Comparison of Landing Biomechanics Between Dancers and Team Sport Athletes via a BTS Bioengineering Motion Capture System

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Sports Medicine

- Sports medicine deals with physical fitness, and the treatment and prevention of injuries in sport and exercise.
- Biomechanics is the study of the mechanical laws relating to the movement or structure of living organisms.
  - Kinetics and kinematics

Introduction Review of Literature Research Question Methods Results Discussion Conclusion
High Risk of Injury in Dancers

• Based on the training that dancers undergo, they are considered elite athletes.
• Skill level and performance demands of professional dancers are often compared to those of professional athletes (Nicholas, 1975).
• The annual rate of injury for professional dancers is reported to be between 67%-95% (Bronner et al., 2003).
• The high degree of repetition, high level of physical demands, and environmental risk factors of dance increase the risk of injury (Koutedakis and Jamurtas, 2004).
Early detection of malalignment in the lower extremities is important.

The assessment of lower extremity alignment can be accurately performed using 3D motion analysis (Orishimo et al., 2009, Ross et al., 2016).

Studying if an athlete has poor control of their lower extremities may help detect and prevent alignment related injuries (Stensrud et al., 2011).
Landing Biomechanics

• Musculoskeletal system and environment play a key role in landing biomechanics.

• Kinetics and kinematics can demonstrate the strategies used by the subjects in an attempt to maintain joint stability during activity (Ross et al., 2005).

• Orishimo et al., (2014) showed that dancers with greater experience demonstrated more biomechanical characteristics that are protective for ACL injury during landing.
How can motion capture, electromyography (EMG), and force data be used to identify differences in EMG activity with kinetics and kinematics in relation to stiffness of the ankle between professional dancers and athletes?
Hypotheses

\( H_0 \): There will be no differences in landing biomechanics between dancers and team sport athletes.

\( H_1 \): During a landing task, professional dancers will display different landing mechanics than those of team-sport athletes.

\( H_2 \): There will be changes in the time and amount of muscle activation between dancers and athletes; these differences will become more extreme when fatigue is a factor.
Methods

1. Participants signed a consent form and answered a demographic questionnaire
2. Motion capture is setup with the subject and calibrated
3. Drop landing tasks are conducted
4. Data was analyzed for statistical significance
Participants

- 20 female professional dancers
- 20 male professional dancers
- 20 female professional athletes
- 20 male professional athletes
- 10 student dancers

Introduction Review of Literature Research Question Methods Results Discussion Conclusion
Motion Capture

BTS Bioengineering SMART DX-700

Setup of Reflective Markers and EMG

Introduction Review of Literature Research Question Methods Results Discussion Conclusion
Landing Task

Drop Landing
- 3 single leg drops
- 30 cm platform

Horizontal Jump
- 3 jumps
- Maximum propulsion

Vertical Jump
- 3 jumps
- Maximum height
Fatigue Protocol

50 step-ups (dominant leg) onto a 30 cm platform

15 maximum height vertical jumps

Vertical jump height decrease of 10%?

If yes, repeat landings
If no, repeat fatigue
**Data Analysis**

**Landings**
- Period of time from initial contact to the point of maximum knee flexion

**Joints**
- Angles were calculated using motion capture data

**Ankle Stiffness**
- Change in ankle moment and angle from the start to the end of each task
Statistical Analysis

**Trials**
- Three trials of each task were averaged together

**3x2 Mixed Model ANOVA**
- Kinetic, kinematic, time to stability

**Variables analyzed**
- Ankle plantarflexion
- Peak ankle dorsiflexion
- Ankle range of motion
- Average ankle stiffness
- Activity of the peroneus and gastrocnemius at initial contact

P value of .05 was set as the threshold for statistical significance

Introduction Review of Literature Research Question Methods Results Discussion Conclusion
Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Men</th>
<th>Women</th>
<th>p</th>
</tr>
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<tbody>
<tr>
<td>Peak plantarflexion</td>
<td>18.3 ± 0.7°</td>
<td>22.5 ± 0.8°</td>
<td>&lt; 0.001</td>
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<td>Peak dorsiflexion</td>
<td>17.8 ± 0.7°</td>
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<td>Range of motion</td>
<td>36.1 ± 0.9°</td>
<td>42.3 ± 1.1°</td>
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<td>Peak moment</td>
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![Graph of Peak Ankle Moment](image1)

![Graph of Ankle ROM](image2)

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• There was a significant difference in landing mechanics at the ankle between professional dancers, student dancers, and professional athletes
• EMG of the gastrocnemius and peroneus were different between dancers and athletes, suggesting that firing patterns of these muscles play a large role in landing biomechanics
• Fatigue exacerbated the differences in landing mechanics
Results

• Women contacted the ground with greater ankle plantarflexion and landed with greater dorsiflexion, thus showing greater range of motion.

• The greater range of motion in women is a compensation for their lower ankle stiffness values in comparison to men.

• Dancers landed with the ankle in greater plantarflexion than did athletes, reflective of the technique training that they do.
Discussion

• The differences in firing patterns of the peroneus muscle across groups may be related to injury avoidance.

• Greater activity of the peroneus at initial contact in athletes may indicate that during landing, athletes place a greater emphasis on avoidance of injury vs form as compared to dancers.

• The lower activity of the peroneus in student dancers could be indicative of weakness due to a lower level of training compared to professional dancers.
Conclusion

• The conclusions with regard to student dancers are limited by the low number of subjects, and that they were all female

• Fatigue protocol was slightly different between the student dancers and other subjects
  • The step used for the previous subjects had been removed from the lab by the time the student dancers were recruited

• Further work could examine differences in these groups during landing at the knee and the hip
Acknowledgments

• Nicholas Institute for Sports Medicine and Athletic Trauma
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Bibliography


