Kinematic Analysis the Champion of Wangshizhu in Hammer Throwing 2015
Peng LI and Ji-he ZHOU
Chengdu sports university Chengdu, China 610041

Objective
The purpose of this study mainly has two aspects: one is the throwing technique of Chinese hammer throwers Wangshizhu's comprehensive three-dimensional kinematics quantitative analysis, the relevant parameters and technical parameters of domestic and foreign elite athletes Wangshizhu hammer athletes compared to study general rule of cable and push the development of hammer technology; two is through special technology the diagnosis of China Wangshizhu hammer technology, improve the scientific level of training and scientific and technological content, strengthen technological innovation, the pursuit of the best training effect.

Methods
Method: 1. through literature retrieval system access to the Internet, Chinese academic journal net, superstar digital library, the relevant research literature at home and abroad, hammer technology retrieval, a comprehensive understanding of the research status of hammer technology, which can determine the research content and method. Three-dimensional video analytic method: using two JVC cameras (50 frames/sec) for 3D shooting in the game of Wangshizhu in action. Using high titanium - D signal 3 star Tec v1.0c 3D video software system analysis, analysis is taken by a dot resolution. With the human model selection is Japan's Hideki Matsui (16 links, 22 joint parameters). The data obtained using the low-pass digital filtering method for smoothing, cut-off frequency is 8 Hz, and the related kinematics indexes obtained are analyzed.

Subjects
According to opening—Men's hammer throw competition in Chengdu 2015, then choosing the best score to analysis.

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>Height(cm)</th>
<th>Weight(kg)</th>
<th>Rank</th>
<th>Level</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wangshizhu</td>
<td>26</td>
<td>185</td>
<td>90</td>
<td>1</td>
<td>Master</td>
<td>72.65</td>
</tr>
</tbody>
</table>

Results and Analysis Index

Division and Throwing Technique with Phase
This article will be three stages: the pre-swing, rotation, and finally forced.

The pre-swing (or a 0): Pre pendulum started out as a preliminary pose zipper ball to hammer the specific trajectory along with high and low points around the human body is circular motion (most athletes are using two weeks in advance of the pendulum). in the two weeks of advance of the ball is uniformly accelerated motion, and generally placed in the second week pre run incline Angle is smaller, the speed is faster, the magnitude and the tension increases.

Second, Rotation: Rotation is key hammer throwing technique. The stage of rotating is to run from the end of the pre-swing right foot to the lowest point of the hammer trajectory the fourth ground time. Specific rotation stage can be divided into nine phases.

Phase division:
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Phase division:

\[ t_0: \text{Before the hammer throwing to the lowest.} \]
\[ t_1: \text{Right foot at the first time off the ground.} \]
\[ t_2: \text{After the first rotation of the right foot touch the ground.} \]
\[ t_3: \text{Right foot at second time off the ground.} \]
\[ t_4: \text{Right foot at the second time landing.} \]
\[ t_5: \text{Right foot at the third time off the ground.} \]
\[ t_6: \text{Right foot at the third time landing.} \]
\[ t_7: \text{Right foot at the fourth time off the ground.} \]
\[ t_8: \text{Right foot at the fourth time landing.} \]

Action is divided into four laps:

\[ T_1 (\text{the first rotating lap}): \text{From the right foot for the first time off ground to the time landing.} \]
\[ T_2 (\text{the second rotating lap}): \text{From the right foot for the second time landing to the time ground.} \]
\[ T_3 (\text{the third rotating lap}): \text{From the right foot for the second time to the third time landing.} \]
\[ T_4 (\text{the fourth rotating lap}): \text{From the right foot for the third time to the fourth time off ground.} \]

The finally force (represented by R): The last stage is very important stage for the hammer throwing a complete technology, its main purpose is to further accelerate the hammer, hammer in hand while the time to maintain the best running condition. In this stage, the human body the more hard working distance is long the force acting on the hammer will be the more; Rotation leads to the hammer throw to the faster speed is more quickly. The division of the last stage from the last rotation lap running track hammer shot to the highest point time.

He last stage is divided into three ratios:

\[ R_1: \text{Right foot at the end of the last lap rotation off ground.} \]
\[ R_2: \text{The lowest point of the last lap hammer rotation track.} \]
\[ R_3: \text{The hammer throwing moment.} \]

### Kinematic Analysis of Pre-throwing Technique Swing Stage

Analysis of throwing technique in the preliminary phase at the process of the set time

<table>
<thead>
<tr>
<th>Name</th>
<th>Time(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wangshizhu</td>
<td>2.13s</td>
</tr>
</tbody>
</table>

The pre-swing is the preparation stage to enter the rotary stage. From table 2 shows that Wangshizhu pre-swing time is 2.13s, the pre swing phase with a longer time, resulting in the pre-swing speed is too slow increase of the rotating load.

Analysis the speed of the hammer throwing in Pre-swing

<table>
<thead>
<tr>
<th>Name</th>
<th>(O)</th>
<th>(T_1)</th>
<th>(T_2)</th>
<th>(T_3)</th>
<th>(T_4)</th>
<th>(R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wangshizhu</td>
<td>15.20</td>
<td>16.71</td>
<td>18.89</td>
<td>21.37</td>
<td>22.60</td>
<td>24.77</td>
</tr>
</tbody>
</table>

From table 3 shows that in throwing technique in different stages of the pre-swing phase of the maximum velocity increment, Wangshizhu hammer pre-swing phase speed 15.20m/s, however, Xiedihe to create a world record in the pre-swing phase velocity is 17.60m /s [1], that he won the larger ball placed in the pre-stage, it is very important to improve the performance of the final play
a role. The pre-swing phase velocity increment for the hammer last shot the initial velocity of about 50%, a reasonable pre-swing speed will make the subsequent rotation rhythm more compact, which is conducive to the successful completion of the action [2], Wangshizhu accounted for 38.6%, compared with the world elite athletes is poor.

The Kinematics Analysis of the Rotating Stage in the Throwing Technique

Analysis characteristics on the time of the rotating stage

<table>
<thead>
<tr>
<th>Name</th>
<th>T_1</th>
<th>T_2</th>
<th>T_3</th>
<th>T_4</th>
<th>T_total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wangshizhu</td>
<td>0.56</td>
<td>0.54</td>
<td>0.49</td>
<td>0.46</td>
<td>2.05</td>
</tr>
<tr>
<td>Litvin Ivanov</td>
<td>0.44</td>
<td>0.60</td>
<td>0.44</td>
<td>0.43</td>
<td>1.91</td>
</tr>
</tbody>
</table>

The hammer throwing technique has high speed, fast rhythm. The increase of rotational speed of each stage of technical action hammer throwing speed and ultimately play a decisive role [3], in order to improve the performance, we need to master the essentials, rhythm must be fast, try to shorten the rotation time. Athletes should take the initiative in the rotating speed, and the rotation time each circle gradually shortened. From table 4 shows that Wangshizhu and Litvin Ivanov are using four rotation technology, rotating time of Chinese athletes in the whole rotation significantly longer than the foreign elite athletes, the time of Wangshizhu is more than Litvin Ivanov 0.14s, there are obvious differences. The rotational displacement of the movement, the longer the relative speed will be slower, obviously Wangshizhu finally throwing a primary first speed low because it is too long. The time of rotating time parameters on China's elite athletes Wangshizhu and world elite male hammer thrower Litvin Ivanov of comparison, each rotation of the short time Litvin Ivanov, so he threw the hammer can get high speed, Wangshizhu should be efforts to shorten the rotating time, increasing the rotation stage of motion coherence and rotational speed. The Litvin Ivanov each rotation of the time controls in about 0.45s, his rotation speed is faster, each circle action rhythm more coherent, which is the key to throw more distant. Wangshizhu needs to focus on training in coherence and speed rotation of the rotating stage rhythm.

Analysis single, double-support of rotating stage

<table>
<thead>
<tr>
<th>Player</th>
<th>T_1 single</th>
<th>T_1 double</th>
<th>T_2 single</th>
<th>T_2 double</th>
<th>T_3 single</th>
<th>T_3 double</th>
<th>T_4 single</th>
<th>T_4 double</th>
<th>T_total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wangshizhu</td>
<td>0.25</td>
<td>0.31</td>
<td>0.32</td>
<td>0.26</td>
<td>0.29</td>
<td>0.21</td>
<td>0.25</td>
<td>0.21</td>
<td>2.10</td>
</tr>
<tr>
<td>Litvin Ivanov</td>
<td>0.20</td>
<td>0.24</td>
<td>0.21</td>
<td>0.26</td>
<td>0.21</td>
<td>0.22</td>
<td>-</td>
<td>-</td>
<td>1.61</td>
</tr>
</tbody>
</table>

Note: Data analysis from throwing technical characteristics of Russian throwers. Single represents the single support phase, Double representatives of the double support phase.

Hammer rotating technology principle confirmed that rotates double support phase is the main accelerating stage, hammer single support phase is run hammer inertia and obtain a reasonable body reverse phase [4]. In order to obtain a continuous acceleration hammer motion in a rotary stage, athletes should as far as possible to increase the working distance between support feet, feet support time should also be more than one foot long time [5] - [6]. Therefore, in the rotation stage of a reasonable single, double support time ratio is particularly important, the rotation stage of the single, double support time than the 1:1 or double support time is slightly larger than the single support time is appropriate [7]. From table 5, we can see that there is also a big gap with Wangshizhu's single, double support time ratio of 1:0.81 than the theoretical 1:1. His feet, total time percentage were 52.85%, 47.15%, and Xiedihe were 46.27%, 53.73%, Wangshizhu 6.58 percentage points is below Xiedihe. During rotation of the single, double support time allocation is unreasonable; the hammer speed growth time is short. Xiedihe in the rotation process not only has the shortest total time of rotation, and the feet support time is always greater than the single support time, accounting for 53.73% of the total time of rotation, so that the maximum acceleration time in the rotation of the hammer applied.
The Kinematics Analysis of the Last Stage of Throwing Technique

Analysis of operation time in each phase of the final stage

Table 6 shows that in the final stage in three periods of time, changing as follows: from R1 to R2 by the time of 0.16s, from R2 to R3 by the time of 0.17s, R1 to R3 by the time of 0.33s, R1 - R2 and R2 - R3 by the time the time compared to the time gradually incremental theory, speed, time can be shortened to reduce, in the final stage of three periods in the speed change significantly. The world record holder Xiedihe last time was 0.27s [1], Wang Shizhu 0.33s, and the time has a large gap. Wangshizhu should be forced to shorten the time to get better final results.

Table 6. The last phase in each phase of the running time of the hammer (s).

<table>
<thead>
<tr>
<th>Player</th>
<th>The running time of the shot R1—R2</th>
<th>R2—R3</th>
<th>R1—R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wangshizhu</td>
<td>0.16</td>
<td>0.17</td>
<td>0.33</td>
</tr>
</tbody>
</table>

Analysis of velocity change of each phase in the final force phase

Table 7. Analysis of velocity change of each phase in the final force phase (m/s).

<table>
<thead>
<tr>
<th>Player</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>Velocity increment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R1—R2</td>
</tr>
<tr>
<td>Wangshizhu</td>
<td>22.12</td>
<td>22.78</td>
<td>23.86</td>
<td>2.9%</td>
</tr>
</tbody>
</table>

The data in Table 7, the first hammer in phase velocity analysis of the final stage, in the final stage in the first period of hammer speed is 22.12m/s, in the second period of 22.78m/s, in the third period of 23.86m/s, in the final stage, each time the speed change hammer shows increasing trend, from the rotation, the speed of data displayed on the hammer has a gradually increasing trend. With the increasing of the rotation of the body force, the hammer speed is gradually constant, which is consistent with the development trend of the world's hammer throw. The first Wangshizhu speed of 23.86m/s, but Xiedihe and the overseas elite athletes last shot speed of 30.7 m /s [8], the biggest gap reached 6.84M/s, which indicates that the shot speed of Chinese male hammer throwers and foreign elite athletes have a large gap, so in the future training, the last shot of the speed of the ability to enhance the need to continue to improve. The changes in each period the hammer speed. Hammer speed increase can be divided into two processes: the first process is from the right moment to process hammer movement lows: the second process from the lowest point to hand hammer movement moment. The overall trend of performance in two processes, for the first time is from the first period to the second velocity increment (R1 - R2) is 2.9%, the second process from the second phase to the third phase velocity increment (R2, R3) is 4.7%. Wangshizhu from the first phase to the third phase velocity increment (R1, R3) is 7.3%. But at the end of stage should pay attention to speed up the R1 -R2, R3 - R3 level, to improve the final hand speed, thus improve the performance.

Conclusion

The pre-swing phase: Wangshizhu pre -swing time is 2.13s, and Xiedihe is 1.06s, the pre -swing stage Wangshizhu with a longer time. The pre-swing speed of Wangshizhu is15.20m/s, compared with the excellent athletes in the world, there is still a gap

Revolving stage: Wangshizhu rotation time is 2.05s and Litvin Ivanov is 1.91s, the time of Wangshizhu is more 0.14s than Litvin Ivanov, there are obvious differences. Wang Shizhu needs to focus on training in the rotation of the rhythm and the high speed of rotation. There is also a big gap with Wangshizhu's single, double support time ratio of 1:0.81 than the theoretical 1:1.

Finally forcibly phase: The final stage in three periods of time, changing as follows: from R1 to R2 by the time of 0.16s, from R2 to R3 by the time of 0.17s, R1 to R3 by the time of 0.33s, R1 - R2 and R2 - R3 by the time compared to the time gradually incremental theory, speed, time can be shortened to reduce, in the final stage of three periods in the speed change significantly. The world record holder Xiedihe last time was 0.27 s[1], Wang Shizhu 0.33s, and the time has a large gap. Wangshizhu should be forced to shorten the time to get better final results.
**Recommendation**

We should strengthen our hammer throwing to increase the pre-swing phase speed, strength and power development speed of effective training methods and means to make full development of physical fitness of athletes.  

Training May be extended appropriately feet support, emphasizing the double-support phases in the rotating acceleration pressure, reducing the single leg support phase of hammer velocity loss  

In training, in order to increase the rotation of the knee kicking speed and power, force to the shorten time to do better acceleration rotation, increasing in the hammer throwing final exertion rate.

**References**


