ANALYSIS OF THE HIGH JUMP CROSSBAR IN FAILED ATTEMPTS

by Brad Hackett, Syracuse University

This article is an original contribution by Brad Hackett, the jumps coach at Syracuse University. Hackett contends that the manner in which the crossbar leaves the standards after being knocked off can provide a starting point for analysis of the missed jump. This can be an important analytical tool for all high jump coaches, particularly those who are still learning the event.

REPRINTED FROM TRACK TECHNIQUE #107

Quite frequently, the analysis of the high jump is strictly confined to analyzing successful attempts, and very little evaluation is performed on missed attempts to clear the crossbar. It is definitely useful to study a jumper's unsuccessful jumps, because the failures, not the successful jumps, define what the jumper needs to develop.

The evaluation of a miss should begin with the crossbar. The crossbar does not fall off the standards the same way every time, and the way the crossbar falls off can begin to explain what the jumper has performed incorrectly.

The ways the crossbar falls off the standards can be categorized into three distinct groups. The crossbar falls by traveling upward and landing toward the back of the pit; by bouncing up and down on the standards before landing on or near the base of the standards; and, thirdly, by being pulled directly down off the standards, landing near the front of the pit.

Technique problems over the bar may cause a missed jump, but most often a failed attempt is caused by a flaw in the approach or takeoff because the jumper's center of mass travels in a flight or parabola pre-determined by the takeoff and approach. In the approach, the jumper must create optimal horizontal velocity to allow for quick bar rotation. The faster the bar rotation the less difficult bar clearance becomes (Jacoby p. 3091, 1986). At takeoff, the jumper must transfer the horizontal velocity of the approach into vertical velocity in an attempt to raise the height of the center of mass. This transfer of velocity is the most important facet of the jump, for the height of flight of the center of mass will ultimately determine the height cleared.

Because the approach and takeoff are the major contributing factors in the high jump, the analysis of a missed jump must initially concentrate in this area. The study of the technique over the bar should be only a secondary evaluation.

1. Crossbar Traveling Upward and Toward Back of Pit

There are three major reasons which may cause the crossbar to leave the standards by traveling up and toward the back of the pit. The bar will travel in this manner if the athlete's plant is too close to the crossbar; if the athlete does not lean away from the pit while running through the turn; or if the athlete does not successfully execute the turn which will affect the angle of the takeoff foot at the plant.

Consistency in the approach is a major key to the high jump, and if an athlete takes off too close to the crossbar it is virtually impossible to clear the bar. This type of takeoff may force the crossbar to travel up off the standards as soon as the takeoff has been executed. The jumper must work to plant at nearly the exact same spot every time, at least an arm's length away from the crossbar. Being on the same mark at the plant on every jump is not determined by the last stride, but rather by being consistent in stride length and frequency of every step of the approach. The entire approach must be developed and refined to allow for a consistent plant at least an arm's length away from the crossbar, to eliminate the crossbar from being struck on the way up.

An analysis of sixteen of Zhu Jianhua's jumps above 2.20m from 1983 and 1984 showed that in all six of his successful attempts his plants were within 9.09 cm of each other. In the eleven misses that were evaluated there was a difference of 36 cm in the plants (Xinwang p. 39, 1986). Obviously, an athlete must work on planting the same distance from the crossbar in every attempt.

By running a curved or J approach, the high jumper is able to create centrifugal force. Centrifugal force allows the high jumper to lean away from the crossbar during the turn and plant, which will permit the athlete to complete the objective of the plant, transferring the horizontal velocity into vertical velocity. If the jumper does not run a curved approach, but rather "cuts" or runs half of a Y, the transfer of velocity will not be accomplished. By cutting at the turn rather than running a smooth curve, centrifugal force will not be created so the athlete will not be leaning away from the crossbar at the plant. Without centrifugal force, the athlete's momentum will be carried into the crossbar, which will also force the bar to leave the standards in a upward direction.

The final cause for the crossbar to leave the standards in this fashion is an incorrect placement of the takeoff foot at the plant. At the plant, the toes of the takeoff foot should be pointed toward the opposite standard at a 10° angle. If the plant is pointed toward the back corner of the pit, at a 45° angle, the jumper's momentum will once again be traveling into the pit, not allowing for the transfer of vertical velocity. Poor execution through the turn will create an incorrect foot placement at the plant. If the athlete is able to run a smooth curve, a 10° angle at takeoff will come naturally, but if the athlete cuts into the turn, the foot placement at the plant will be closer to 45°, which will carry the jumper into the bar and hit it on the way up.

2. Crossbar Bouncing Up and Down on the Standards

The crossbar often bounces up and down on the standards before falling to the ground. Two reasons why this happens can be attributed to faults in the approach and plant. The crossbar will leave the standards in this way if the jumper loses speed at the takeoff, or if the jumper takes off too far away from the crossbar. A third action that will force the crossbar to bounce up and down is caused by a technical flaw by the jumper in the air, hitting the crossbar with the buttocks.

Often a jumper will suggest that he or she has had a great deal of height but then crashed right down onto the crossbar. This is caused by a loss of horizontal speed for bar rotation, which may happen for three different reasons: too much time on the ground at takeoff, a long lever drive knee, and a lack of arm drive through the turn. All three of these have a common theme—each allows strong transfer of vertical velocity, but each also forces a loss of horizontal speed.

The penultimate or second-to-last stride must be the longest stride of the approach. When the last stride is slightly shorter than the second-to-last stride the center of mass begins to move vertically before takeoff has even taken place. If the last stride is longer than the penultimate stride, a great deal of horizontal velocity will be lost as the jumper attempts to transfer the center of mass vertically. Quite frequently an indication of this is also when the toes of the drive leg can be heard scraping on the ground.

On the analysis of Zhu's jumps referred to earlier, there were a total of twenty-one jumps evaluated, eleven successful jumps and ten failed attempts. In all eleven made jumps, the last stride was shorter than the penultimate and, transversely, in all eleven unsuccessful jumps the last stride was longer than the penultimate stride (Xinwang, p. 39, 1986).

The drive knee can also affect the maintenance or loss of horizontal speed at takeoff. The drive knee, the right leg for a left-footed jumper, must create a short lever in order to not lose any speed. A short lever is created by the femur being parallel to the ground and the heel being under the buttocks. If the foot is out in the direction of the opposite standard, a long lever has been created, which will increase the time of the plant, slightly delay takeoff, and, therefore, decrease the horizontal velocity for bar rotation.

The lack of continued arm swing as the jumper runs through the turn will also force the athlete to lose speed. The tendency of many high jumpers is to drop their arms in the turn, to "gather" for the takeoff. It is imperative that the jumper continue to accelerate through the turn, which must be enhanced by arm drive.

These three causes for the loss of horizontal speed for bar rotation will each force the bar to bounce up and down off the standards. The cue for the jumper to eliminate this problem is that the object at the takeoff is to maximize vertical velocity, but at the same time minimize the loss of horizontal velocity (Doolittle, p. 8).

Just as being too close to the crossbar at takeoff may cause a miss, being too far away at takeoff may also cause a miss. The height of the center of mass may be enough to clear a given height, yet if the plant is too far away, the height is obviously obtained too early, and again the crossbar will be hit as the center of mass is coming down, forcing the bar to bounce up and down off the standard. As with being too close to the crossbar, consistency in the approach is the solution to this problem.

When the crossbar is hit by the buttocks it means that the jumper has a timing problem over the crossbar. Newton's Third Law states that every action has an equal and opposite reaction. In the high jump the main example of this

is that a high jumper must snap his or her head in order to lower the hips which will raise the legs. Certainly, timing is very important, and if the head is moved when the buttocks are over the bar, the movement will force the hips down onto the bar. Therefore, the head should not move until the hips have already cleared the crossbar.

3. Crossbar Pulled Off and Down

When the crossbar is pulled off and down and lands in the front of the pit, it is usually hit by the jumper's leg or foot. This usually can be attributed to either a timing problem or an overarching problem.

As an athlete improves his or her approach so that more speed can be controlled through the turn and plant, the jumper will also develop faster bar rotation. The increase in bar rotation will force the jumper to react faster over the bar. If the athlete is unable to do this, the crossbar will be struck by the jumper's lower leg. It is imperative that, as the jumper improves the approach and takeoff, the athlete must be conscious of the increased demand on the timing over the crossbar as well.

An overarching over the crossbar may also cause the bar to fall off in a pulled down manner. If the athlete overarches, the heels will pass under the bar, and even when Newton's Third Law is applied it will be difficult for the feet to clear the crossbar. Overarching may be caused by the head looking directly back between the shoulders. The way to eliminate this problem is by looking over the shoulder which is on the same side as the drive leg. By looking off to the side with the head, the hips will be slightly lower and the feet will not pass under the crossbar.

The high jumper must also concentrate on spreading the knees apart and the heels together when clearing the crossbar; this creates a short lever. By creating a short lever, the speed of rotation over the bar will be increased. This too should eliminate the chance of the crossbar being taken off by the lower leg or heels.

4. Conclusion

The crossbar definitely falls off several different ways and the way the crossbar falls off can indeed indicate the possibilities of what the jumper has done incorrectly. A missed jump, therefore, can be very useful to the development of a jumper, and a miss must be analyzed as much, if not more than, a successful jump.

REFERENCES

Cooksey, S., "Teaching Progression in the Flop", *Track and Field Quarterly,* Vol. 86 n4, Winter 1986, pp. 36-37.

Doolittle, D. "Biomechanics - The Jumps", TAC Level II Coaching Certification Manual, pp. 2-25.

Ecker, T. Basic Track and Field Biomechanics, Los Altos, California, *Track and Field News Press,* 1985, p. 62.

"High Jump: Results of a Biomechanical Study", *New Studies in Athletics,* Vol. 1 n4, December 1986, pp. 33-49.

Humphrey, S. "High Jump - The Back Layout", *Track and Field Quarterly,* Vol. 86 n4, Winter 1986, pp. 32-35.

Jacoby, E. "High Jump - A Technique Evaluation", *Track Technique,* Vol. 97 Fall 1986, pp. 3089-3093.

Myers, B. "Mechanics of the High Jump", TAC Level II Coach-Certification Manual, pp. 1-5.

Ozolin, N. "The Mechanics of the High Jump Takeoff", The Jumps, Los Altos, California, *Track and Field News Press,* 1981, pp. 36-39.

Reid, P. "Approach and Takeoff for the Back Layout High Jump", *National Strength Coaches Association Journal,* Vol, 8 n1, 1986, pp. 5-9.

Schnoter, G. "Corrections of Flop Faults", The Jumps, Los Altos, California, *Track and Field News Press,* 1981, pp. 50-53.

Xingwang, F. *"An Analysis of Zhu Jianhua's Run-Up Technique", Track and Field Quarterly,* Vol. 86 n4, Winter 1986, pp. 38-41.