Effect of static stretching and potentiation on power development in athletes

Power is an important component in numerous biomotor abilities including sprinting, jumping, and throwing. Acutely enhancing power output would be advantageous for these skills. There are numerous factors that affect power development including muscle mechanics (force-velocity & length-tension relationships), morphological factors (muscle fiber type & architecture, tendon properties), and neural factors (motor unit recruitment, firing frequency, etc.) (Cormie, McGuigan, & Newton, 2011) Despite the complex interaction of these factors, there is some literature that suggests that various neuromuscular exercises may be performed prior to competition or assessment to enhance subsequent power performance. Specifically, post-activation potentiation (PAP) of the agonist muscle and static stretching of the antagonist muscle have independently demonstrated improved power development (Bergmann, Kramer, & Gruber, 2013; Berning et al., 2010; Folland, Wakamatsu, & Fimland, 2008; Gouvea, Fernandes, Cesar, Silva, & Gomes, 2013; Miyamoto, Kanehisa, Fukunaga, & Kawakami, 2011; Sandberg, Wagner, Willardson, & Smith, 2012; Trimble & Harp, 1998; Wilson et al., 2013)

Methods

A within-subjects design was used to determine if statically stretching and potentiation effects power development. The dependent variables in this study include VJ height and electromyography activity in the gluteus maximus, vastus lateralis, gastrocnemius medialis, and tibialis anterior during vertical jump. The neuromuscular exercise treatments served as the independent variables. All subjects were tested for these dependent variables with and without the neuromuscular exercise treatments. All participants completed a control condition of no treatment, stretching treatment, potentiation treatment and combination treatment. A convenience sample of 20 healthy, recreationally trained male rugby players were recruited to
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participate in this study. The subject’s mean age was 23.9±3.5 years, height 170.2±5.2 cm, and weight 68.0±11.7 kg.

Stretching Treatments

The stretching treatment before the VJ emphasized the stretching of the hip flexors and ankle dorsiflexors. The stretching treatment consisted of the lunge stretch performed passively. Three repetitions were performed and each stretch was held for 30 seconds. (Bandy, Irion, & Briggler, 1997) The subject was instructed to internally rotate his leg to emphasize the stretch on the hip flexors and decrease the stretch of the rectus femoris. Each subject was instructed to assume an appropriate upright posture, place the stretch side hand on the hip to be stretched, and drive that hip forward. To stretch the ankle dorsiflexors, subjects were lying flat on their back on a massage table. The feet were extended over the table, unrestricted in space. The investigator pulled on the toes and pushed on the heel to stretch the foot in plantar flexion.

Maximum Voluntary Isometric Contraction

A MVIC was performed for all leg extensor muscle groups (hip extensors, knee extensors, ankle plantarflexors) prior to the vertical jump test for the treatment trials by executing a functional isometric deadlift. All MVIC’s were held for 5 seconds, 3 repetitions with 20 seconds rest between repetitions. The subject performed this maneuver by standing in an athletic stance on a strap and holding the attached handles, simulating a deadlift. The subject then pressed as hard as possible with his legs from the deadlift position while keeping the strap firmly in his hands preventing vertical movement.

Vertical Jump Test

The vertical jump test was performed using a Vertec device (Sports Imports, Columbus, OH, USA) and the protocol described by Bean. (Beam & Adams, 2010) The subject followed the
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proper jumping maneuver for three trials with 20-30s of recovery between attempts. If the subject continued to improve on the third trial, then subsequent trials were given until no further improvements were observed on two consecutive trials. This test has been found to have a high reliability (r=0.94) (Chimera, Swanki, & Straub, 2004; Young, MacDonald, Heggen, & Fitzpatrick, 1997).

Electromyography

Surface electromyography (EMG) signals were obtained from the gluteus maximus (GM), vastus lateralis (VL), medial gastrocnemius (MG), and tibialis anterior (TA). The electrodes were 99.9% Ag bars, which are 10 x 1 mm in diameter with an interelectrode distance of 10 mm. EMG detection was performed through differential means, input impedance of $>10^{15}\Omega //0.2\text{pF}$, Common Mode Rejection Ratio (CMRR) $\geq 100$ dB, a Signal to Noise Ratio (SNR) $\leq 1.2\mu\text{V}$, and the Gain was set at 1000 Hz. Some subjects had the gain set at 10000Hz for the (GM) to increase the signal due to adipose tissue in this area. Sampling of the EMG was completed at 1550 Hz through a 16-bit A-D board. Data was collected on a computer using Cortex software (Motion Analysis, Santa Rosa, CA) and processed using Visual3D software (C-Motion Inc., Germantown, MD). Filtering was performed using a Butterworth band pass filter with a bandwidth of 20-500Hz. Moving RMS (30 ms) was used to rectify and smooth the EMG signal.

Results

Table 1 displays the mean vertical displacement for each condition. An ANOVA was used to determine statistical significance between groups. F= 9.125 signifying statistical significance. The effect size is 0.617 and power is 0.983.
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Table 1: Mean, Standard Deviation, Relative and Absolute Difference as Compared to Baseline.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean Vertical Displacement (cm)</th>
<th>Std. Deviation</th>
<th>Relative Difference (%)</th>
<th>Absolute Difference (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>51.13 ± 11.56</td>
<td></td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Stretch</td>
<td>51.96 ± 10.79</td>
<td></td>
<td>1.61</td>
<td>0.83</td>
</tr>
<tr>
<td>Postactivation Potentiation</td>
<td>52.53 ± 10.92</td>
<td></td>
<td>2.73</td>
<td>1.40</td>
</tr>
<tr>
<td>Combination*</td>
<td>52.72 ± 10.63</td>
<td></td>
<td>3.10</td>
<td>1.59</td>
</tr>
</tbody>
</table>

*Significant difference from control (p<.001)

Table 2 is a post-hoc analysis of difference between means. Six t-test were used between the 4 conditions. A Bonferroni correction was used to account for multiple comparisons and decrease the chance of type one error. After correction the experiment-wise alpha was set to 0.008. The only statistically significant finding of the post-hoc analysis was a 1.58cm increase in vertical jump height in the combination treatment compared to the control.

Table 2: Post-Hoc Analysis of Treatments.

<table>
<thead>
<tr>
<th>T-Test</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control vs. Stretch</td>
<td>-0.8255 ± 1.76145</td>
<td>0.050</td>
<td></td>
</tr>
<tr>
<td>Control vs. Potentiation</td>
<td>-1.397 ± 2.25308</td>
<td>0.012</td>
<td></td>
</tr>
<tr>
<td>Control vs. Combo*</td>
<td>-1.5875 ± 1.4199</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Stretch vs. Potentiation</td>
<td>-0.5715 ± 2.07969</td>
<td>0.234</td>
<td></td>
</tr>
<tr>
<td>Stretch vs. Combo</td>
<td>-0.762 ± 1.19421</td>
<td>0.010</td>
<td></td>
</tr>
<tr>
<td>Potentiation vs. Combo</td>
<td>-0.1905 ± 1.809</td>
<td>0.643</td>
<td></td>
</tr>
</tbody>
</table>

*Statistically significant at α=0.008 after Bonferroni correction

No statistically significant differences were discovered for the EMG data in the present study.

Discussion

The present findings suggest that power can be acutely enhanced through a combination of antagonist stretching and postactivation potentiation. The implications of this study propose that these neuromuscular exercises could be preformed prior to short duration, power sports to increase performance. The exact mechanism responsible for this enhancement should be further researched.
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**References**


Bergmann, J., Kramer, A., & Gruber, M. (2013). Repetitive hops induce postactivation potentiation in triceps surae as well as an increase in the jump height of subsequent maximal drop jumps. *Plos One, 8*(10), e77705.


