Biomechanical comparative analysis of take off dynamics parameters in blocks and spikes of female volleyball

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1. Introduction

In the competition between volleyball teams, it is the effectiveness of the blocks and attacks that determines the victory. The defensive play at the net consists mainly in performing an in position block or a run up block by the front row players. The offensive play is dominated by attack line spikes and back row attacks, as well as the popular in female volleyball slide attacks. A characteristic element of motion technique in volleyball jumps is the swing of the upper limbs and the lowering of the general body mass (depth of knee bend) of volleyball players. The swing motion preceding the take-off phase increases the initial force as a result of the action of the lower limb muscles during the extension-contraction cycle. The increase in the elastic energy of muscle fibers results in the achievement of higher values of lower limb and torso power as well as better jumping ability, which determine the ground reaction forces during the take-off phase of a given technical element.

2. Methods

2.1 Example

The purpose of this study was to demonstrate changes of parameters of take off dynamics in technically diverse female volleyball plays, such as: block from a run-up, slide attack, attack line spike and the back row attack. The study covered a group of female volleyball players of the first team in the AZS AWF Poznan sports club (N=4), competing at the highest national level - Female Volleyball League - in the 2007/2008 season. The measurements were performed in the biomechanical-kinesiological lab of the Department of Biomechanics USPS in Poznan. Two research methods were applied: piezoelectric dynamometry (KISTLER platform) as well as video recording (two Canon digital cameras) for visual recording and analysis of the motion technique.

Table 1 Kinematic and biomechanical parameter values calculated on the basis of the $Rz_o(t)$, $Rx_o(t)$ and $Ryo(t)$ line graphs.

<table>
<thead>
<tr>
<th>Take-off</th>
<th>Characteristic</th>
<th>$Rz_{o\text{max}}$</th>
<th>$Rxy_{o\text{max}}$</th>
<th>$&lt;Rz_o&gt;$</th>
<th>$&lt;Rxy_o&gt;$</th>
<th>$Iz_o$</th>
<th>$Ixy_o$</th>
<th>$Pz_o$</th>
<th>$Pxy_o$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>AV</td>
<td>2.18⁹</td>
<td>0.67⁹</td>
<td>1.46⁹</td>
<td>0.31⁹</td>
<td>6.18⁹</td>
<td>1.74⁹</td>
<td>613.25⁹</td>
<td>123.84⁹</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.12</td>
<td>0.16</td>
<td>0.20</td>
<td>0.11</td>
<td>2.00</td>
<td>0.60</td>
<td>36.45</td>
<td>38.92</td>
</tr>
<tr>
<td>B</td>
<td>AV</td>
<td>2.70⁹</td>
<td>0.86⁹</td>
<td>1.84⁹</td>
<td>0.48⁹</td>
<td>17.74⁹</td>
<td>4.92⁹</td>
<td>409.08⁹</td>
<td>101.72⁹</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.09</td>
<td>0.03</td>
<td>0.09</td>
<td>0.04</td>
<td>2.26</td>
<td>0.55</td>
<td>51.62</td>
<td>6.95</td>
</tr>
<tr>
<td>C</td>
<td>AV</td>
<td>2.68⁹</td>
<td>0.76⁹</td>
<td>1.88⁹</td>
<td>0.43⁹</td>
<td>12.64⁹</td>
<td>3.17⁹</td>
<td>536.70⁹</td>
<td>100.07⁹</td>
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<td></td>
<td>SD</td>
<td>0.11</td>
<td>0.14</td>
<td>0.10</td>
<td>0.06</td>
<td>4.00</td>
<td>0.78</td>
<td>48.38</td>
<td>17.77</td>
</tr>
<tr>
<td>D</td>
<td>AV</td>
<td>2.93⁹</td>
<td>0.91⁹</td>
<td>1.90⁹</td>
<td>0.50⁹</td>
<td>11.84⁹</td>
<td>2.75⁹</td>
<td>578.33⁹</td>
<td>131.19⁹</td>
</tr>
<tr>
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<td>SD</td>
<td>0.05</td>
<td>0.18</td>
<td>0.08</td>
<td>0.04</td>
<td>0.77</td>
<td>0.45</td>
<td>47.52</td>
<td>41.59</td>
</tr>
</tbody>
</table>

F⁹ represents statistical significance at the level of p<0.05 in the Friedman ANOVA test

A - block from a run-up, B - slide attack spike, C - attack line spike, D - back row attack

The recorded characteristics of components of ground reaction forces were used to determine the values (maximum/integral averages) of vertical component and the resultant of horizontal components of ground reaction forces during take-off ($Rz_{o\text{max}}/Rz_o$ and $Rxy_{o\text{max}}/Rxy_o$), their increase indexes ($Iz_o$ and $Ixy_o$) and force impulses ($Pz_o$ and $Pxy_o$). Mean values and standard deviations of these physical quantities in typical technical elements used by female volleyball players during the take-off are presented in table 1.
Force vs time line graphs of the vertical component $Rz(t)$ and the resultant of the horizontal components of ground reaction forces $Rxy(t)$, based on the recorded characteristics $Rx(t)$ and $Ry(t)$, during take-off in one of the selected volleyball plays - the back row attack, are presented in figures 1 and 2 respectively.

![Fig. 1 Line graph of $Rz(t)$ during a take-off for the back row attack](image1)

![Fig. 2 Line graph of $Rxy(t)$ during a take-off for the back row attack](image2)

3. Results

The level of take off dynamics in four typical female volleyball plays: block from a run-up, slide attack, attack line spike and the back row attack, was described with the following parameters: $Rz_{max}$ and $Rxy_{max}$, $<Rz>$ and $<Rxy>$, $Iz$ and $Ixy$ as well as $Pz$ and $Pxy$. In the compared technical female volleyball plays, during the take-off phase there exist statistically significant differences (Friedman ANOVA test $p<0.05$) between the mean values of vertical component of each individual dynamic parameter. Furthermore, significant differences were observed (Friedman ANOVA test at a level of $p<0.05$), between the mean values of: the vertical component ($z$) and the resultant of the horizontal components ($xy$) of each individual dynamic parameter.

4. Discussion

Taking into account the values of maximum and mean total ground reaction forces (vertical component and the resultant of the horizontal components), the authors found that the highest level of dynamics could be observed in the take-offs of the back row attack jumps, where the highest values of these parameters were recorded. As far as the ground reaction force increase indexes $Iz$ are concerned, the take-off of the jump during the slide attack was the most dynamic one. The factor that had a significant influence on such a high value of this parameter in this element was the evidently shortest time of maximum ground reaction force production during the short phase of the take-off. However, a different situation occurred in case of the analysis of the force impulses. The highest value was determined for the vertical component during the take-off phase of the jump in the block from a run-up play.

Keywords: ground reaction forces, piezoelectric platform, take-off dynamics, volleyball

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1. References