Kinematical Comparison Analysis on the Discus Athletes Throwing Techniques Based on Data Project

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Abstract: In the discus final site of throwing event series game of China’s track and field sport in April, 2015, three dimensional camera analytical method which is an application of kinematical data project was used on female discus athletes’ discus throwing technology. And analysis was made for the top four discus throwers’ last exertion action, related kinematics parameter was thus obtained. Analysis results show that: first, Lu Xiaoxin behaves better in body twist tight effect when it is left foot on the ground and in capacity of beyond devices, followed by Su Xinyue and Tan Jian, with Feng Bin relatively weaker; second, our athletes’ discus shots speed is to be upgraded compared with world excellent female discus athletes; third, discus is left slightly earlier, with Tan Jian throwing in a reasonable angle, Feng Bin, Lu Xiaoxin in a larger angle, and Sue Xinyue in a smaller angle. Feng bin has a higher height of release, followed by Lu Xiaoxin and Tan jian.

1. Introduction
In recent years, China has seen a number of female discus athletes attracting the attention of the world. However, we still have a far cry from world elite discus throwers in the throwing techniques. In this paper, with the method of three-dimensional camera techniques in female discus throwers and the resolution for the last exertion movement video of top four athletes, kinematics parameters of four female discus throwers in the game are obtained. That means we can summarize movement characteristics and shortcomings of each person through comparative analysis in a way to throw a light on theoretical basis and technical reference for the improvement of the Chinese women's discus throwing techniques.

2. Subjects and Methods

2.1. Subjects
The subjects in this study were top four female discus throwers in the discus final of throwing event series game of China’s track and field sport in April, 2015. According to the scores, the top four were Lu Xiaoxin, Tan Jian, Su Xinyue, and Feng Bin (Lu, Tan, Su, Feng for short). We will introduce some basic information about these four athletes in Table 1.

Table 1. Subject Information and Trials Used for Analysis
2.2. Methods
Three dimensional camera analytical method was mainly used. In the discus final of throwing event series game of China’s track and field sport in April, 2015, three dimensional fixed-point high speed cameras were used to record the movement of the top four female discus throwers. Two JVC GC-PX10AC cameras were placed on the rear and right side around the discus circle with an approximately 90° angle at a shooting frequency of 50Hz. SignaltEC3D video analysis software was applied to parse the video and Matsui Xiuji model of human body (21 points, 16 links) was selected for experimental use. Original data was handled through low-pass filter smoothly, at a cut-off frequency of 8Hz.

3. Results and Analysis
Last exertion stage of throwing discus is the movement process from the time when discus throwers’ left foot is on the ground to the moments of discus shots. Therefore, the last exertion stage has a decisive role on discus results[1], which is targeted on back-to-back rotating action. The last exertion technique makes full use of rotating momentum and favorable release posture, thus exerting all the body strength to the discus through the arm and hand throwing. As a result, maximum release speed and optimum angle of release can be obtained, reaching the best effect of throwing and getting excellent results[2].

3.1. Time analysis on the last exertion stage
We can know from Table 2 that the time used in the last exertion stage for Lu, Tan, Su, Feng is 0.18 second, 0.12 second, 0.14 second, and 0.24 second respectively. While the time for world elite female discus throwers is between 0.1 and 0.2 second[3], we can see that three of our athletes have a reasonable time control except Feng with longer time.

Table 2. Time Used in the the Last Exertion Stage

| Name     | Lu Xiaoxin | Tan Jian | Su Xinyue | Feng Bin | World elite Female Discus Throwers |
|----------|------------|----------|-----------|----------|-----------------------------------|
| Time (s) | 0.18       | 0.12     | 0.14      | 0.24     | 0.1-0.2                           |

3.2. Analysis of kinematic parameters on the moment of left foot on the ground
From Table 3, on the moment of left foot on the ground, the pull angle of Lu, Tan, Su and Feng is respectively 121.8 °, 129.0°, 125.0 °, and 142.1 °. These data indicate that Lu keeps a stronger capacity in beyond devices when it is the moment of left foot on the ground and has a better control in
keeping the discus behind compared with the three others, with Su and Tan followed, and Feng the weakest.

From Table 3, on the moment of left foot on the ground, the shoulder-hip angle of Lu, Tan, Su, and Feng is 65.3°, 60.2°, 61.6°, 50.4° respectively. We can conclude from the data of shoulder-hip angle that among four athletes, Lu has a better torso twist pose and a posture of hip well beyond the shoulder, followed by Su and Tan, with Feng the worst.

Speed difference of discus release between the left and right shoulder can be considered as an evaluation index for the discus speed kept to a certain degree in the last exertion stage. From Table 3, speed difference of discus release between the left and right shoulder of four athletes is respectively 3.27m/s, 2.42m/s, 2.52m/s, and 2.07m/s. Lu has a larger shoulder speed difference compared with the three others, which indicates Lu has a larger range of opening among chest, shoulder and arms, and stronger capacity in beyond devices, followed by Su and Tan. Feng has a relatively smaller range of opening among chest, shoulder and arms, and weaker capacity in beyond devices, thus effecting the last exertion.

Table 3. Kinematics Parameter on the Moment of Left Foot on the Ground

| Name       | Lu Xiaoxin | Tan Jian | Su Xinyue | Feng Bin |
|------------|------------|----------|------------|----------|
| Shoulder-Hip Angle (°) | 65.3       | 60.2     | 61.6       | 50.4     |
| Pull Angle (°)       | 121.8      | 129.0    | 125.0      | 142.1    |
| Shoulder Speed Difference (m/s) | 3.27       | 2.42     | 2.52       | 2.07     |

3.3. Analysis on the speed of discus release
The speed, angle and height of discus release is key factors influencing the throwing distance. The study has showed that only the speed of release is the most significant among three factors. We can know from Table 4 that the speed of four athletes is 23.65m/s, 23.09m/s, 23.24m/s, 22.57m/s in comparison to 25m/s of world counterparts, which means improvement for our discus throwing speed. Of four throwers, Feng performs the slowest in the speed of discus release in dire need of strengthening special training.

Table 4. Kinematics Parameter on the Moment of Discus Release

| Name       | Lu Xiaoxin | Tan Jian | Su Xinyue | Feng Bin | World elite Female Discus Throwers |
|------------|------------|----------|------------|----------|-----------------------------------|
| Speed of Release (m/s) | 23.65       | 23.09    | 23.24      | 22.57    | About 25                         |

3.4. Analysis on the relevant angle of discus release
From the Table 5, the angle of release for four discus throwers is 41.2°, 36.4°, 32.8°, and 41.7° respectively. From some documents, we can know that the reasonable range of release angle for female discus throwers is between 35° and 40°. Among four, Tan behaves best with a reasonable release angle, while Feng and Lu behave with a larger angle and Su with a smaller angle.

In the last exertion process, shoulder-hip angle should gradually decrease, and pull angle should gradually increase, thus the stored energy in the chest, shoulders and arms can be released, at the same time, the right foot should actively pedal with the left foot forming the stable support on the left, enabling the shoulder axis to rapidly surpass the hip axis, which will lead the rapid throwing of
discus[3]. We can know from Table 5 that the shoulder-hip angle of Lu, Tan, Su, and Feng in the moment of discus shot is respectively 18.1°, 18.5°, 17.5°, and 10.4°, which shows the right shoulders of four athletes all fall behind their right hips in the moment of discus shot. However, the most optimum shoulder-hip angle is about 0° according to some related literature[4]. Therefore we can see that Feng has a larger force range, with Lu, Su, and Tan relatively weaker. Once the last exertion range is smaller, the force produced by body twist fails to fully pass to the discus. Pull angle of discus release for four female throwers is 167.5°, 163.3°, 170.0°, and 170.9° respectively. That means that four players fail to fully unleash the elastic potential energy reserved in their shoulders, hips and arms in a result of throwing the discus slightly earlier.

### Table 5. Parameter on the Relevant Angle of Discus Release

| Name           | Lu Xiaoxin | Tan Jian | Su Xinyue | Feng Bin |
|----------------|------------|----------|-----------|----------|
| Shoulder-Hip Angle (°) | 18.1       | 18.5     | 17.5      | 10.4     |
| Pull Angle (°)          | 167.5      | 163.3    | 170.0     | 170.9    |
| Angle of Release (°)    | 41.2       | 36.4     | 32.8      | 41.7     |

3.5. Analysis on the height of discus release

The height of discus release is closely associated with technique characteristics and the height of athletes[5]. From the Table 1, the height of four discus throwers is 1.77m, 1.75m, 1.78m, 1.81m. From the Table 6, the height of discus release of four female throwers is 1.607m, 1.561m, 1.674m, 1.712m respectively. The gravity height on the moment of discus release is 1.090m, 0.995m, 1.030m, 1.130m respectively. Through the comparison analysis of data above, we know that Feng and Su have a higher release, followed by Lu, with Tan the lowest.

### Table 6. Kinematics Parameter on the Moment of Discus Release

| Name           | Lu Xiaoxin | Tan Jian | Su Xinyue | Feng Bin |
|----------------|------------|----------|-----------|----------|
| Height of Release (m) | 1.607      | 1.561    | 1.674     | 1.712    |
| Gravity Height (m)    | 1.090      | 0.995    | 1.030     | 1.130    |

4. Conclusions

We can draw the following conclusions from the kinematical comparison analysis on the discus athletes’ last exertion techniques based on data project.

4.1. The final force phase is used to conclude

Feng uses a larger time of 0.24s in the last exertion stage with the three others relatively reasonable in the time control.

4.2. Left-footed momentary kinematic conclusion

According to the data of pull angle of four athletes on the moment of left foot on the ground, Lu keeps a stronger capacity in beyond devices at a pull angle of 121.8° and has a better control in keeping the discus behind compared with the three others, with Su and Tan followed, and Feng the weakest. According to the data of shoulder-hip angle, Lu has a better torso twist pose and a posture of hip well
beyond the shoulder at a shoulder-hip angle of 65.3°, followed by Su and Tan, with Feng the worst. According to the shoulder speed difference, Lu has a larger range of opening among chest, shoulder and arms at a speed difference of 3.27m/s, and stronger capacity in beyond devices, followed by Su and Tan. Feng has a relatively smaller range of opening among chest, shoulder and arms, and weaker capacity in beyond devices, thus effecting the last exertion.

4.3. Discus shot speed conclusion
Lu and Su have a relatively faster speed of discus release at 23.65m/s and 23.24m/s respectively. However, improvement is still needed compared with world elite female discus throwers. Of four throwers, Feng performs the slowest in the speed of discus release of 22.57m/s in dire need of strengthening special training.

4.4. The conclusion from the Angle of the discus
Tan behaves best with a reasonable release angle of 36.4°, while Feng and Lu behave with a larger angle. If Su increases her release angle better results can be scored. The data of pull angle show that four players fail to fully unleash the elastic potential energy reserved in their shoulders, hips and arms in a result of throwing the discus slightly earlier.

4.5. Discus shot a high degree of conclusion
The comparison of data about release height show that Feng and Su have a higher release, followed by Lu, with Tan the lowest.

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