KINEMATIC CHARACTERISTICS OF THE STEINEMANNSTEMME MOVE ON THE UNEVEN BAR: A CASE STUDY

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The purpose of this paper is to present a biomechanical analysis of an innovative technique on the uneven bar in international gymnastic competitions. Based on the motion trajectory of body's center of gravity, the angle variation diagram of shoulder and hip joints and the principle of Coriolis, the study has probed into some key techniques used in this routine. They are as follows: The first technique is from ordinary grip to back somersault and arm extension. Secondly, the technique of downswing to low vertical plane of the bar is examined, followed by that of the releasing grip in order; then the turn with bend and extension adjustment in flight and finally the balance of handstand on the lower bar. The proper technical method and its main points are provided here for reference of elite gymnasts, coaches and researchers.

KEY WORDS: rotation inertia, Coriolis force, turn power, strength balance

INTRODUCTION: The steinemannstemme movement, which includes a half turn on the upper bar to handstand on the lower bar, is relatively new in the sport of gymnastics. This move introduces an original interpretation of technique for uneven bar routines. As a difficult move to execute, it has a higher bonus point factor in international gymnastics and has been categorized as D+C (virtuosity and degree of difficulty). In competition, this move can be awarded 0.2 bonus points according to the rules of international women's gymnastics. From its structure, it can be seen that this move is an adapted and refined version of the exceedingly difficult movement in men's horizontal bar. Since the uneven bar is thicker than the horizontal bar and a woman's hands are smaller than those of a man and much strength is needed from the muscles of the shoulder and dorsum, it is a much more difficult move for women gymnasts to perform. As to its creativity, this movement is the first of its kind to be accomplished in the world and brings a new dimension to the technical realm of gymnastics. The significance of this innovative technique can be compared with the creation of moves such as "Tkatschev" and "Thomas" in the past. Meanwhile, as a result of knowledge obtained through biomechanical analysis of this technique, great changes will take place in women's gymnastics in the foreseeable future.

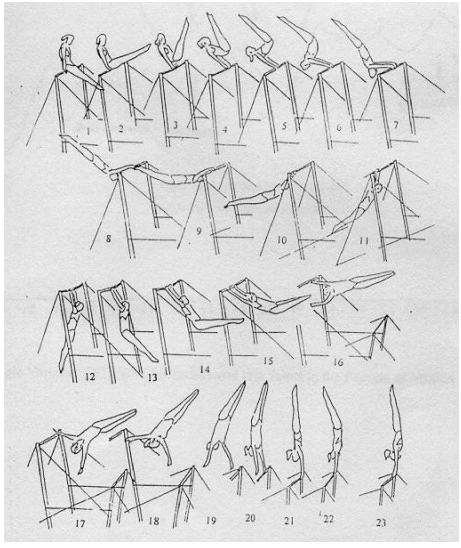

Figure 1 – The steinemannstemme with Harl Tum on the upper bar to handstand on the lower bar.

METHODS: This movement was performed with great precision by an American elite gymnast (A. Y.), in one of the 1997' intentional gymnastics matches (Fig 1). Her height and weight are 157cm and 42kg respectively.

The pictures were made after taking fixed-point scanning photos by a high-speed film camera, (Lanzhou, China). The frequency is 80F/s. The calculation was made with motion analyzer GP-2000 (Japan). The body rotation inertia and the movement mechanism were calculated and analyzed on the basis of the rules of theoretical mechanics.

RESULTS AND DISCUSSION: The first phase is from ordinary grip and back support on the upper bar

to back somersault and arms extension (1~9 in Fig.1). This process requires that both arms press the bar with exertion and the legs are raised high as abdomen contracts with shoulder, downward and backward 42.5° (4~5 in Fig.1). During this phase, the body has much potential energy and the peak of the center of body weight is 0.37m high on the surface of the bar (Fig.2.5). Then, the body exerts sufficient force to extend backward with much extension of shoulder and hip joint. At this point, the longest distance between the center of body weight from the bar is 0.919m (Fig.2.9) and the moment of gravity was 39.05kgm.

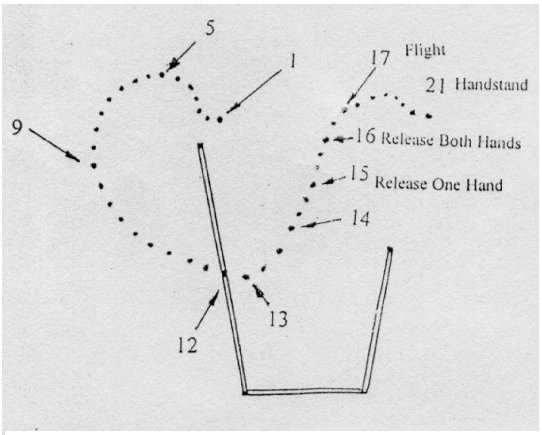

Figure 2 – Movement path of the center of body weight.

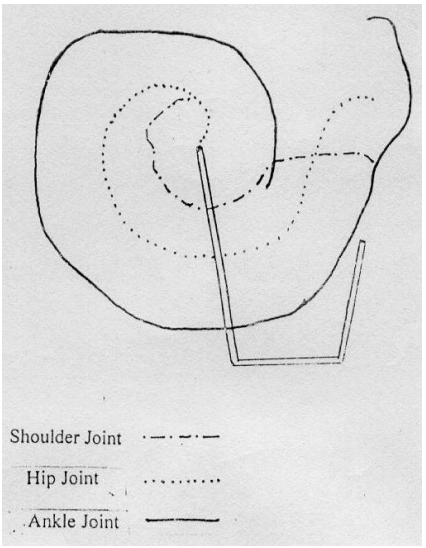

Figure 3 – Movement path of body joints.

In this move, the action of contracting abdomen and elevation of the leg in rear support is a serious concern. In order to produce a sufficiently powerful bend from the hip, the hip joint should be extended in rear support and the abdominal muscles should be fully extended. This produces rapid leg elevation with contraction of the abdomen to generate the best effect (Fig.3). The motion path of the athlete's shoulder, hip and ankle joint, demonstrates a considerable space between each one, at the horizontal level of upper bar (1~17 in Fig.4). The variation of flexion in shoulder joint from small to large indicates straight ascent, but hip joint flexion is at minimum when buttocks are lifted high. This can be seen at the position of Fig.4.7, and is followed by stretching backward. Therefore, the variation flexion of hip joint is also a straight ascent and reaches the position of 17. This demonstrates that A. Y. can fully extend her shoulder and hip joints when stretching backward to finish the movement, in order to provide optimum conditions for the next phase, the swing downward.

The Second Phase. This includes the technique of "steinemannstemme" downswing to the low vertical plane of the bar (9-13 in Fig.1). This component of the move involves the transfer of potential energy and muscle exertion into kinetic energy of rotation, using appropriate and accurate skills to swing downward. Owing to the precise technical characteristics, the swing downward needs to be smooth and continuous. The lowest position and the radius of center of gravity should be 1.243m and the tangential speed of the center of gravity should be 7.032m/s.

The Third Phase: This phase consists of the swing kick forward, braking with the leg and releasing the grip, in that order. This is followed with a half turn to handstand on the lower bar (13-23 in Fig.1). This phase is the most important and complicated in the whole process. First, with regard to kick skill, the gymnast should make use of considerable angular velocity of rotation to increase energy of the body significantly. Increased energy levels are due to passing through low vertical plane of the bar (12-13 in Fig.2). Therefore, as a result of an effective kick and bending of the hip joint, a considerable amount of Coriolis

inertia force is produced by the center of gravity of the body moving rapidly around the rotational axis of the bar. This causes force moment of rotation 43.59kgm for rotation axis, then time of action is multiplied. As a result, no less moment of impulse can be obtained at this point. That is to say, the kinetic energy transferring into potential energy and Coriolis moment of impulse could provide the body with more energy to ascend and to obtain optimum conditions for releasing the grip and turning while in flight. As for the degree of the hip joint bending, it should be based on what the technique requires.

A second factor is the need to pay attention to the releasing grip in correct sequence or order. Timing of the releasing grip is important to vertical body movement. It is necessary to utilize the time of centrifugal force of inertia, which is the starting point for tangential motion of body. It has been shown that only by exact timing of release grip, the accurate and appropriate parabola of the center of body weight can be achieved. The subject/gymnast for this study performed this skill well (Fig.2, 3, 4). Her method of releasing grip adhered to a specific sequence (15-17 in Fig.1), and not only a precise parabola was obtained but it also favored the position for the half turn.

A third factor to be considered is the turning skill (15-21 in Fig.1). In order to finish half turn, the gymnast starts rotation at far end of the bar, turning the inner aspect of the toes (left turning) during kicking leg upward after passing through the low vertical plane of the bar (15 in Fig.1). This action then turns the whole body with the rotation of the hip joint, demonstrating the characteristics of rotation. This is considered to be the correct way to gain turning power. To turn smoothly in flight, certain hip extension and leg braking skills should be performed (27-31 in Fig.4). At the same time, the shoulder joint is thrust forward (29-30 in Fig.4). The principal lies in effective hip extension reducing body rotation inertia which turns around the longitudinal axis and increases the angular velocity of turn to finish the move, on the basis of the conservation law of moment of momentum. In short, this turn must involve body twist from bottom to top, the release of grip in sequence, the reduction of rotational inertia of longitudinal axis by hip extension and no evidence of throwing the bar before release of the grip. The final segment of the move is downward to handstand on the lower bar. Three factors can be analyzed through the execution of handstand on the lower bar. One is the right position of parabola of the center of flight which is just above the vertical plane of the lower bar (21 in Fig.2), and the limited stable rest, i.e. the action line of gravity is attained by passing though the effective area in support of the grip. The next factor is that the turning speed of body in flight was hardly exhausted before reaching the handstand, which will benefit from the excess. The last factor, when body is in flight, relates to the movement of the hip joint, in which bending and extension not only adjusts the body turn, but also assists in readiness for handstand on the lower bar. This enables the gymnast to assume the correct handstand position with the full extension of the shoulder and hip joints, with the whole body straight and by using both hands for a stable grip.

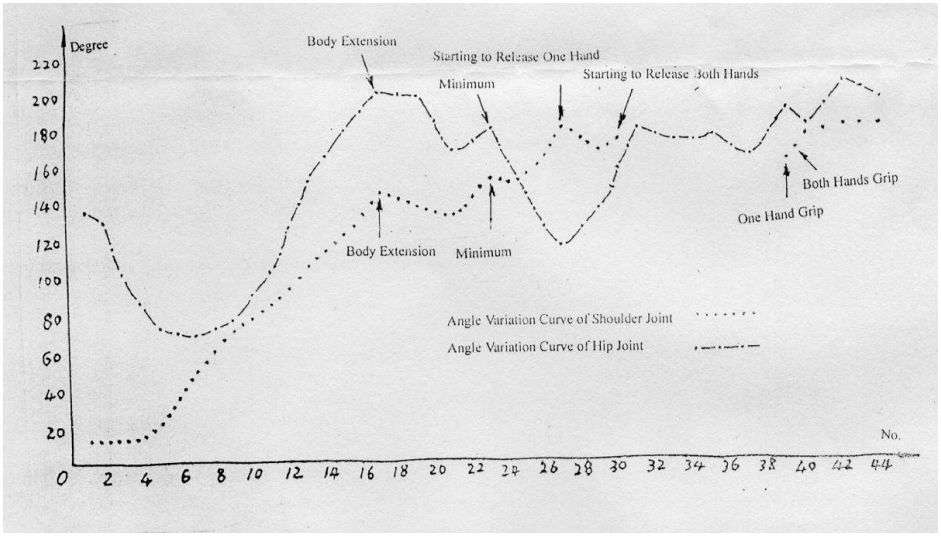

Figure 4 – Angle variation diagram of shoulder and hip joints in the process of motion.

CONCLUSIONS: To summarize the sequence of action in this technique, the momentum of the backward somersault with both arms extended and pressing backward, causes the arms to turn when the peak of body's center of gravity over the upper bar is at its highest (0.37m). Potential energy levels are at maximum in this phase. Subsequently, the body stretches to furthest point during extension behind the horizontal plane of the bar. The distance of the body center from the upper bar is 0.919m so as to obtain more potential energy and consequently, turning capacity.

When body swings downward through the low vertical plane of the bar, the exertion of the body results in the leg kicking upward, and the toes twisting (left) to produce an initial speed. The action of braking with the legs prior to release of grip in the specific order also causes the body to turn. In order to perform a steady handstand on the lower bar, the slight bending and extension of the hip joint in flight can adjust the position of both the turn and the handstand.

A variety of changes can be made to the technique for this sophisticated gymnastic move. These include changing the steinemannstemme into either one or double circle and the steinemannstemme with half turn can be changed into that with 1/1 turn or 1½ turn. There is also potential for new and more difficult techniques for such advances as changing somersault into grip. In order to increase complexity and virtuosity in a gymnastic routine, this technique has much potential in future international competitions.

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