LOWER EXTREMITY ASYMMETRIES DURING JUMP-LANDING TASKS

1 Evangelos Pappas, 2Felipe P. Carpes
1Division of Physical Therapy, Long Island University, Brooklyn, NY, USA, evangelos.pappas@liu.edu
2Laboratory of Neuromechanics, Federal University of Pampa, RS, Brazil

SUMMARY
Higher side-to-side asymmetry among female athletes compared to their male counterparts during bilateral athletic tasks such as landing from a jump has been proposed as a potential source of non-contact knee injuries. However, the kinematic symmetry and potential sex differences during bilateral landings have not been examined. The purpose of this study was to evaluate lower extremity kinematic symmetry in 13 male and 15 female athletes during maximum forward jump-landings (FL) and drop landings (DL). Knee valgus (p=0.006) was more asymmetrical during FL than DL and a similar trend was demonstrated for hip adduction (p=0.057). A trend was found for females landing with greater knee valgus asymmetry during FL (p=0.078) and with greater ankle abduction asymmetry during DL (0.091). The greater asymmetry during landings exhibited by female athletes may add to the biomechanical factors that have been identified as responsible for the higher rate of knee injuries among females and may assist in the development of injury prevention programs. As some of the sex differences were apparent in one landing task but not in the other, the importance of testing a variety of athletic tasks in the laboratory is emphasized.

INTRODUCTION
Female athletes suffer anterior cruciate ligament (ACL) injuries at a higher rate than male athletes [1]. Several theories have been proposed to explain this phenomenon. One of these theories, known as the “leg dominance theory” suggests that higher side-to-side differences during landing from a jump is a major factor contributing to the higher number of ACL injuries among female athletes [2]. Higher asymmetry among female athletes compared to males has been previously demonstrated for lower extremity muscle recruitment, strength and flexibility [2]. Asymmetries in frontal plane kinematics during running have been reported which may contribute to increased risk of overuse injury [3]. However, asymmetries of lower extremity kinematic variables during athletic tasks such as landing from a jump (that are likely to be more applicable to the explanation of the higher rate of ACL injuries among females) have not been reported. The purpose of this study was to evaluate lower extremity kinematic symmetry in male and female athletes during landing tasks.

METHODS
Thirteen male [age:26(2) years, height:182(7) cm, weight: 84(11) kg] and 15 female [age: 25(3), height: 167(6) cm, weight: 59(7) kg] recreational athletes without history of lower extremity injury performed three maximum bilateral forward jump-landings (FL) from 20cm away from the force plate and three bilateral drop landings (DL) from a 40cm box with both legs on an force plate (OR6-5, AMTI). Kinematic data were captured at 240Hz with eight Eagle cameras (Motion Analysis Corp.) tracking 22 markers (Helen Hayes marker set). Kinematic symmetry was defined as the absolute difference between the right and left joint for each data point and averaged across the first 40ms after landing for hip adduction, hip flexion, knee valgus, knee flexion, ankle abduction (frontal plane motion only) and ankle flexion. The first 40ms after landing were chosen as it has been demonstrated that this is the phase of landing when ACL injuries occur [4]. Six separate ANOVAs were performed to statistically evaluate the effect of task (FL vs. DL), sex (male vs. female) and their interaction on each one of the kinematic variables. The α level was set a priori at 0.05 while a statistical trend was defined between 0.05 and 0.10.

RESULTS AND DISCUSSION
Overall, there was more asymmetry between the two legs for hip and knee frontal plane than for sagittal plane variables (Table 1). Task had a significant effect on knee valgus with athletes having more asymmetry in FL compared to DL (p=0.006). Additionally, a trend was found for hip adduction during FL having more asymmetry than during DL (p=0.057). Trends were also observed for the interaction of task and sex on knee valgus with females exhibiting higher asymmetry than males during FL but not during DL (p=0.078) and on ankle abduction with females exhibiting more asymmetry than males during DL but not during FL (p=0.091).

The importance of frontal plane kinematic variables during landing from a jump as they relate to potentially explaining the sex disparity on ACL injuries is highlighted by the findings of this study. It has been previously shown that high knee valgus angles during DL are predictors of ACL injury among females [5] and that females have more prominent side-to-side asymmetries than males in respect to muscle recruitment, strength and flexibility [2]. However, this is the first study to demonstrate that asymmetries in lower extremity kinematics during jump-landing tasks may exist and differ between male and female. It is, therefore important for injury prevention programs to emphasize symmetry during functional tasks and for coaches to screen athletes for obvious
asymmetries during landing tasks at the beginning of the season. Visual feedback techniques such as performing jump landing tasks in front of a mirror may be used to restore symmetry in addition to traditional plyometric, stretching and strengthening interventions.

FL elicited greater asymmetry for hip adduction and knee valgus compared to the DL task. The two tasks are inherently different with FL having both a concentric and eccentric phase while DL has only an eccentric phase. Athletes are more familiar with the FL task that is commonly practiced during sports and may, therefore be more generalizable to the field while DL is easier to standardize in the laboratory setting. Athletes commonly have a preferred jumping leg which during bilateral forward jumps may create asymmetry that is not corrected during the airborne phase causing the athletes to land with greater asymmetries compared to DL.

Limitations of this study include low sample size and subsequent low statistical power and a laboratory environment that may have limited generalizability to the field. Kinetic variables could not be calculated as athletes landed with both legs on the force plate. Future studies should use larger sample sizes, additional tasks such as stop-jump landings and prospectively evaluate kinematic and kinetic variables as predictors of future injury. The persistence of leg asymmetries after injury and different protocols of rehabilitation are also among further topics for investigation.

CONCLUSIONS
This preliminary study demonstrated that female recreational athletes may exhibit greater side-to-side asymmetry than male athletes for knee valgus and ankle abduction kinematics during the initial phase of landing from a forward jump. These findings may provide insight into the biomechanical factors responsible for the higher rate of knee injuries among females and may guide the development and improvement of injury prevention programs. Additionally, FL produced more prominent lower extremity kinematic asymmetry than DL.

REFERENCES

### Table 1: Side-to-side lower extremity kinematic variable symmetry during forward jump-landings and drop landings.

<table>
<thead>
<tr>
<th>Joint Angle [deg (SD)]</th>
<th>Forward Jump-Landings</th>
<th>Drop Landings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>Hip Adduction</td>
<td>7.1(4.0)</td>
<td>7.6 (5.0)</td>
</tr>
<tr>
<td>Hip Flexion</td>
<td>1.8(1.2)</td>
<td>1.9(0.8)</td>
</tr>
<tr>
<td>Knee Valgus</td>
<td>4.0(3.2)^*</td>
<td>6.2(3.3)^*</td>
</tr>
<tr>
<td>Knee Flexion</td>
<td>3.9(2.6)</td>
<td>4.6(3.8)</td>
</tr>
<tr>
<td>Ankle Abduction</td>
<td>3.4(4.0)</td>
<td>2.9(2.6)</td>
</tr>
<tr>
<td>Ankle Flexion</td>
<td>3.5(1.9)</td>
<td>3.7(2.5)</td>
</tr>
</tbody>
</table>

*higher asymmetry in forward jump-landings compared to drop landings (p=0.006)
^trend for higher asymmetry in forward jump-landings compared to drop landings (p=0.057)
^trend for higher asymmetry in females compared to males (p≤0.091)