INTRODUCTION

Numerous studies have shown that arm swing has a significant influence on jump height (e.g., Lees et al., 2004). These studies indicated that an arm swing increases the angular velocity and torque at lower extremity joints, COM height, and velocity at takeoff for a countermovement jump. Additionally, Hsieh and Heise (2006) found that arm swing was one of the most important factors which contributed to volleyball spike jump height. Studies found that the takeoff velocity can be enhanced by 6-12% when comparing countermovement jumps with arm swing to no arm swing. Arm swing raised the COM height at takeoff by 2-3% when compared to no arm swing (Feltner et al., 1999; Harman et al., 1990; Lees et al., 2004; Ravn et al., 1999). Although these studies examined the effect of arm swing on jump height, few of them have examined the performance of the arm swing in different skill level players. Additionally, few of the volleyball coaching texts adequately explain the importance of arm swing for the volleyball spike jump.

Therefore, the main purpose of present study was to investigate the difference of arm swing performance patterns between advanced and recreational female volleyball players.

METHODS

Twenty female volleyball players were recruited from college-level teams. Ten players (mean body height = 1.75 ± 0.09 m; mean body mass = 66.0 ± 8.5 kg) were playing on a highly competitive team (NCAA Division I) and the other ten players (mean body height = 1.71 ± 0.11 m; mean body mass = 62.3 ± 7.4 kg) were actively playing volleyball at a local recreation center. All policies and procedures for the use of human subjects were followed and approved by the local Institutional Review Board.

Each subject was required to warm-up for at least 5 min by stretching all major muscle groups for jump performance and practicing several normal spike jumps in front of a net and camera (see Figure 1). All subjects performed 10 volleyball spike jumps.

Two-dimensional coordinate data from one side of the body were obtained with a 60-Hz video camera in conjunction with a motion analysis system (Vicon Motus). Data were collected from movement onset until after the peak of the jump. Coordinate data were filtered and then kinematic variables of arm swing were examined: the range of motion (X1), angular velocity (X2), the coordination of arm swing (X3), hyperextension joint angle at shoulder joint (X4), and the jump...
The coordination of arm swing was defined as the time when maximum hyperextension of shoulder joint was occurred prior to the feet impact. The data were analyzed and compared (t-test, p < .05) between advanced and recreational female volleyball players.

Figure 2. Three kinematic variables of arm swing ($X_3$, $X_4$, & $X_5$) of a volleyball spike jump.

RESULTS AND DISCUSSION

Results showed that the kinematic variables of arm swing were significantly greater in the advanced volleyball players group. Additionally, the jump height of advanced female volleyball players was significantly higher than recreational female players. Table 1 shows the kinematic variables of arm swing and jump height for both advanced and recreational female volleyball groups. The skilled female volleyball players demonstrated the ability to use the arm swing to facilitate the spike jump by swinging arms faster with a greater range of motion. Advanced volleyball player illustrated earlier onset of arm swing with greater shoulder hyperextension joint angle when compared to the recreational female volleyball players.

A successful volleyball spike jump consists of several different factors and a balanced combination of these variables. Arm swing was recognized as one of these variables. During the approach phase, skilled players brought the arm back farther and earlier prior to the impact of both feet when compared to recreational players. This process assists the arm to store and release the energy from the muscle and tendon at lower extremities meanwhile help the trunk to move upward (Lees et al., 2004). That is, the increased range of motion for the arm swing in addition to the earlier time of initiation allowed the arm to generate more energy, which is transferred to various body points to improve vertical jump performance.

Pedagogically, instructors, coaches, and trainers may want to focus on the coordination of arm swing during the performance of a volleyball spike jump. Arm swing forward should have begun before the feet planted at the last step.

REFERENCES


Table 1: Kinematic variables of arm swing performance for advanced and recreational female players. *(p < 0.05)*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Advanced (mean ± SD)</th>
<th>Recreational (mean ± SD)</th>
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</thead>
<tbody>
<tr>
<td>Jump Height* ($X_3$)</td>
<td>$0.45 \pm 0.05 \text{ m}$</td>
<td>$0.30 \pm 0.03 \text{ m}$</td>
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<tr>
<td>Range of Motion* ($X_1$)</td>
<td>$225.43 \pm 37.63^\circ$</td>
<td>$165.07 \pm 40.91^\circ$</td>
</tr>
<tr>
<td>Angular Velocity* ($X_2$)</td>
<td>$-456.96 \pm 59.49^\circ$</td>
<td>$-375.82 \pm 70.93^\circ$</td>
</tr>
<tr>
<td>Hyperextension Joint Angle* ($X_4$)</td>
<td>$95.01 \pm 34.74^\circ$</td>
<td>$68.87 \pm 34.74$</td>
</tr>
<tr>
<td>Coordination* ($X_3$)</td>
<td>$0.24 \pm 0.06 \text{ s}$</td>
<td>$0.20 \pm 0.03 \text{ s}$</td>
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