Post-Activation Potentiation (PAP)

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What is PAP?

- Acute increase in muscle power and performance
- Post heavy muscle pre-loading
- Warm-up activities

- **Balance** between fatigue and potentiation

Critical Variables

1. Training experience
2. Strength
3. Volume
4. Rest time
5. Intensity
6. Gender
7. Activity and movement

Practical Application

Heavy squat then rest 7-10 min?

Enhanced VJ
Mechanisms

1. Phosphorylation of myosin regulatory light chains
2. Recruitment of higher order motor units
3. Calcium influx (crossbridges)

PAP Protocols

1. Overload
2. Ballistic
3. WBV
4. Overspeed
Overload
Heavy Squat Experience on Squat Jumps

- 95% 1RM
- 5 x 1 reps
- 5-18.5 min rest
- Increase >athletes

Heavy Squats on Squat Jumps

- 85% 1RM
- 1 x 5 reps
- 3 min rest
- Increased VJ

Heavy Squat Volume on VJ

- 85% 1RM
- 1 x 2-5 reps
- 5 min rest
- No increase in post VJ

Heavy Squat Rest on Power

- 85% 1RM
- 1 x 5 reps
- 5-20 min rest
- Individual increase in post Wingate (related to strength)

Heavy Squat Intensity and Rest on VJ

- 56%, 70% and 93% 1RM
- 1 x 2-5 reps w/equal work
- 0-12 min rest
- Increased VJ at 4 & 8 min (related to intensity)

Heavy Deadlifts on VJ

- 85% 1RM
- 1 x 5 reps
- 15s - 16min rest
- Decreased VJ

Overload Critical Variables

1. Training experience (>athletes)
2. Strength (1RM/BW)
3. **Volume** (>multiple sets/reps)
4. **Rest time** (~7-10 min)
5. **Intensity** (>60%-85%)
6. Gender (no)
7. **Activity and movement!**

Box Jumps on VJ

- 5%-20% BW vest
- 1 x 5 jumps
- 2 min rest
- Increased post VJ

Depth Jumps vs. Box Jumps on VJ

- Box at lateral condyle (BW)
- 1 x 10 jumps
- 10 min rest
- Decreased post VJ (in club)

## Depth Jump Plyo Volume on VJ

<table>
<thead>
<tr>
<th>Condition</th>
<th>Vertec jump height (cm)</th>
<th>Condition Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td>0 jumps</td>
<td>41.31±4.69</td>
<td>40.78±4.44</td>
</tr>
<tr>
<td>3 jumps</td>
<td>41.91±4.73</td>
<td>41.23±4.11</td>
</tr>
<tr>
<td>6 jumps</td>
<td>41.16±4.37</td>
<td>40.49±4.41</td>
</tr>
<tr>
<td>9 jumps</td>
<td>39.74±4.10</td>
<td>39.66±4.56</td>
</tr>
<tr>
<td>12 jumps</td>
<td>41.01±4.63</td>
<td>39.96±3.99</td>
</tr>
<tr>
<td>Time average</td>
<td>41.02±4.50</td>
<td>40.42±4.30 *</td>
</tr>
</tbody>
</table>

- Box at lateral condyle (BW)
- 1 x 0-12 jumps
- 10 min rest
- **Decreased post VJ**

Vertical Jump on Club Head Speed

- BW
- 1 x 3 jumps
- 1min rest
- Increased CHS

Ballistic Critical Variables

1. Training experience (>athletes)
2. Strength (1RM/BW)
3. Volume (>multiple sets/reps)
4. Rest time (~1-4 min)
5. Intensity (Max)
6. Gender (no)
7. Activity and movement!

**WBV on Knee Strength**

<table>
<thead>
<tr>
<th>Test</th>
<th>WBV</th>
<th>Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT 60° d/s</td>
<td>142.14 (43.61)</td>
<td>140.64 (42.72)</td>
</tr>
<tr>
<td>PT 180° d/s</td>
<td>93.88 (35.18)</td>
<td>96.37 (31.53)</td>
</tr>
<tr>
<td>PT 300° d/s</td>
<td>78.36 (26.04)</td>
<td>80.13 (26.08)</td>
</tr>
</tbody>
</table>

- 10 x 30s WBV-mini plyos (w/isometric squats)
- No increase in knee strength
- Same as dynamic

WBV on Bat Speed

- 1 x 30s WBV-mini plyos
- 30s rest
- No increase in bat swing
- Same as dynamic

WBV on VJ

- BW
- 4 x 30s WBV-mini plyos (w/squat)
- 30s-4min rest
- Individual increase in post VJ (rest)

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Post</th>
<th>30 s</th>
<th>1 min</th>
<th>2 min</th>
<th>4 min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>54.44 (13.74)</td>
<td>54.99 (13.88)</td>
<td>55.20 (14.24)</td>
<td>54.94 (14.19)</td>
<td>55.41 (13.57)</td>
<td>55.11 (13.66)</td>
<td>56.93 (13.98)‡</td>
</tr>
</tbody>
</table>

WBV Critical Variables

1. Training experience (>athletes)
2. Strength (?)
3. Volume (3-4reps/30s/squat)
4. Rest time (30s-4min)
5. Intensity (30Hz/2-4mm)
6. Gender (no)

7. Activity and movement!

New Assisted Protocol

- Acute increase in muscle power and performance
- Light, explosive muscle pre-loading
- Warm-up activities
- **No balance** between fatigue and potentiation

Sliding Filaments

1. **Phosphorylation of myosin regulatory light chains**
2. **Recruitment of higher order motor units**
3. **Calcium influx (crossbridges)**
4. **Increased motor neuron excitability**
5. **Motor unit activation**
6. **Motor unit synchronization**

Overspeed

Hill Slope

Towed Sprinting

Table 2. Biomechanical variables of the acceleration phase of sprinting.†

<table>
<thead>
<tr>
<th>Variable</th>
<th>MS</th>
<th>TS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SL (m)</td>
<td>1.90 ± 0.11</td>
<td>2.03* ± 0.15</td>
</tr>
<tr>
<td>SR (Hz)</td>
<td>4.26 ± 0.09</td>
<td>4.25 ± 0.08</td>
</tr>
<tr>
<td>Dh (m)</td>
<td>0.15 ± 0.02</td>
<td>0.22* ± 0.04</td>
</tr>
<tr>
<td>(V_h) (m(\cdot)s(^{-1}))</td>
<td>8.06 ± 0.49</td>
<td>8.63* ± 0.60</td>
</tr>
</tbody>
</table>

† MS = maximal sprint; TS = towed sprint; SL = stride length; CoM = center of mass; SR = stride rate; Dh = horizontal distance from the CoM of the foot to the CoM of the body; \(V_h\) = horizontal velocity of the CoM.

* Significant (p < 0.001) differences between MS and TS.

Light vs. Heavy Bat Warm-up on Normal Bat

- Max velocity
- 1 x 5 swings
- 30s rest
- Increased post normal w/light bat

Assisted Jumping

- BW-40% assistance
- 5 conditions
- Increase at 30%-40%

**Assisted VJ on VJ**

- 30% assistance
- 1 x 5 jumps
- 1min rest
- Increased post VJ

Assisted Sprinting

- BW-40% assistance
- 5 conditions
- Increase at 30%-40%

### Assisted Sprinting on Sprint Speed

- **30% assistance**
- **20 meters/5m splits**
- **30s-4min rest**
  - Athletes increased post 0-5m at 1 & 2min

<table>
<thead>
<tr>
<th>ATHLETES</th>
<th>BL</th>
<th>30s</th>
<th>1min</th>
<th>2min</th>
<th>4min</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5m</td>
<td>1.21±0.04s</td>
<td>1.21±0.08s</td>
<td><strong>1.15±0.06s</strong>#@</td>
<td><strong>1.16±0.06s</strong>#</td>
<td>1.18±0.07s</td>
</tr>
<tr>
<td>5-10m</td>
<td>0.83±0.03s</td>
<td>0.84±0.04s</td>
<td>0.84±0.04s</td>
<td>0.85±0.04s</td>
<td>0.85±0.04s</td>
</tr>
<tr>
<td>10-15m</td>
<td>0.74±0.02s</td>
<td>0.74±0.03s</td>
<td>0.74±0.02s</td>
<td>0.75±0.02s</td>
<td>0.75±0.03s</td>
</tr>
<tr>
<td>15-20m</td>
<td>0.70±0.03s</td>
<td>0.71±0.03s</td>
<td>0.71±0.04s</td>
<td>0.71±0.02s</td>
<td>0.71±0.04s</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>REC</th>
<th>BL</th>
<th>30s</th>
<th>1min</th>
<th>2min</th>
<th>4min</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5m</td>
<td>1.26±0.06s</td>
<td>1.25±0.07s</td>
<td>1.27±0.08s</td>
<td>1.25±0.06s</td>
<td>1.29±0.10s</td>
</tr>
<tr>
<td>5-10m</td>
<td>0.89±0.06s</td>
<td>0.91±0.07s</td>
<td>0.90±0.07s</td>
<td>0.91±0.06s</td>
<td>0.89±0.06s</td>
</tr>
<tr>
<td>10-15m</td>
<td>0.79±0.06s</td>
<td>0.91±0.07s</td>
<td>0.80±0.07s</td>
<td>0.80±0.09s</td>
<td>0.81±0.07s</td>
</tr>
<tr>
<td>15-20m</td>
<td>0.79±0.07s</td>
<td>0.89±0.05s</td>
<td>0.80±0.07s</td>
<td>0.79±0.08s</td>
<td>0.80±0.07s</td>
</tr>
</tbody>
</table>

Overspeed Critical Variables

1. Training experience (>athletes)
2. Strength (>1RM/BW)
3. Volume (5 reps/20 meters)
4. Rest time (1-2min)
5. Intensity (30%-40% BWA)
6. Gender (no)

7. Activity and movement!

<table>
<thead>
<tr>
<th>Population</th>
<th>Strength</th>
<th>Intensity</th>
<th>Volume</th>
<th>Rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overload</td>
<td>&gt;athletes</td>
<td>&gt;1RM/BW</td>
<td>80-90% 1RM</td>
<td>&gt;multiple sets/reps</td>
</tr>
<tr>
<td>Ballistic</td>
<td>&gt;athletes</td>
<td>&gt;1RM/BW</td>
<td>Max (5-20%)</td>
<td>&gt;multiple sets/reps</td>
</tr>
<tr>
<td>WBV</td>
<td>&gt;athletes</td>
<td>???</td>
<td>30Hz 2-4mm</td>
<td>&gt;multiple sets/reps</td>
</tr>
<tr>
<td>Overspeed</td>
<td>&gt;athletes</td>
<td>&gt;1RM/BW</td>
<td>30-40% Assisted</td>
<td>&gt;multiple sets/reps</td>
</tr>
</tbody>
</table>
So What? Who Cares?

...training studies supporting the use of PAP complex training are lacking and therefore it remains to be determined whether performing PAP complexes over time leads to greater training adaptations than interventions where the plyometric or speed exercises are not performed in a PAP format but rather in isolation.

Other Activities & Movements
Acknowledgments
Thank You!

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