth jumping and box drills
- Bounding
- High-stress sport-specific drills

**6-Steps in implementing a plyometric program**

1. Structured play
2. Basic exercises
3. Progression
4. Overload
5. Specificity
6. Feedback

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Integrating Plyometrics into the Rehabilitation Program: Clinical Concerns

Plyometrics effective functional CKC exercise

Beneficial management of tendinitis due to loading = Increases in tensile strength

• Can be categorized by loads applied to tissue
  – Medial/lateral
  – Rotational
  – Shock absorption /deceleration

• Further divided
  – In place
  – Dynamic/distance drills
  – Depth jumping


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Lecture Summary

1. Plyometric goals ___________________________, activity specific
   • aimed at developing movement efficiency

2. Plyometric __________________ is more important than _______
   • train at with maximal intensity

3. Greater _______________ = greater _____________________
   • proper technique is no longer demonstrated = criteria for stopping session

4. _______________________ of athlete on regular basis
   • provide progression and feedback information