EFFECT OF HIP ABDUCTOR FATIGUE IN A LOWER LIMB KINEMATICS AND MUSCLE ACTIVITY DURING A CUTTING MANEUVER

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INTRODUCTION
The purpose of this study was to assess how sub-maximal fatiguing exercise of the hip abductors affects lower limb alignment and muscle activity around the hip joint. ACL injuries are serious and have a significant rate of occurrence in athletes. Previous studies have found that females who have weak hip abductors shift to hip and knee abduction during a single leg squat [1]. This, alignment has been associated with ACL injury and particularly the “point of no return” injury to the ACL. Current research has focused on the role of the hip abductors strength and training in preventing point of no return injury [2]. Yet to date, the relationship between hip alignment and abductor activity has not been examined under fatiguing conditions.

METHODS
Thirteen female athletes who play netball were recruited from the university students (Age 19.5±1.2, Height 170.2±7.2 cm, Weight 66.3±10.4 kg). All were free from lower limb injury for the previous 6 months and had no history of previous ACL injury or surgery to the lower limb. This study was approved by the Otago Human Ethics Committee.

Surface electrodes (TELEMYO 900) (EMG) were attached on the belly of 6 muscles around the hip joint: Gluteus medius (Gmed), Gluteus maximus (Gmax), Rectus femoris (RF), Adductor magnus (AM), Semitendinosus (ST) and Biceps femoris (BF) after skin preparation. These data were analyzed from 40 ms before IC to 80 ms post:contact (total 120 ms) using MATLAB (R2009a, The MathWorks, MA,USA) [3]. The sampling rate was 750 Hz and the raw EMG signal was filtered using Butterworth filter (cut off frequency 4 Hz, bandwidth up to 200 Hz). Then, a Hanning window was used to obtain sequential waveforms and a power spectrum was obtained by Fast Fourier Transformation [4]. To capture the motion, a ten-camera motion analysis system (Vicon, Oxford, UK) was used and 25 reflective markers were placed on the anatomical features of the lower limb and pelvis. Three-dimensional kinematic and kinetic data were collected using Vicon hardware and software and analyzed using Visual 3D (3.79, C-Motion, MD, USA) and MATLAB.

Participants performed 6 cutting maneuvers from a 40 cm high box at a 90° angle before and after the fatigue protocol. After the fatigue protocol, participants completed 6 post-fatigue trials within 210 s.

The dominant stance leg was used as the test leg which was defined as the opposite leg from the one they would use to kick a ball for distance. Participants were positioned side lying in front of the isokinetic dynamometer for the fatigue protocol. The speed of the isokinetic resistance was set at 60°/s during concentric hip abduction and at 180°/s during adduction phase [5]. This task was continued until exhausted (Mean repetition 112.2±40.4 reps). To prevent cheating, participant’s pelvis was held by an assistant during the protocol.

Paired t-tests were performed between pre- and post-fatigue of the hip angles at initial contact and after 40 ms in each plane, which is associated with ACL injury. Correlation coefficients between Gmed and the other muscles were calculated to reveal relationships between muscle pairings.

RESULTS AND DISCUSSION
Hip extension, abduction and external rotation were significantly increased at IC and hip extension and external rotation at 40 ms after the fatigue protocol (Table1). Although there was no significant difference in knee joint angle, it tended to shift to more valgus and external rotation, which are associated with the posture “point of no return” [6]. Gmed median frequency was significantly decreased by the fatigue protocol (p=0.02). The median frequency between Gmed and Gmax had a strong positive correlation in the pre-fatigue cutting condition, whereas no correlation was evident in the post-fatigue condition (Figure1). In addition, Gmed and ST had a strong positive correlation in the pre-fatigue cutting condition, whereas no correlation was evident in the post-fatigue condition (Figure1). In addition, Gmed and ST had a strong positive correlation in the pre-fatigue cutting condition, whereas no correlation was evident in the post-fatigue condition (Figure2). This means that Gmax could support obtaining more external rotation in the post-fatigue condition in terms of muscle function since Gmax activation worked by itself regardless of Gmed activation. Similarly obtaining more hip extension in post-fatigue condition can be explained by the fact that ST frequency is high as Gmed frequency is decreased.

From the results, it was indicated that hip angle change strongly depends on the muscle fatigue state. It was also noted that the fatigue of the abductors affected the relationship between gluteus muscles. However, further research into the motor control between Gmed and Gmax is needed.
Hip abductor fatigue affected hip angle change and the relation between Gmed and Gmax during a cutting maneuver. From the kinematic point of view, accumulated fatigue in the hip abductors may increase one’s susceptibility to ACL injury by placing the hip position.

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REFERENCES

Table 2: Mean ± SD hip and knee angle in each plane at IC and 40 ms before and after the fatigue protocol.

<table>
<thead>
<tr>
<th></th>
<th>IC Sagittal*</th>
<th>IC Frontal*</th>
<th>IC Horizontal**</th>
<th>40ms Sagittal*</th>
<th>40ms Frontal*</th>
<th>40ms Horizontal**</th>
<th>Knee Sagittal</th>
<th>Knee Frontal</th>
<th>Knee Horizontal</th>
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<tbody>
<tr>
<td>Pre</td>
<td>25.2±8.7</td>
<td>16.9±4.9</td>
<td>12.3±6.5</td>
<td>28.5±9.2</td>
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<tr>
<td>Post</td>
<td>23.0±7.5</td>
<td>18.5±4.5</td>
<td>14.3±6.6</td>
<td>25.7±7.7</td>
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<td>0.4±2.7</td>
<td>3.3±6.1</td>
</tr>
</tbody>
</table>

Hip→ (+): Flexion, abduction and external rotation  Knee→ (+): Extension, valgus and external rotation
* p<0.05 difference between Pre and Post  **p<0.01 difference between Pre and Post