INTRODUCTION

The high jump demands explosiveness, power, speed and body control. Significant changes in technique have occurred over the years especially when the landing pit of sand or sawdust was replaced with foam mats.

HISTORIC OVERVIEW

During the 1968 Olympic Games in Mexico City high jumping was introduced to a new technique known as the Fosbury Flop named after the jumper who developed this style of clearing a high jump bar.

Instead of going over the bar face-first by swinging first one leg and then the other using a technique known as the straddle, Fosbury went over the bar on his back and landed on his shoulders. Not only was going over the bar unique, the approach run to the bar was also unique because it included a distinct curved portion for the first time.

Subsequent research illustrated why the Fosbury Flop is mechanically more effective than any style of high jumping preceding it. The most significant segment of this modern style of high jumping is the approach.

THE FOUR PHASES

The four phases of the high jump are the: Approach, Take off, Flight, and Landing.
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The goals for each phase are:

- **Approach**: generate optimum (not maximum) speed and prepare for the take off.
- **Takeoff**: generate vertical velocity and initiates rotations necessary for bar clearance.
- **Flight**: rise to the bar and then clear it.
- **Landing**: land safely on the shoulders in the pit with head tucked forward.

**APPROACH PHASE**

The approach is the most important part of the jump. The first part follows a straight line, perpendicular to the plane of the standards. The last four to five strides follow a curve. The curve causes the jumper to lean away from the bar at the start of the takeoff phase.

The curved run-up has mechanical benefits over the straight approach. However, it is difficult to learn and requires substantial attention from the coach and athlete in order for it to be performed consistently. If the athlete does not always follow the same path, the distance between the takeoff point and the bar will vary from one jump to the next. This inconsistency will make it difficult for the athlete to reach the peak of the jump directly over the bar.

During the approach there are two paths of interest. One path is the one followed by the athlete’s footprints and the other path is traced by the athlete’s center of gravity.

As you can see here, when the athlete runs the curve the body leans in toward the center of the circle. The athlete maintains this lean while running the curve. The path of the center of gravity follows a path slightly closer to the center of the curve than does the path of the footprint. At the end of the curve the path of the athlete’s center of gravity and the footprints converge and the center of gravity is almost directly above the footprint.

The final angle the athlete’s center of gravity (p) is always larger than the corresponding angle of the footprint path (f). The extension of the path of the center of gravity is the red dotted line. The extension of the footprint path is inside the center of gravity path. The extension of the footprint path provides the takeoff angle (f). The extension the center of gravity path is the direction of motion of the center of gravity (p).

The curves run by elite high jumpers are quite varied. It takes time to determine the most suitable path so the take off for each individual jumper is maximized. The jumper’s approach will change according to their level of strength and skill development.
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APPROACH SPEED

Some athletes walk a few steps at the beginning of the approach and then start running, while others use a standing start. For beginners the standing start is probably more appropriate. During the first 5 strides the athlete progressively makes each stride a little longer and faster than the previous one. By stride 5 the high jumper is running with long, relaxed strides, at a pace similar to that of 400/800 m runners.

In the last 2-3 stride of the approach the athlete gradually lowers the center of gravity by bending the knees. The goal is to accomplish this maneuver with minimal loss of running speed.

TAKE OFF PHASE

The takeoff phase occurs between the instant the takeoff foot touches the ground (touchdown) and the instant it loses contact with the ground (takeoff) for the flight over the bar. During this time the takeoff leg pushes down on the ground and in reaction, the ground pushes up on the body through the takeoff leg with an equal and opposite force. The upward force produces a large upward vertical velocity that projects the jumper into flight.

The athlete’s vertical velocity at the end of the takeoff phase determines how high the jumper’s center of gravity will travel. Two factors determine the vertical velocity at the end of the takeoff phase:

- The amount of vertical force produced on the ground
- The time over which this vertical force is exerted

A fast approach increases the vertical force on the ground. This happens because a faster approach places more stretch on the muscles during touch down.

When the takeoff leg is planted ahead of the body at the end of the approach, the knee extensor muscles resist against the flexion of the leg. However, the leg is forced to flex because of the forward momentum of the jumper.

During this process the knee extensor muscles located in the front of the thigh of the takeoff leg are stretched. This stretching stimulates muscles that, in turn, increase their contraction to produce a forceful extension of the takeoff leg in the second half of the takeoff phase. In this way, a fast approach increases the vertical force at takeoff.
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The time of vertical force application is increased if the center of gravity passes through a long vertical path during the takeoff phase. This is achieved by making the center of gravity low at the start of the takeoff phase, and high at the end of the takeoff phase.

Most high jumpers easily manage a high center of gravity at the end of the takeoff phase, but achieving a low position at the touchdown of the takeoff foot is more difficult. To accomplish this the body has to be supported by a deeply flexed non-takeoff leg during the next-to-last (penultimate) stride. This requires a very strong non-takeoff leg. The neuromuscular control permitting the athlete to pass over the deeply flexed non-takeoff leg without losing running speed is difficult to learn. For this reason an approach that is fast and low during the last 2-3 strides requires considerable practice and strength development.

Here’s a pitfall. The athlete’s leg strength is a major factor. If the athlete is too fast and too low a weak takeoff leg will flex excessively during the early part of the takeoff, and be unable to extend forcefully in the final part of the takeoff. The takeoff leg may even “buckle” under the stress. There is an optimum combination of run-up speed and center of gravity height and this will vary for different athletes.

EXPERIMENT WITH THE APPROACH

Experiment with a slightly faster and lower approach. If the athlete jumps well with the new approach speed, try a slightly faster and lower approach. Repeat this process until the approach speed causes the takeoff leg to buckle, or the height of the jump is reduced. When this point is reached, it indicates the athlete has surpassed the optimum combination of speed and center of gravity height for their level of strength. The jumper can then experiment with slower approach speed and a slightly higher center of gravity than the one that produced the buckling or the lower jump height. Experiment until you find the combination that produces the best jumps.

Here is a really important point! A faster and lower approach places considerable stress on the takeoff leg and ankle. Your athletes will have various levels of ankle pronation and weak ankles can easily be injured. A faster and lower approach will require strengthening the takeoff leg and ankle so it can withstand the higher impacts produced during takeoff foot plant.

ARM ACTION

Arm action during the takeoff phase affects the outcome of the jump. The upward
acceleration of the arms during the takeoff phase exerts a compressive force down through the trunk, into the takeoff leg and then to the ground. The increased downward vertical force exerted on the ground increases upward vertical force exerted by the ground on the athlete producing a higher vertical velocity at the end of the takeoff phase and consequently a higher jump.

The most effective arm action appears to occur when both arms are swung forcefully forward and up during the takeoff phase. The elbow angle is between 90 degrees of flexion and full extension.

Some athletes position the arm nearest the bar forward instead of backward at the beginning of takeoff. This limits its vertical range of motion during the takeoff phase. However, this arm position is only moderately effective. The athletes with the strongest arm action bring both arms back during the final one or two strides of the approach. This allows the arm nearest to the bar to swing more actively during the takeoff phase. Learning a double arm technique takes some time and effort, but appears to be the better arm technique.

TAKE OFF DISTANCE

The distance between the toe of the takeoff foot and the plane of the bar is the “takeoff distance”. This distance determines the position of the peak of the jump relative to the bar.

If an athlete takes off too far from the bar, the center of gravity will reach its maximum height before crossing the plane of the standards and the jumper will fall on the bar.

If the athlete takes off too close to the bar, there is the risk of hitting the bar while the center of gravity is on its way up, before reaching its maximum height.

The optimum takeoff distance for each athlete depends both on the final direction of the approach and on the amount of residual horizontal velocity the athlete has left after the completion of the takeoff phase. Athletes who run faster over the final strides of the approach will have more horizontal velocity left after takeoff. Therefore, they will travel through larger horizontal distances after the completion of the takeoff phase than slower jumpers will. For this reason a jumper who uses a faster approach speed needs to take off farther from the bar in order for the center of gravity to reach its maximum height directly over the bar.

• The jumper can determine if the takeoff was too close or too far from the bar by paying attention to when the bar was hit.
• A jumper who hits the bar coming down from the peak of the jump indicates the
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takeoff was too far from the bar. The solution is to move the starting point of the approach slightly closer to the bar.

A jumper hitting the bar on the way up toward the peak indicates the takeoff point was too close to the bar. The solution is to move the approach starting point slightly farther from the bar.

GENERATING ROTATION

One goal of the takeoff is to convert horizontal velocity into vertical velocity while keeping sufficient horizontal velocity to move over the bar.

However, there is also a second goal at takeoff and this is to generate rotation so the back is toward the bar at bar clearance. We will now focus on how rotation for optimum bar clearance is achieved.

Changing takeoff body orientation so the back is facing the bar at bar clearance is quite complicated so let’s begin by simply overviewing the basic components involved. Then we will come back and discuss each component in a bit more detail.

Body layout position at bar clearance is generated during the takeoff phase. Two broad rotational components are involved.

1. Twisting the body around the vertical axis. This is achieved by two actions – the swinging free leg action and the active turning of the shoulders.

2. Implementing two somersaulting actions – one forward and the other lateral. A forward somersault is produced by the backward lean at the touch down. A lateral somersault is produced by the approach curve.

Now let’s examine the generation of rotation in more detail.

TAKE OFF ROTATIONAL BIOMECHANICS

The twist

The twist is necessary to rotate the body around the foot so that the athlete’s back is toward the bar. The twisting motion about the vertical axis is caused by two actions. One is the swinging action of the lead leg up and away from the bar during the takeoff phase, and there is also an active turning of the shoulders. Most athletes have little difficulty obtaining an appropriate amount of twist about a vertical axis. The problematic area is the somersaulting action.
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The somersault actions

The somersault actions are a little bit more difficult to explain. The combined effect of the forward and lateral somersaulting rotations is seen while clearing the bar. It causes the shoulders to go down while the knees go up.

The forward somersaulting action is depicted as HF in the diagram.

During the takeoff phase, rotation is produced by the backward lean. As the foot plants the body rotates over the foot face first. This is due to the fact that the foot acts like a brake but because the athlete has considerable forward momentum the upper body will rotate over the planted foot.

The lateral somersaulting action is produced by the curve of the approach.

In the transition from the straight portion into the curve a force will tend to pull the athlete’s body away from the circular arc. This force is called the centrifugal force. The jumper leans towards the center of the fictional circle in an effort to prevent being pulled off the curve. The lean will boost the centripetal force that tends to pull the body toward the center of the fictional circle. An even balance of these forces puts the jumper in the optimum position for the circular run. Everything has to be optimal at the take off – the lean, the centrifugal and centripetal (center seeking) forces, the speed and the final angle of the jumper’s approach. At the takeoff the centripetal force weakens and the centrifugal force pulls the jumper from the path.

The path the jumper follows will be tangential to the curve.

It is important to consider the lean of the athlete because when running the curve the feet and ankles are under tremendous pressure. The athlete experiences foot torsion. The more the lean the higher the forces the ankle will experience. Very high forces can lead to chronic ankle strain.

The sum of the forward and lateral somersaulting rotational components causes a somersaulting action over the bar.

Here is a view looking down at the head of the jumper. It is right at the moment of takeoff. Here is the lateral somersaulting rotation due to the inward lean on the curve. Here is the forward somersaulting rotation due to the backward lean.

Here is the combination of the two rotations that results in the rotation of the jumper over the bar. In other words rotating over the bar requires both backward lean and inward lean toward the center of the curve.
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**Flight**

The rotation in the air is determined primarily by the rotation the jumper has during the airborne phase. Pulling the head forward causes the legs to raise so that the heels will clear the bar. This is Newton’s law of action-reaction.

**Reference**
