Jump Training: ¿Why and How?:

an Exhaustive Review

Biological Bases for Jump Training

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Jump training exercises usually implicate an **eccentric** muscle action rapidly followed (after a short amortization/transition time period) by a **concentric** muscle action.

A rapid stretch of the muscle during the eccentric portion of the SSC may stimulate the myotatic reflex.


The myotatic reflex implicates the activation of muscle proprioceptors (e.g., muscle spindles; sensitive to muscle stretch), which might facilitate the activation of muscle fibers during a brief time period....


...therefore, facilitating “explosive” performance through a potentially greater number of muscle fibers activated during the concentric portion of the SSC.
See how the “performance enhancing” effect of the SSC is present across all loads (i.e., high and low).

Fig. 1. Average velocities and standard deviations associated with the concentric bench-press throw and the rebound bench-press throw over a range of loading intensities (30–80% one repetition maximum [1RM]).
In the muscle spindle, NUCLEAR BAG intrafusal muscle fibers are especially sensitive to changes in muscle velocity (e.g., stretch velocity).

The myotatic reflex (i.e., monosinaptic reflex) implicates 3.5 ms in the spinal cord.


Muscle force inhibition through Golgi tendon organ synaptic cycle (nervous fiber type 1b) requires more time than the myotatic monosynaptic reflex from muscle spindles (nervous fiber type 1a), which can explain the muscle facilitation during SSC muscle actions (aside from the fact that Golgi tendon organ can reduce its sensitivity through training).


Although training may not improve myotatic reflex velocity, it might improve muscle force during the myotatic reflex, potentially improving the SSC velocity.

Robinson, L.E. The effects of land versus aquatic plyometrics on power torque velocity, and muscle sorenes. Master Thesis. Graduate School of The Ohio State University, 2002.

Therefore, the myotatic reflex may facilitate the concentric performance (i.e., velocity, power, force) during an acute SSC muscle action……which may help to achieve greater training adaptations in the long-term.

Aside from the myotatic reflex, the muscle ability to use the energy-force from muscle elastic components, may also improve the explosive performance during SSC muscle actions.

In this way, during the eccentric portion of the SSC, the load is transferred to the muscle elastic components, storing elastic energy in the process, which can be used during the concentric portion of the SSC.


The ability of the muscle to use elastic energy might depend on the transition period of the SSC, stretch magnitude and stretch velocity, and may be greater after a rapid eccentric phase and a short transition period.

The role of muscle elastic energy on explosive performance was demonstrated in early experiments from……...

**Acta physiol. scand. 1974. 91. 385—392**

From the Laboratory for the Theory of Gymnastics, August Krogh Institute, University of Copenhagen, Denmark

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### Storage of Elastic Energy in Skeletal Muscles in Man

By

Erling Asmussen and Flemming Bonde-Petersen

<table>
<thead>
<tr>
<th></th>
<th>Peso (kg)</th>
<th>SJ</th>
<th>CMJ</th>
<th>DJ, 23 cm</th>
<th>DJ, 40 cm</th>
<th>DJ, 69 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>71.0</td>
<td>0.366</td>
<td>0.386</td>
<td>0.396</td>
<td>0.408</td>
<td>0.389</td>
</tr>
</tbody>
</table>

Values in meters
The biological mechanisms implicated in the SSC may also implicate a reduced energy cost during the concentric portion of the cycle....


...and this acute energy-saving mechanism may have long-term positive transference.....as several studies had demonstrated that jump training might improve “movement economy”....
9 weeks of JT
Elite runners from 20 to 30 y of age (VO2max 68 ml/kg/min)
Increased 8% RE and 3% a 5-km time trial

6 weeks of JT
Runners (VO2max 57 ml/kg/min)
Increased 4-7% RE and 3% a 3-km time trial

9 weeks of JT
Elite runners from 20 to 30 y of age (VO2max 68 - 70 ml/kg/min)
Increased 4% RE

6 weeks of JT
Male and female runners (mean VO2max = 65 ml/kg/min)
Increased 2.8% a 2.4-km time trial

…..and these improvements are independent from changes in VO2max…

Although the physiological mechanism of the increased RE are not clear…
It must be considered that during the eccentric portion of the SSC a greater muscle-fiber tension can be developed, due to altered motor-unit recruitment pattern and utilization of muscle fibers, which may favor myofibrillar damage.

Skeletal muscle fibers before marathon

Skeletal muscle fibers after marathon

Normal sarcomeres, with intact patterns of lines and bands, before JT

Z: normal Z line
Mt: mitochondria
1: small damage to Z line
2: moderate damage to Z line
3: rupture of Z line

Damaged sarcomeres (i.e., Z line and, also, mitochondria) after JT
Diminished dystrophine staining (see arrows) as marker of muscle damage, 3 days after PT (i.e. 100 SJ).

Damage was greater in type II muscle fibers (75% vs. 25%).

However, repeated JT protect against muscle damage.

**Fig. 3.** Comparison of soreness in men and boys after 2 bouts of plyometric exercise. Bouts were separated by 2 wk. Values are means ± SE. *Significant difference between groups in bout 1 (P < 0.05). †Significant difference across time within bout; ‡significant difference across bout, within time (P < 0.05).


Compared with horizontal jumps, vertical jumps allow a greater utilization of muscle elastic energy (e.g., greater difference between a SJ and CMJ).

“Fast” SSC muscle actions (e.g., DJ with ground contact time <250 ms) would induce mainly neural adaptations.

This may be related with the short amplitude (and duration) of the eccentric muscle action (i.e., muscle-tendon complex is stretched, but reduced stretch is generated on individual muscle fibers).

Also, the short duration of the muscle action would reduce the metabolic stress, and this may reduce the hypertrophic stimulus.
The rapid adaptations observed with JT (e.g., 2-wk) may also be explained by neural adaptations.
In addition, it is interesting to note that youths are very responsiveness to JT (especially before PHV), and this might be related with their greater rate of neural development........
for example, we have observed significant adaptations in youth soccer players after only 6-7 weeks……in adults also, but the rate of improvement may be slower ……

(Rodrigo Ramirez-Campillo, unpublished data)
Review of the Day
SSC muscle actions are usually related with the activation of the myotatic reflex, muscle elastic energy, and movement efficiency (at short and long term).

SSC muscle actions with high load (volume, intensity) and relatively new to the athlete (especially adults), may increase muscle damage and delayed onset of muscle soreness (DOMS).

Although with potential effects on muscle hypertrophy, JT usually induce neural adaptations (especially through fast SSC muscle actions), which seems to appear in relatively brief (i.e., <8 weeks) time periods.

In youths, their greater rate of neural development (compared to adults), may help to explain their rapid and elevated responsiveness to JT through SSC muscle actions, both, fast and slow.