

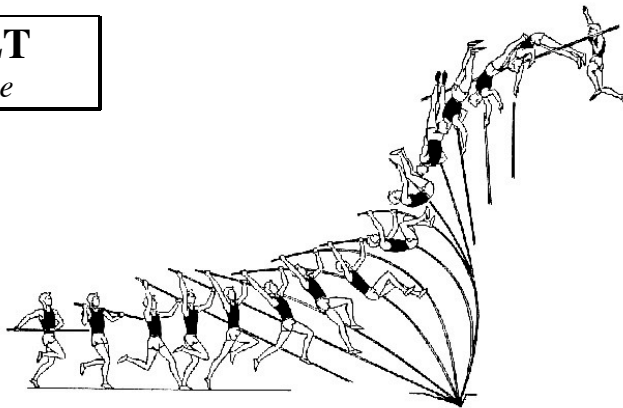
# MECHANICS OF THE POLE VAULT

## *Mechanical bases of effective pole vaulting technique*

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## THE VAULTER

### 1. TALL AND LEAN.

Elite vaulters are generally tall. Taller athletes have an advantage in the pole vault, especially at the pole strike. A taller athlete usually has a higher reach, and an athlete with a higher reach can strike the pole at a higher angle than a shorter athlete with a lower reach. Perhaps this tip should be entitled "Have a high reach height." Most elite male pole vaulters stand more than 6'0" tall. American record holder Jeff Hartwig is 6'3". Olympic champion Tim Mack is 6'2". American record holder Jenn Stuczynski is 6'0". World record holder Yelena Isinbayeva is 5'8½". There are exceptions, of course - Scott Huffman, Greg Duplantis, Svetlana Feofanova for example. Elite vaulters are lean. There are no exceptions to this rule.

### 2. FAST.

Excellent sprinting ability is necessary for success in the pole vault. During the last steps of their approach runs elite male vaulters reach speeds in excess of 9.5 m/s (29.5 ft/s) while elite female vaulters reach speeds in excess of 8.2 m/s (26.9 m/s). Not all fast vaulters are elite vaulters, but all elite vaulters are fast.

### 3. EXPERIENCED.

Elite vaulters are experienced vaulters. Most elite vaulters vault for more than 15 years before reaching elite status. Pole vaulting is a complicated and difficult event to learn. It takes a long time to learn how to pole vault and even longer to become proficient at it. Most elite vaulters achieve their best performances in their late 20's or early 30's. Jeff Hartwig set his last American record in 2000 at 6.03 m (19'9¼") when he was 32 years old. He was the number one ranked pole vaulter in the world in 2002 when he was 35 years old. Stacy Dragila set her last American record in 2004 at 4.83 m (15'10") when she was 33 years old. Tim Mack was a month shy of his 32nd birthday when he won Olympic gold. It may not be age that is the factor here, but the number of vaults taken.

### 4. PATIENT.

It takes years of training and vaulting to achieve success at the elite level. Vaulters should not expect large improvements to occur overnight. The body takes time to respond to physical training and to learn new techniques. Pole vaulting can be a frustrating and discouraging event. Many vaulters who achieved great success in high school but never achieved success at the elite level. Many of them lacked the patience and perseverance necessary to keep improving.

### 5. SMART.

Successful pole vaulters are smart. They study the event and learn as much as they can about it. Numerous pole vault coaching and instruction books, articles, videos and DVD's are available (*From Beginner to Bubka* by Launder & Gormley, *USATF Pole Vault Education Manual*, Jan Johnson's *SkySystems* videos, etc). Valuable material may also be found on the web (<http://www.pvei.com>, <http://www.pvscb.com>, <http://polevaultpower.com>, <http://www.stabhochsprung.com/>, <http://www.neovault.com>, etc.)

### 6. FUN.

Vaulting is fun. Keep it that way, or #3 and #4 will be difficult to achieve.

## THE EQUIPMENT

### **7. HIGH GRIP ON A LONG STIFF POLE.**

Elite vaulters use high handgrips on long stiff poles. Grip heights used by elite male vaulters are in excess of 4.90 m (16' 1"). The average grip height used by the ten male finalists in the 2000 Olympic Games was 5.00 m (16' 5"). The flex numbers of the poles used by elite vaulters are 15.0 cm or smaller, indicating pole weight ratings of 90 kg (198 lb) or greater. Grip heights used by elite female vaulters are in excess of 4.25 m (13' 11") and keep getting higher.

### **8. POLE LENGTH, SIZE, AND PERFORMANCE MATCHED TO THE ABILITY OF THE VAULTER.**

Elite vaulters are able to hold high on long stiff poles because of their superior technique and physical abilities. They match pole size and grip height to their ability so that they can set their standards 60 cm (24 in) or further from the back of the box. Non-elite vaulters should do the same.

## THE APPROACH RUN

### **9. FAST RUN.**

There is a significant correlation between speed over the last 5 meters of the approach run and crossbar height cleared. This is the most important determinant of success in pole vaulting. (see #2 above).

### **10. VERTICAL POLE CARRY AND POLE DROP.**

Elite vaulters employ a pole drop technique during the run up. This reduces the forces imposed on them when they carry the pole in a more horizontal orientation. An possible alternative technique is to push or slide the pole down the runway.

### **11. MID-MARK (COACH'S CHECKMARK).**

A coach's checkmark should be used to mark the optimal position of the start of the fourth to last step. Most vaulters have a coach's checkmark at the beginning of their sixth to last step, but research indicates that this checkmark would be more effective at the start of the fourth to last step. The approach run up until the fourth to last step is programmed, i.e., the vaulter tries to make this part of the approach run the same from vault to vault. But, errors occur, and because of these errors, the vaulter must adjust his steps or "steer" at the end of the approach run in order to hit the correct takeoff mark. The adjustments in the step lengths ("steering") don't occur until the last four steps. A checkmark at the start of the fourth to last step would indicate how accurate the programmed part of the vaulter's approach run was. Adjustments in the vaulter's start mark should be based on how far the vaulter is off the coach's checkmark.

### **12. ACCELERATE DURING THE LAST THREE STEPS.**

Elite vaulters maintain their speed or accelerate into the last steps of the approach run. They also increase their speed from the second to last step to their last step before takeoff. Most developing vaulters slow down during the last three steps. This is easy to do, since this is when the vaulter initiates the pole plant and adjustments in step lengths occur to ensure proper position for takeoff. Many hours of practice are required before a vaulter is able to accelerate during the last steps of the approach run.

### **13. A LONGER SECOND TO LAST STEP AND A SHORTER QUICKER LAST STEP.**

Most vaulters take a longer penultimate step and a shorter, quicker last step. This sets the vaulter up for a jumping takeoff. The ratio between the last step length and the second to last step length is between 0.90 and 0.95 for most elite vaulters. Step rate is increased during the last step so that speed does not slow as a result of the shorter step. Elite vaulters overcompensate for the shorter step length by increasing step rate such that speed actually increases during the last step.

## PLANT AND TAKEOFF

### 14. UPRIGHT POSTURE.

Elite vaulters stay more upright at the instants of last touchdown, pole strike, and takeoff. Less skilled vaulters tend to lean backward during this phase. This may have an effect on takeoff velocity. It also affects the maximum angle between the pole and runway and the height of the center of gravity at the instant of takeoff.

### 15. MAXIMUM ANGLE BETWEEN THE POLE AND THE RUNWAY AT POLE STRIKE.

This reduces the angle the pole must rotate through to get to a vertical position. It also allows for a more efficient transfer of energy to the pole. As grip height increases, this angle decreases, so elite vaulters have smaller pole angles than less skilled vaulter. This angle is also affected by the vaulter's height and reach. A taller vaulter with a higher reach will be able to achieve a higher pole angle. At pole strike, the pole angle for elite vaulters is slightly less than 30°. It increases slightly between the instants of pole strike and takeoff.

### 16. RIGID BODY AT THE INSTANT OF POLE STRIKE.

The pole strike marks the beginning of the energy transfer from the vaulter to the pole. If the body is "loose", energy which could have been transferred to the pole may be lost through inelastic stretching of the muscles and tendons. Pre-tension in the muscles of the trunk, shoulder girdle, and arms will minimize this energy loss. Some movement will occur at the shoulder joint, but this may be beneficial if it results in a greater contraction of the shoulder extensors due to the stretch reflex response of these muscles.

### 17. HIGH PLANT.

The top hand should be as high overhead as possible. This arm should be extended vertically as much as possible. This will help achieve a high pole angle at pole strike (see #14 above). Interestingly, the relative vertical extension of the plant arm for some elite vaulters is less than that of less skilled vaulters. Perhaps the pretension in the muscles in their shoulders and arms (see #15 above) causes these elite vaulters to reduce the relative vertical extension of their plant arm.

### 18. TOES OF TAKEOFF FOOT DIRECTLY BENEATH TOP HANDGRIP.

At the instant of pole strike (the instant when the pole butt plug first strikes the back of the box) the top hand should be directly above the toes of the takeoff foot. This puts the vaulter in the best position for transferring energy to the pole. This also means that at the instant of takeoff the top hand will be in front of the takeoff foot, since the top hand moves forward as the pole begins to bend. Most vaulters plant the pole with their takeoff foot in front of their top hand. Elite vaulters position their takeoff foot more directly below their top hand.

### 19. POLE STRIKE OCCURS WHEN THE VAULTER IS UP ON HIS TOES.

Don't plant the pole while you are still on the heel of your takeoff foot. The timing of the pole strike (the instant when the pole first strikes the back of the box) is crucial. The sequence of events occurs like this: the takeoff foot hits the ground (touchdown), the pole hits the back of the box (pole strike), and the takeoff foot leaves the ground (takeoff). These events occur in 0.08-0.12 s (the total time of takeoff foot support) for elite vaulters. For elite vaulters, pole strike occurs in the second half of the support phase, closer to the instant of takeoff. This indicates that they are actively pushing off the ground. They are "on their toes" when pole strike occurs and they actively push the pole upward and forward. If pole strike occurs during the first half of the support phase, closer to the instant of touchdown, then the vaulter will be not be able to actively push the pole upward and forward. The vaulter will be jerked off the ground by the pole. The timing of the pole strike is related to takeoff foot position and the extension of the plant arm (see #16 and #17).

### 20. JUMPING TAKEOFF.

A fast takeoff velocity is necessary for vaulting high. Elite male vaulters have resultant takeoff velocities faster than 8.0 m/s (26.2 ft/s) while elite female vaulters have resultant takeoff velocities faster than 7.0 m/s (23.0 ft/s). The resultant takeoff velocity is composed of a horizontal (forward) velocity and a upward (vertical) velocity. A fast horizontal takeoff velocity is produced by a fast approach run. A fast vertical velocity is produced by an upward jump at takeoff. Elite male vaulters have horizontal takeoff velocities faster than 7.7 m/s (24.9 ft/s) and vertical takeoff velocities faster than 2.2 m/s (6.6 ft/s). Elite vaulters have takeoff angles between 17 and 19 degrees for men and between 18 and 20 degrees for women. Takeoff angles which are too low may lead to pole breakage.

## POLE BENDING PHASE

### 21. LOWER HAND INITIATES POLE BEND.

This begins at the pole strike and continues only briefly into the follow through phase, until about 0.20 s after takeoff. The force exerted against the pole by the lower hand greatly reduces the compressive force necessary to bend the pole. Although the pushing action of the lower hand is instrumental in initiating the pole bend, it also slows down the rotation of the vaulter. So, the pushing action only occurs for a brief period of time. Shorter vaulters may have to push more than taller vaulters.

### 22. SWEEPING AND WHIPPING EXTENDED TRAIL LEG.

The centripetal force generated by the sweeping, whipping action of a long and extended trail leg loads the pole and maintains the vaulter's swinging momentum.

### 23. HANGING AND SWINGING FROM TOP HANDGRIP.

The force exerted by the hands downward toward the butt end of the pole is a compressive force or column load which is primarily responsible for bending the pole. The larger this force is and the further this force is away from the butt end of the pole, the easier it is to bend the pole. Therefore, the vaulter should attempt to swing from his top hand to ensure that this force is exerted on the pole as high as possible. The vaulter should neither pull with this arm nor flex at the elbow, rather the vaulter should think of this arm as a cable and let the pulling force of the pole pull through this cable. Keeping the body swinging in an elongated position will also increase the force which bends the pole. Some pulling force will be exerted by the bottom hand after its initial push to start the pole bending. This pulling force assists the vaulter in rotating his body upside down. Vaulters who used a large pushing force with the bottom hand to bend the pole (see #21) will have to pull with a much larger force in the bottom hand in order to get upside down.

## POLE STRAIGHTENING PHASE

### 24. AXIS OF ROTATION MOVES FROM TOP HAND TO SHOULDERS.

During the long swinging action of the vaulter immediately following takeoff, the vaulter's axis of rotation is around the top handgrip. As the pole reaches maximum bend, this axis of rotation moves from the hands to the shoulders. The vaulter's hips and legs are lifted upward relative to his handgrip.

### 25. CENTER OF GRAVITY ALIGNED WITH OR BEHIND THE POLE.

Allowing the center of gravity to pass in front of the pole while the vaulter extends upward produces a moment about the handgrips which causes the vaulter's backward rotation to stop. The legs and trunk then begin to drop and rotate towards the bar. To avoid this, the vaulter should try to stay as close to the pole or behind it as he inverts, extends and turns. The vaulter should strive to "beat the pole" - get into position on top of the pole to take advantage of the energy return from the pole. Pole selection and grip height (see #8 above affect the ability of the vaulter to "beat the pole").

## RELEASE AND CLEARANCE

### 26. SAFE LANDING.

Vaulters who land safely in the pit are happy vaulters. They have more fun and are able to vault again. Ensure safety by using a larger than minimum size pit, padding or removing hard surfaces near the pit, padding standard bases, using a box collar and using common sense.