Effects of Volitional Preemptive Abdominal Contraction on Trunk and Lower Extremity Biomechanics and Neuromuscular Control During a Drop Vertical Jump

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INTRODUCTION

Anterior cruciate ligament (ACL) injuries continue to be a significant concern relative to short- and long-term effects on quality of life and participation in physical activity [1]. Recognizing individuals who have an increased risk for ACL injury and discovering interventions that may reduce their risk are important to patients, clinicians, and researchers. Altered neuromuscular control plays a prominent role in most ACL injury models. Previous research has focused primarily on examining the neuromuscular control of the lower extremity (LE) [2]. However, LE control also may be influenced by activation of the abdominal muscles [3]. The effects of abdominal muscle contraction may be transmitted to the LE via the pelvis, which provides a mechanical link between the trunk and the LE thus influencing the entire chain [4]. Although, volitional preemptive abdominal contraction (VPAC) has been shown to improve spine stability [5], very little is known about the effects of VPAC on trunk and LE biomechanics and neuromuscular control in healthy individuals, with implications for ACL injury risk. Therefore, the purpose of our study was to determine the effects of VPAC on trunk and LE biomechanics and neuromuscular control during a drop vertical jump (DVJ). We hypothesized that VPAC, would improve trunk and LE stabilization and neuromuscular control during the landing phase of the DVJ.

METHODS

A repeated measures design was used to examine the effects of VPAC using an abdominal bracing strategy [5] on biomechanical and neuromuscular control variables measured during a DVJ from two heights. Thirty two healthy and active subjects (17 men and 15 women; M±SD age 24.6±2.4 yr, height 1.76±0.12 m, and mass 77.6±19.0 kg) participated after providing informed consent. Volunteers were excluded if they had LE pain, history of LE or lumbar spine surgery, active abdominal or gastrointestinal condition, or if pregnant. Subjects were taught and allowed to practice VPAC. The presence of VPAC during the DVJ was verified by a review of the recorded electromyographic (EMG) data immediately after each trial. Eighteen reflective markers were placed on the LE and trunk. Surface EMG electrodes were placed over eight muscles on the right side LE and trunk. Each subject performed three successful DVJs from a raised platform from each of two heights (30 and 50 cm) with and without VPAC, presented in a random order. 3D kinematic data were recorded using an 8 camera Vicon-Peak system (120 Hz), while ground reaction force (GRF; Bertec Corp.) and EMG (Noraxon, Inc.) were recorded simultaneously (1200 Hz). Data were pre-processed using Motus (Vicon-Peak), exported and reduced using custom laboratory algorithms developed in Matlab (Mathworks). Dependent variables included trunk, hip, knee and ankle joint angles, and internal joint moments in 3D, sagittal plane LE joint powers, EMG root mean square (RMS) amplitudes pre- and post-initial ground contact. A total of 96 independent variables were incorporated in an exploratory analysis. Kinematic maxima, minima, range of motion and values at initial contact, kinetic maxima, minima and impulse, and the pre- and post-contact EMG RMS values were analyzed statistically (SPSS; α=0.05).

RESULTS AND DISCUSSION

At the 30 cm landing height, VPAC resulted in statistically significant (P ≤ 0.05) greater knee internal rotation angle, greater knee flexion range of motion, greater knee internal abduction moment, greater knee energy absorption, greater medial hamstring post contact activity, greater trunk left
rotation, and greater external oblique activity pre- and post-contact (Table 1).

At the 50 cm landing height, VPAC resulted in statistically significant (P≤0.05) less ankle inversion angle, greater knee flexion angle at contact, greater medial hamstring activity pre- and post-contact, greater hip flexion angle at contact, less hip energy absorption, greater trunk left rotation angle post contact, greater trunk left rotation angle at contact, greater external oblique muscle activity pre-contact, and less external oblique muscle activity post-contact (Table 2).

CONCLUSIONS

VPAC altered LE and trunk biomechanics and neuromuscular control when performing DVJ from 30 and 50 cm heights, although not all changes were consistent with greater knee protection. More potential clinical advantages were observed at the lower height, where increased medial hamstring activity, knee flexion and knee energy absorption during VPAC suggest an enhanced protective LE response. Similarly, VPAC triggered increased external oblique activity that may indicate enhanced trunk stability under lower loading conditions, when more neuromuscular control options are available. The demands of the 50 cm DVJ may have superseded the effectiveness of VPAC. Similarly, competing neuromuscular control requirements (trunk vs. LE) may have resulted in less attention to the abdominal contraction, and greater attention to the task at the higher height. Further study is needed to determine whether VPAC is effective for reducing ACL injury risk. The effects of VPAC on pelvis motion and relative motion among spinal segments should be examined as well.

REFERENCES


ACKNOWLEDGMENTS

Graduate students Lee Atkins, Natalie Burg, Nathan Jarman, Vittal Nagar.

Table 1: Mean (SD) values for 30 cm drop vertical jump with and without VPAC (statistically significant variables only).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Internal rotation (deg)</th>
<th>Flexion (deg)</th>
<th>Internal abduction moment (Nm)</th>
<th>Energy absorption (W)</th>
<th>Medial hamstring post contact (mV)</th>
<th>Left rotation (deg)</th>
<th>External oblique pre contact (mV)</th>
<th>External oblique post contact (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VPAC</td>
<td>33.7 (13.6)</td>
<td>44.9 (13.7)</td>
<td>15.4 (6.4)</td>
<td>37.3 (69.0)</td>
<td>0.000392 (0.000273)</td>
<td>0.34 (0.15)</td>
<td>0.000201 (0.000123)</td>
<td>0.000199 (0.000117)</td>
</tr>
<tr>
<td>Without VPAC</td>
<td>31.0 (10.9)</td>
<td>40.9 (12.5)</td>
<td>15.0 (6.6)</td>
<td>29.7 (64.1)</td>
<td>0.000343 (0.000239)</td>
<td>0.28 (0.16)</td>
<td>0.000165 (0.000133)</td>
<td>0.000169 (0.0000968)</td>
</tr>
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</table>

Table 2: Mean (SD) values for 50 cm drop vertical jump with and without VPAC (statistically significant variables only).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Inversion (deg)</th>
<th>Flexion at contact (deg)</th>
<th>Medial hamstring pre contact (mV)</th>
<th>Medial hamstring post Contact (mV)</th>
<th>Flexion at contact (deg)</th>
<th>Energy absorption (W)</th>
<th>Left rotation (deg)</th>
<th>Left rotation post contact (deg)</th>
<th>External oblique pre contact (mV)</th>
<th>External oblique post contact (mV)</th>
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</thead>
<tbody>
<tr>
<td>VPAC</td>
<td>9.9 (8.9)</td>
<td>19.1 (7.9)</td>
<td>0.0000219 (0.000163)</td>
<td>0.000334 (0.000274)</td>
<td>27.2 (6.8)</td>
<td>277.6 (253.6)</td>
<td>1.29 (0.08)</td>
<td>1.29 (0.08)</td>
<td>0.000231 (0.000138)</td>
<td>0.000177 (0.000101)</td>
</tr>
<tr>
<td>Without VPAC</td>
<td>14.2 (8.1)</td>
<td>16.5 (8.0)</td>
<td>0.000164 (0.000112)</td>
<td>0.000311 (0.000301)</td>
<td>25.4 (7.2)</td>
<td>301.6 (254.3)</td>
<td>1.25 (0.13)</td>
<td>1.26 (0.11)</td>
<td>0.000197 (0.000119)</td>
<td>0.000209 (0.000113)</td>
</tr>
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