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KINEMATIC ANALYSIS OF LI YA SALTO CONNECTING STRADDLED JAEGER SALTO ON THE UNEVEN BARS

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He Kexin, called the “UB princess”, is the only individual event grand slam winner on uneven bars of the Chinese Women's Gymnastics Team. Her special skill “Straddled Jaeger Salto with a 1/2 Turn to re-grasp HB (also called Li Ya Salto) connecting the Straddled Jaeger Salto” was videotaped and 3-D analyzed. The conclusive kinematic characteristics of this high skilled element can provide useful information for the technical training of coaches and athletes, and enrich gymnastic theories.

KEY WORDS: 3-D photographic analysis, Kexin He, Li Ya Salto, straddled Jaeger salto, kinematics

INTRODUCTION: In 2012, as of the Final of the uneven bars in Chinese Gymnastics Championships, Kexin He perfectly performed a set of movement reached 7.2 degree of difficulty, in which the movement of Li Ya salto connecting straddled Jaeger salto（shown in figure 1） was extraordinarily splendid. The Flight connection of E plus D used in this movement, which has high coefficient of action and high quality of accomplishment, made a indispensable contribution to the champion He achieved. After looking up the literature, for now, there were few papers about the Straddled Jaeger Salto (Chen Li, 2007), while the whole connecting movement has not been analyzed yet. Due to the feature of motion continuity of gymnastics, it is very important to discuss the connection between the movements. Therefore, with kinematics analysis of this element performed by Kexin He, the individual event grand slam athlete, this study can reveal the kinematic characteristics of Li Ya salto connecting straddled Jaeger salto, and provide a reference for the technical training of coaches and athletes.

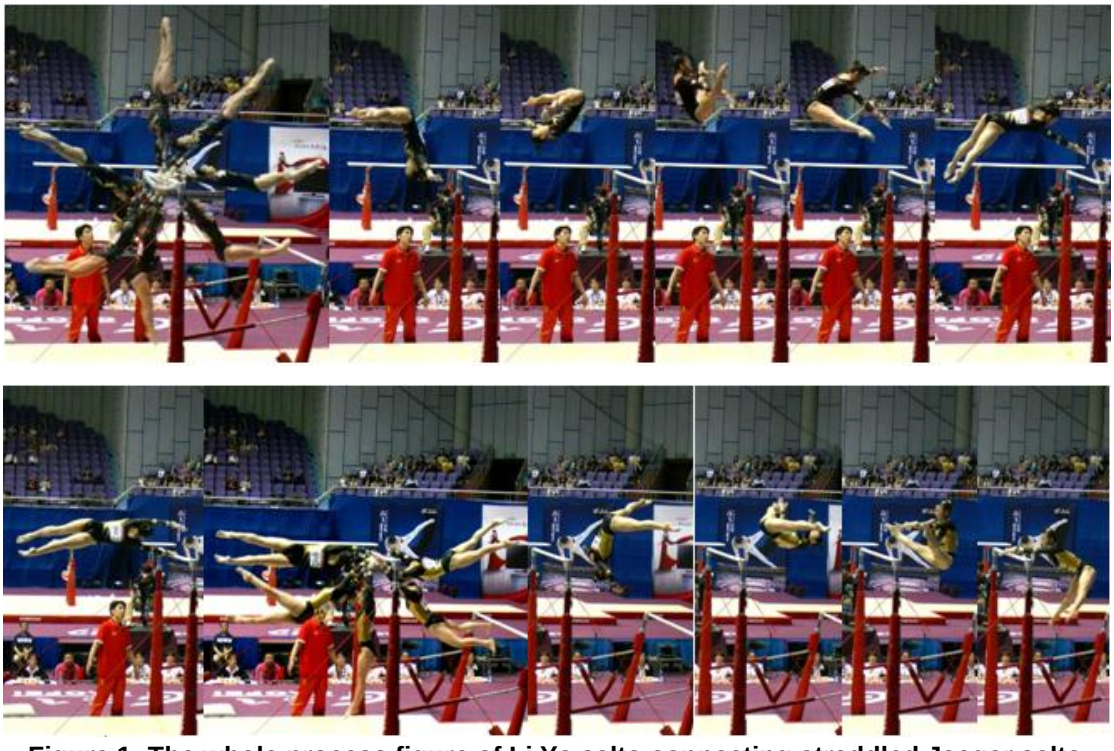

Figure 1: The whole process figure of Li Ya salto connecting straddled Jaeger salto

METHODS: In 2012, as of the Final of the uneven bars in Chinese Gymnastics Championships, the whole process of the competition was recorded by two GC-PX10 video cameras (JVC, Japan) at 50 Hz from different angles (the included angle of the principal optic axes of two cameras was about 130 °). The video of Li Ya salto connecting straddled Jaeger salto was analyzed by 3-D Signal Tec system, which is a manual digitisation system. The original data was smoothed by low-pass filter with a cutoff frequency of 6 Hz.

RESULTS AND DISCUSSIONS: In order to analyze efficiently, the element was divided into 4 phases, namely 1) the swing backward stage, 2) the flight stage, 3) the swing stage and 4) the second flight stage.

Swing backward: This phase is the process from the reverse handstand moment to the moment when hands release the bar.

When He started to downswing，the vertical distance between CG and the bar surface was 0.900 m, the shoulder joint angle and hip joint angle were 166.6°and 172.9° respectively. When the centre of mass was at the level of the bar, body's CG reaches the maximum horizontal distance from the bar axis. In the present study, this distance was 1.080m. In the meantime, the shoulder angle and hip angle were 174.2°and 160.5° respectively. In this body position, the angular momentum of the body also reached the highest value, which would benefit the performance of the movements to follow.

During the downswing, when the body reaches close to the vertical plane under the bar, the bar will be deformed due to the application of body weight. The recoil force generated by the recovery of the deformed bar would benefit to the completion of upswing movements. In this study, among other changes of body posture, the reduction of the hip angle was most obviously, reaching 136.5°. The velocity of CG was 5.52 m/s, reaching its maximum value. The Horizontal component was 5.44 m/s and played leading role in the increase of the total velocity. The time spent in downswing from the reverse handstand position to the position on the vertical plane below the bar was 1.04s.

After the downswing, when the body passed the vertical plane below the bar, the velocity of the feet rapidly increased, attaining 12.90m/s. The hip angle was gradually increased and when the body arrived at the horizontal position behind the bar, hip angle attained 208.3°. The body was in an inverse bow posture. Technically, during the legs accelerated upswing, the shoulder joint should be well controlled to avoid raising both the shoulder and head. Failing to do this will diminish the speed of the legs. In this phase, the velocity of shoulder was low, only 2.58m/s.

When the body continued to upswing, the shoulder angle remained almost at the same value, while the hip angle was gradually decreased. Before release, He's legs braked, which resulted in feet velocity decreased to 3.87m/s. At the same time, the moment of momentum of legs transmitted to that of the upper body, which resulted in velocity of shoulder started to increase. When hands release the bar, the value of 3.09m/s was achieved. This explains technique that during feet brake, the arms were pressing the bar. At the moment of release, the shoulder angle was 206.4° while the hip angle was decreased to 146.8°. At the same time, the CG of the body was 0.830m apart from bar in the horizontal direction and 0.150m higher than the bar, forming an angle of 10.2° with the bar horizontal level.

Flight: The flight phase is the motor process from hands release the bar to hands mixed re-grasped the bar after forward straddled salto in the air.

After releasing the bar, during uprising, the hips rapidly flexed, the legs braked, and the trunk was bent forward. During this process, the hip angle was considerably decreased and reached the minimum value of 56.8°. When CG arrived at the highest point, the horizontal of CG dropped to minimum values which were -0.02m/s. As CG achieved the highest point, the body has already turned for more than 3/4 circle. At this position, the upper body was almost vertically straight with slightly forward inclination. The vertical distance between the highest point of CG and the bar was 0.906m. After CG arose to the highest point of the parabola, the body began to fall due to gravity. Since the horizontal velocity was as slow as 0.02m/s, the

falling trajectory of CG was almost vertical with a slight forward arc. This characteristics of CG movement provided good condition for athlete to catch the bar. He's hands grabbed the bar at different time with the right hand first. As the right hand touched the bar, the position of the body is lower with the perpendicular distance between the CG and the bar being 0.225m and horizontal distance 0.892m. Compared with the highest position, when the hand caught the bar, the CG dropped for 0.681m. However, if compared with the position of CG at release, the CG at the time the hand caught the bar was 0.080m higher and moved forward for 0.067m, showing almost the same vertical and horizontal distance from the bar. This was attributed to the parabolic path of the CG that was almost vertically rising up and vertically dropping after achieving the highest position. This also reflected that He had perfect position and timing of release and re-grasp of the bar, which was one of the most important key techniques to successfully accomplish this skill. As the left, also the second, hand touched the bar, the CG was only 0.002m higher the bar, demonstrating the same level of the CG and the bar. After accomplishing the salto, He began to prepare the twist. The hip angle considerably enlarged, the body stretched, and both legs put together. When He's first hand touched the bar, the left and right shoulder angles were 166.3° and 169.0° respectively, and the left and right hip angles were 159.0° and 172.8°. These figures reflected the facts that in order to accomplish the twist, the athlete twisted the body, resulted in different amount of hip angles. While the velocity of the CG was quite large (3.84m/s), both legs hardly put together. When He's second hand touched the bar, the twist was completed for over 90°. The data showed that He had quite high flight height and, therefore, long flight time which was 0.78s.

Swing: The swing phase is the motor process from hands re-grasped the bar to hands release the bar again.

After the hands re-grasped the bar, when the CG of the body continued to swing to the vertical plane below the bar, where the 180° twist was completed, the body was basically straight. At the same time, the vertical distance between CG and the bar surface was 1.034m and the hip angle was 171.6°.

When the body passed the vertical plane below the bar, the hip angle and shoulder angle were gradually increased and when the hands released the bar second time, the hip angle and shoulder angle attained 208.4° and 215.3° respectively. The body was in an inverse bow posture. Before release, He's legs braked, which resulted in feet velocity decreased to 3.39m/s. At the moment of release, CG was 0.829m apart from bar in the horizontal direction and 0.062m lower than the bar, forming an angle of 4.3° with the bar horizontal level.

Second flight: The second flight phase is the motor process from hands release the bar to hands re-grasped the bar again.

Just like the first time, the parabolic path of the CG was almost vertically rising up. The hip angle reached the minimum value of 60.4°. When CG arrived at the highest point, the horizontal velocity of CG were -0.34m/s. As CG achieved the highest point, the body has already turned for about 1/2 circle. The vertical distance between the highest point of CG and the bar was 0.317m. As the second time the hands touched the bar, the position of the body was lower with the perpendicular distance between the CG and the bar being -0.271m and horizontal distance 0.717m. The hip angle and shoulder angle were 113.3° and 155.6°. Compared with the highest position, when the hand caught the bar, the CG dropped for 0.588m. However, if compared with the position of CG at release, the CG at the time the hand caught the bar was 0.209m lower and moved forward for 0.112m. It took 0.60s from releasing to re-grasping the bar again. Compared with the first flight, the second time had lower flight height and shorter flight time, because the swing distance of the circle was short and the initial velocity was slow.

CONCLUSION: This study provided kinematics movement model of Li Ya Salto connecting straddled Jaeger salto performed by Kexin He. In handstand position, the vertical distance of CG to the bar was 0.900m, and the shoulder and hip angles were 166.6°and 172.9° respectively. At the moment the CG moved to the lowest position, the hip angle was 136.5°

and the velocity of CG was 5.52 m/s, which was fast. When the CG reached the position horizontal to the bar, the hip angle was 208.3°. At the moment the hands released the bar, the hip angle was 146.8°, and the release angle of CG was 10.2°. As the CG arrived at the highest position during the first flight, the horizontal velocity of CG was 0.02m, and the CG was 0.906m higher than the bar. Due to the fact that He had completed the movement perfectly, she had reasonable position and timing of release and re-grasp of the bar. He gripped the bar with both hands in a sequence: right hand first followed by left hand. As the both hands caught the bar, 90° twist had been accomplished. The complete twist was accomplished when the CG arrived at the lowest position in its trajectory. Second time the hands released the bar, the hip angle was 208.4°, and the release angle of CG was 4.3°. As the CG arrived at the highest position during the second flight, the CG was 0.317m higher than the bar. As the second time the hands touched the bar, the perpendicular distance between the CG and the bar was -0.271m. The second flight had lower flight height and shorter flight time than the first one's.

The kinematics characteristics showed that Kexin He performed the Li Ya Salto connecting the Straddled Jaeger Salto well. Nevertheless, there were still some elements needed improvement, such as straddled a little bit early and both legs brought together a little bit later after straddled salto completed.

REFERENCES:

C. Li, X.W. Yao & Y.H. Wen, (2007).The Athletics Analysis on Li Ya's Reverse Suspense Straddle front Somersault to Re-grasp the Bar on Asymmetrical Bars, *Sport Science and Technology*, 02, 51-56.

X.W. Yao, Z.H. Yao & X.D. Wang, (2007). Kinematics Analysis of Actions of Upside Down-Salto Forward with Legs Together-Holding the Bar Again on Uneven Bars performed by Lin Li, *Journal of Beijing Sport University*, 12, 1707-1708, 1714.