Pole Vault Diagnostics

Falk Schade

\[ E_{CM} = mgH_{CM} + \frac{my^2_{CM}}{2} \]

\[ E_{tot} = \sum_{i=1}^{12} m_i g h_i + \sum_{i=1}^{12} \frac{m_i v_i^2}{2} + \sum_{i=1}^{\text{segments}} \frac{\Theta_i \omega_i^2}{2} + \frac{\Theta_{Tlo} \omega_{Tlo}^2}{2} + \text{potential energy} + \text{kinetic energy translatory} + \text{kinetic energy rotatory} \]
Excursion

Energy Exchange Concept - Pole Vault -

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Energy Exchange Concept - Pole Vault -
Energy Exchange Concept - Pole Vault -

1 J/kg \approx 10 \text{ cm}

<table>
<thead>
<tr>
<th>CM height</th>
<th>CM velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>potential energy</strong></td>
<td><strong>kinetic energy</strong></td>
</tr>
<tr>
<td>at touch down: 1 m</td>
<td>10 m/s = 50 J/kg</td>
</tr>
<tr>
<td>9,5</td>
<td>= 45,1</td>
</tr>
<tr>
<td>9,4</td>
<td>= 44,2</td>
</tr>
<tr>
<td>9,0</td>
<td>= 40,5</td>
</tr>
<tr>
<td>8,5</td>
<td>= 36,1</td>
</tr>
<tr>
<td>8,0</td>
<td>= 32,0</td>
</tr>
</tbody>
</table>

at maximum CM height: 5 m = 49,05 |
6 m = 58,86

1,2 = 0,72 |
1,8 = 1,62

approach velocity

velocity at bar clearance

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Pole Vault Projects

• WC Athens 1997  (IAAF)
• since 1998: nat. comp. diagnostics
• OG Sydney 2000  (IOC)
• EC München 2002  (DLV)
• WC Helsinki 2005  (IAAF)
• WC Berlin 2009  (DLV/IAAF)
• BISp Projects 1998, 2002
• since 2013: measuring station
Pole Vault Projects

Methodological Studies:
• Influence of energy models  
  \(\text{(Schade, Arampatzis \& Brüggemann 2000, JOB)}\)
• Criteria for interaction athlete/pole  
  \(\text{(Arampatzis, Schade \& Brüggemann 2004, JOB)}\)
• Reproducibility  
  \(\text{(Schade, Arampatzis \& Brüggemann 2006, JOB)}\)

Applied Studies:
• men vs. women  
  \(\text{(Schade, Arampatzis, Brüggemann \& Komi 2004, JSpSci)}\)
• Influence of pole plant time on performance  
  \(\text{(Schade \& Arampatzis 2012, JOB)}\)
Influence of energy models

![Graph showing energy vs. time with annotations]

- similar time histories
- no differences in 2D vs. 3D
- differences in $E_{CM}$ vs. $E_{total}$

(Schade et al. 2000)
Interaction Model

(nach Arampatzis et al. 2004)
Reproducibility of Energy Parameters

(Schade et al. 2006)
Reproducibility of Energy Parameters

Intraclass Correlation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Correlation</th>
<th>Mean RMS [%]</th>
<th>Mean (sd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egain-net [J/kg]</td>
<td>0.6</td>
<td>17</td>
<td>7 (1.9)</td>
</tr>
<tr>
<td>Crit2 [J/kg]</td>
<td>0.9</td>
<td>46</td>
<td>2.5 (1.4)</td>
</tr>
<tr>
<td>Crit1 [J/kg]</td>
<td>0.9</td>
<td>15</td>
<td>6 (1.7)</td>
</tr>
<tr>
<td>E-final [J/kg]</td>
<td>0.9</td>
<td>2</td>
<td>50 (4.5)</td>
</tr>
<tr>
<td>E-initial [J/kg]</td>
<td>0.9</td>
<td>2</td>
<td>43 (3.9)</td>
</tr>
</tbody>
</table>

Interaction

Initial and final conditions

(Schade et al. 2006)
mean energy
- Athlet -

\[ \text{CM}_{\text{max}} : 5,80 \text{m} \ (0,12) \]

\begin{align*}
\text{men} & : 5,88 \pm 1,02 \\
\text{women} & : 5,74 \pm 1,63
\end{align*}

\text{(Schade et al. 2004)}
Mean angular momentum

female vaulters: different interaction
• less energy transfer
• less pole bend
• passiv swing
• less muscular work

explanations:
  a) strength
  b) technical skills

(Schade et al. 2004)
Interaction Model II
- jump and plant complex (JPC) -

(Schade & Arampatzis, 2012)
Interaction Model II
- jump and plant complex (JPC) -

(Schade & Arampatzis, 2012)
relation of pole energy and T-PP

\[ r^2 = 0.760 \quad p < 0.00 \]

early pole plant:
higher pole energy as a result of decrease in athlete’s energy

relation of athlete’s energy and T-PP

\[ r^2 = 0.618 \quad p < 0.00 \]

no benefit

(Schade & Arampatzis 2012)
The energy loss of the vaulter/pole system is not influenced by T-PP, decreasing energy loss during jump action.

(Schade & Arampatzis 2012)
Interaction Modell

1. 2D-KSP \(\approx\) 3D-TOT
2. Interaction is reproducible
3. different interaction men vs. women
4. no direct influence of T-PP on energy level at TO

Practical derivations:

Training/diagnostics

- 2D-CM energy considerations are mostly sufficient
- one trial for analysing intervention influences
- spend less time on T-PP
- reduce energy loss during jump
- increase work in first pole phase
- increase specific strength, especially women
Applied Diagnostics
Applied Diagnostics
Interaction Modell
- transfer of knowledge -

(Schade, 2004)
Systemic Approach
- combination of diagnostics and intervention -

biology based functions and processes

ATHLETE
Generation X
Generation „WHY“ etc.

competence
COMMUNICATION
confidence, respect

psychology based functions and processes

soziology based functions and processes

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