INTRODUCTION:

Jumping and cutting activities are commonly performed in laboratory settings to investigate knee kinematics. Traditionally, optical motion capture (OMC) technologies are used to quantify the motion of the femur and tibia. While OMC is non-invasive and allows for entire jumping and cutting movements to be captured, it is subject to soft tissue artifact at impact. Thus, high speed biplanar x-ray technology has become an alternative tool for accurately quantifying knee bone motion without soft tissue artifact at impact. Understanding the measurement differences between these two motion capture modalities during high impact activities (i.e. those which are more susceptible to soft tissue motion artifact) are important in deducing the capabilities of each system during ground contact, where the knee is under the greatest impact stress.

The purpose of this study was to compare knee kinematic measurements between OMC and biplanar x-ray motion capture during a jump-cut activity. It was hypothesized that soft tissue artifact would significantly alter the kinematics obtained from OMC after contact.

METHODS:

All experimental procedures were approved by the Institutional Review Board. After granting informed consent, 10 healthy volunteers, 5 males (25±4.2 years old) and 5 females (26±2.3 years old), with no prior knee injuries were outfitted with retro reflective surface markers on one leg. The outfitted leg was randomly selected (6 L, 4 R).

Activity: The jump-cut maneuver was based on an activity designed to mimic maneuvers associated with non-contact ACL injury [1,2]. Three targets were placed in the testing environment: one on the center of a force plate (Fig. 1) and the other two toward the left and right of the landing target at an angle of 45° and a distance of 1m. These two targets provided a reference for the subject to cut toward and jog past. Before beginning the maneuver, the subject was asked to stand ~1m from the force plate with their knees bent at ~45°. A verbal prompt was used to cue the subject to jump upward and forward toward the landing target. A visual directional prompt (L or R) instructed the subject to perform a sidestep cut and jog toward one of the angled targets. For example, when subjects cut to the left, they pushed off with their right foot and led with their left (Fig. 1). Ten trials (5 in each direction) were performed and the subject was unaware of the directional prompt prior to each trial.

RESULTS:

The mean rotational RMS values ranged from 1.3±0.9° to 6.8±2.9°. The mean translational RMS values ranged from 2.3±2.2mm to 9.3±3.8mm (Table 1).

Table 1: Mean±SD rotation and translation RMS between OMC and biplanar x-ray. Matching glyphs (t or rt) depict significance between A, B, & C.

<table>
<thead>
<tr>
<th>Component</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLEX (°)</td>
<td>2.0±1.81</td>
<td>1.3±0.91</td>
<td>2.3±1.80</td>
</tr>
<tr>
<td>AD/AB (°)</td>
<td>3.4±2.48</td>
<td>2.8±2.44</td>
<td>2.25±2.18</td>
</tr>
<tr>
<td>IN/EX (°)</td>
<td>1.2±1.75</td>
<td>1.6±1.59</td>
<td>3.4±2.55</td>
</tr>
<tr>
<td>ME/LA (mm)</td>
<td>4.2±3.19</td>
<td>4.6±4.08</td>
<td>3.30±4.03</td>
</tr>
<tr>
<td>AN/PO (mm)</td>
<td>3.8±1.68</td>
<td>3.8±1.69</td>
<td>56.1±12.44</td>
</tr>
<tr>
<td>CO/DI (mm)</td>
<td>6.8±2.85</td>
<td>76.8±2.67</td>
<td>79.3±1.37</td>
</tr>
</tbody>
</table>

DISCUSSION:

We found that soft tissue artifact significantly altered knee kinematic measurements obtained from OMC after peak impulse for all rotations and translations. Peak optical motion capture joint rotations and translations were observed to change as much as 15° and 20mm in some cases (Fig. 2). This is thought to result from the oscillatory affect of the skin and soft tissue upon impact.

As expected, the OMC kinematic measurements followed the biplanar x-ray measurements more closely during the period before contact where soft tissue motion is lowest. Additionally, most kinematic measurements weren’t significantly affected by soft tissue artifact during the period between contact and peak impulse. This is largely a consequence of passive leg loading where the muscles have not engaged and the soft tissue has not begun to oscillate about the bones.

SIGNIFICANCE:

This study is a significant step toward understanding the ways biplanar x-ray motion capture and OMC can be used together for answering kinematically driven questions. Additionally, this study provides a foundation for creating methods for modeling soft tissue motion in order to mitigate its affect on kinematic outcome measures.

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REFERENCES:


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