Biomechanical Quantification of the Key Parameter Related to the Forehand Overhead Smash in Badminton

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How do we teach a beginner?

Self-learning?
Introduction

- The Badminton Forehand Overhead Smash

- Three Phases of the Forehand Overhead Smash
The Forehand Overhead Smash (#4 in the Figure 1) has been described as a shot toward the opponent’s court with a downward power and speed wherein the angle of the shuttlecock’s trajectory is very steep (Yap, 2012).

Figure 1. All five basic badminton forehand strokes ¹
Three Phases of the Forehand Overhead Smash

1. Preparation
   - Footwork
   - Waiting Position

2. Acceleration
   - Back-Swing
   - Forward-Swing
   - Contact point

3. Follow Through

**Figure 2.** Three phases of badminton forehand overhead smash with dynamic shuttlecock
Influential Factors in Relation to Smash Quality

The Lack of Previous Scientific Researches
Body Positioning

Body Positioning is defined as the relationship of anterior-posterior distance between the center of gravity (COG) and shuttlecock (D_{a-p}) immediately before contact (stage three in the acceleration phase) in current study.

- The closer the player is from the shuttlecock, the less steep the smash will be\(^1\),\(^2\).
- The smash angle can affect the trajectory of the shuttlecock\(^3\).

Literature Review

1. Zhao, 2007
2. Chen et al., 2009
3. Tong, 2004
The Lack of Previous Scientific Researches

- The fundamental aspect (i.e. body positioning) was hardly addressed in existing badminton research.

- A lack of scientific research and the limited data on the assessment of which biomechanical factors are necessary and desirable in badminton technique as compared to other racket sports\textsuperscript{11-14}.

\textsuperscript{11} Hussain et al., 2011
\textsuperscript{12} Teu et al., 2005
\textsuperscript{13} Huynh & Bedford, 2011
\textsuperscript{14} Liu et al., 2010
Aims

✓ to quantify the relationship between body positioning and smash quality
✓ to compare the characteristics of techniques found in the Novice Group (NG) and Skilled Group (SG) in order to reveal the influence of experience
**Study Objectives**
Body Positioning

**Smash Quality**
- Shuttlecock Release Speed ($V_{\text{release}}$)
- Clearance Height ($H_c$)
- Shuttlecock Release Angle ($\alpha_{\text{release}}$)

**Subjects’ Groups**
- Skilled Group (SG)
- Novice Group (NG)

3D Motion Capture (Mo-cap) System & 15-Segment Full-body Modeling
Subjects

Table 2. Age, Body Height, Weight, Training Period and Gender

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Age (yrs.)</th>
<th>Height (m)</th>
<th>Weight (kg)</th>
<th>Experience (yrs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NG</td>
<td>10</td>
<td>24.3±4.7</td>
<td>1.71±0.07</td>
<td>62.05±9.24</td>
<td>0</td>
</tr>
<tr>
<td>SG</td>
<td>14</td>
<td>23.2±2.8</td>
<td>1.77±0.05</td>
<td>71.56±7.73</td>
<td>6.6±3.1</td>
</tr>
</tbody>
</table>

- A total of 24 subjects (ages 20-35, Male: n= 17 ; Female: n= 7)
Lab Set Up

The static shuttle test - a static shuttle hanging from the ceiling

The dynamic shuttle test - a dynamic shuttle served from the other side of the net
Lab Set Up

- 39 reflective markers for building a 15-segment, full-body biomechanical model
Lab Set Up

- **A standard racket**: 13 reflective adhesive markers/tape (2 marks on handle and 11 tapes on frame)
- **The standard shuttlecock**: one tape on the cork of the shuttle
- **The standard net**: three markers
Data Collection — Static Shuttlecock Test

The three static body positioning tested in the study:

$D_{a-p}$ - The anterior-posterior distance between the center of gravity (COG) and shuttlecock.

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Data Collection — Dynamic Shuttlecock Test

- One highly trained subject was chosen to hit a high serve in the dynamic shuttlecock test.
Smash Quality Parameters

- **Shuttlecock Release Speed** ($V_{\text{release}}$) - is the magnitude of shuttlecock’s velocity (the rate of change of shuttlecock’s position) after the moment of contact.

- **Shuttlecock Release Angle** ($\alpha_{\text{release}}$) - is decided by the angle between the direction of shuttlecock flight and horizontal plane (+: upward release; -: downward release).

- **Clearance Height** ($H_c$) - is determined by the vertical distance between the shuttlecock and the top of the net at the movement when the shuttlecock passes above the net.
Results

- The Result of Body Positioning between Body Centre of Gravity and Shuttlecock
- The Result of the Static Positioning Compared to the Dynamic Smash
- The Result of the Significant Influences of Body Positioning
### Table 1. Comparison of $D_{a-p}$ between Dynamic (Dyn) and the Three Static Positions

<table>
<thead>
<tr>
<th></th>
<th>Dyn</th>
<th>SF</th>
<th>SM</th>
<th>SR</th>
</tr>
</thead>
<tbody>
<tr>
<td>NG</td>
<td>0.45 ± 0.22</td>
<td>-0.08 ± 0.11**</td>
<td>0.41 ± 0.11</td>
<td>0.67 ± 0.09**</td>
</tr>
<tr>
<td>SG</td>
<td>0.59 ± 0.07</td>
<td>-0.00 ± 0.14**</td>
<td>0.36 ± 0.06</td>
<td>0.70 ± 0.10**</td>
</tr>
<tr>
<td>Difference</td>
<td>31.12%</td>
<td>1%</td>
<td>13.43%</td>
<td>4.48%</td>
</tr>
</tbody>
</table>

** – highly significant (p<0.01)
Table 2. Kinematic Data of Smash Quality Parameters (negative $\alpha$: downward)

<table>
<thead>
<tr>
<th>Group</th>
<th>Position</th>
<th>$V_{\text{release}}$ (m/s)</th>
<th>$\alpha_{\text{release}}$ ($^\circ$)</th>
<th>$H_c$ (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NG</td>
<td>Dyn</td>
<td>36.65 ± 8.47</td>
<td>8.8 ± 11.8</td>
<td>1.16 ± 0.86</td>
</tr>
<tr>
<td></td>
<td>SF</td>
<td>30.18 ± 8.15</td>
<td>7.1 ± 8.1</td>
<td>1.24 ± 0.68</td>
</tr>
<tr>
<td></td>
<td>SM</td>
<td>32.69 ± 7.48</td>
<td>1.9 ± 8.9</td>
<td>0.86 ± 0.50</td>
</tr>
<tr>
<td></td>
<td>SR</td>
<td>34.64 ± 8.88</td>
<td>-3.7 ± 5.2</td>
<td>0.49 ± 0.25</td>
</tr>
<tr>
<td>SG</td>
<td>Dyn</td>
<td>58.86 ± 9.59</td>
<td>-9.1 ± 4.1</td>
<td>0.12 ± 0.28</td>
</tr>
<tr>
<td></td>
<td>SF</td>
<td>41.80 ± 9.85</td>
<td>-7.4 ± 9.0</td>
<td>0.55 ± 0.58</td>
</tr>
<tr>
<td></td>
<td>SM</td>
<td>44.15 ± 9.47</td>
<td>-11.1 ± 9.7</td>
<td>0.43 ± 0.67</td>
</tr>
<tr>
<td></td>
<td>SR</td>
<td>45.31 ± 7.81</td>
<td>-14.8 ± 8.0</td>
<td>0.08 ± 0.49</td>
</tr>
</tbody>
</table>

ns – no significant, * – significant (p<0.05), ** – highly significant (p<0.01)
Body positioning (i.e. SF, SM and SR) has no significant influence on power generation.

The body positioning influenced the quality of the $\alpha_{\text{release}}$ and $H_c$ of a smash.
Body positioning plays a role for beginners in learning a proper smash $\alpha_{\text{release}}$.

1) The SG has always produced a downward flying shuttlecock, the NG could only create such a flying bird in SR.
2) The NG completed smashes with an upward $\alpha_{\text{release}}$ in Dyn, SF and SM.
The best positioning would be between SM and SR.

1) One could use a static comfortable selection (i.e. SM) for determining a proper positioning for learning and training.
2) Positioning the body 0.35 m behind one’s static comfortable selection (SM) would have better smash accuracy ($\alpha_{\text{release}}$ and $H_c$) than SM.
3) A learner should step back by about one and a half feet (the average foot length of 1.71 m person is 24.5 cm) from the static comfortable selection (SM).
Several advantages existed when smashing between SM and SR:

**SM/SR** $(D_{a,p}>0)$ **VS** **SF** $(D_{a,p}<0)$

- **Between SM & SR:** the players are more able to see opponent’s movement for anticipating and planning
- **In SF:** looking upward
- **Between SM & SR:** the players could easily control balance for quickly moving forward toward the center court
- **In SF:** lose balance
- **Between SM & SR:** a powerful smash will be executed by a concentrated power outbreak.
- **In SF:** consuming the power in more upward direction
Conclusion

- The findings divulged that the body positioning has direct influence on $\alpha_{\text{release}}$ and $H_c$
- The best positioning would be one and a half feet behind the static comfortable selection (SM).
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