Investigating the Influence of Preparatory Arm Swing on Ankle Kinematics and Force Production During the Horizontal Jump

Daisy Hansana and Wendi Weimar

Preparatory movements prepare the body to perform ballistic movements. During the horizontal jump, the preparatory movement includes a vigorous arm swing and a countermovement marked by hip and knee flexion. While several studies investigated the mechanical role of the arm swing in enhancing the performance of the horizontal jump, the reason for this enhancement remains unclear. Previous work has indicated that the arm swing raises the center of mass and increases the force into the floor but has not found if alterations in the preparatory arm swing can alter ankle kinematics and/or the forces exerted on the floor by the body. This project, by adding an extra arm swing to the preparatory movement, will seek to determine if this extra motion prepares the body to experience a greater gain from the stretch shortening cycle during the counter movement of the horizontal jump. The stretch shortening cycle is a term used to describe a phenomenon demonstrated by counter movements, in which the body stretches the muscles about to be used in the performance of a ballistic task. This stretch stores elastic potential energy that is released as kinetic energy during the propulsion phase of a ballistic movement, like the horizontal jump. Our hypothesis is that the extra arm swing will remove some of the "slack" in the muscle prior to the stretch and thereby allow for the storage of more elastic potential energy during the stretch.

To test this hypothesis, we measured changes in ankle motion and the forces exterted into the floor during the horizontal jump, during a normal jump performance, and during a performance in which an extra arm swing is added to the preparatory movement. Our pilot study included four participants between 19 and 30 years of age who voluntarily consented to perform the two-day trial that lasted 1.5 hours. Each participant was given an unlimited time to warm up after which reflective markers were attached to the participant in order to track the movement of the body segments. Following the warm-up, the participants performed six jumps of maximal effort under two different conditions:

1. **Condition 1:** Three jump trials that began with an extra arm swing preparatory arm movement (bilateral swing) prior to initiation of the jump.
2. **Condition 2:** Three jump trials utilizing their "normal" or typical start form.

Foot placement along with stance remained the same throughout all six trials, whereas the order of jump types was randomized via coin flip. Data from each jump were collected using a 10-camera Vicon ® optical motion capture system at 240Hz, and an AMTI ® force plate (1000Hz).

Results indicated that the extended arm swing condition yielded the following outcomes:

(a) more ankle dorisflexion during the counter movement
(b) more ankle plantar flexion at take-off
(c) greater peak vertical force
(d) greater peak posterior force.

An increase in each of these variables implies increased performance on the horizontal jump. The increased ankle dorsiflexion during the counter movement indicated that a greater stretch was realized at the knee and the hip. The increased plantar flexion at take-off indicates that the body pushed through a greater range of motion at take-off. The increases in vertical and horizontal forces indicates that the body exterted greater forces into the ground, which should be realized in greater jump performance.

At this time, it is difficult to discern whether the inclusion of an additional preparatory arm swing produced the kinematic changes at the ankle, or whether the changes in ankle motion were a byproduct of the changes brought about at the hips and knees. Regardless, the increase in force production indicates that the additional preparatory arm swing is beneficial to horizontal jump performance.

Statement of Research Advisor

Daisy investigated the interconnectedness of the body by evaluating the influence of a pre-preparatory movement on the kinematics and kinetics of the ankle during the horizontal jump.

-Wendi Weimar, Kinesiology