WARMING UP
PRE-ACTIVITY ROUTINES
FOR THE THROWER

ALSO:
GETTING ATHLETES
TO THE LINE READY
TO COMPETE

REVITALIZING THE
WOMEN'S TRIPLE JUMP
FINESSE IN JAVELIN THROWING

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he single most important factor for success in javelin throwing is the velocity at release. Indeed, a javelin thrower who has the capacity (conditioning) to produce higher velocities will eventually be able to put together a long throw. On the other hand, if that capacity is lacking, a long throw will be impossible to achieve.

Therefore, the evaluation of the maximum release velocity is probably the best way to assess the maximum throwing potential of a javelin thrower for the near future. However, we should not expect that a high speed alone would result in a long throw. In cases where the javelin thrower is able to generate high release velocities that do not result in (the expected) long throws, this may be an indication that the thrower should spend some time in improving the essential dynamics of the execution of the throw. Those dynamics as a whole also describe what has been called the finesse in javelin throwing. Over the years, a few throwers have been able to both exhibit high release velocities and to develop the finesse necessary to consistently achieve long throws. Examples of such throwers, from the recent years are, Ian Zelazny (men’s world record holder) and Andreas Thorkildsen (the men’s Olympic record holder). Both have been able to consistently produce long throws and repeatedly win major javelin competitions. From this point of view, finesse is of paramount importance for consistent long javelin throws and it expresses the ability of the javelin thrower to achieve long distances during most competitive situations. It also expresses the ability of the thrower to coordinate the various technical elements of the throw so that each element contributes maximally to the overall performance. The point is that often, more than 5-10 meters may be lost, as release data from Campos, Brizuela & Ramon (2004) may imply, due to lack of finesse in javelin throwing.

BASIC ELEMENTS OF FINESSE

Run Up

The length of the run up should be such that the velocity attained is the maximum that the thrower can control during the final transition prior to release. From a mechanical point of view, Newton’s second law shows that attaining a javelin velocity that during the delivery position is greater than zero can increase the release velocity. This is the primary function of the run up. Theoretically, the largest run up speed should be used in order to maximize release speed. However, the attained speed should also be controllable and that control is important to the production of the highest release speed possible. Run up speed control also has to do with the degree of front foot flexion which is caused by the shock of landing. If the front leg is not able
to provide a firm support, then the efficacy of the energy transfer from the run up to the javelin itself may decrease due to the lack of a sturdy base of support for the trunk. This certainly addresses the need for leg strength in javelin throwing since the amortization phase (time to maximum knee flexion after front foot contact) should be short. A smooth and controlled run up can be achieved either by bounding type of strides or by a progressive acceleration into the throw. Some throwers maintain more of the run up speed during the transition steps and therefore require a longer follow through which may necessitate a planting of the front foot far behind the foul line. Others maintain less of the run up speed, do not require as long a follow through and, are able to plant the front foot closer to the foul line, thus gaining measured throwing distance. It has been observed (Komli & Mero, 1985; Miller & Munro, 1983) that although a thrower may maintain higher speed into the transition steps he may lose some of this advantage by planting the front foot far behind the foul line thus, losing some measured throwing distance. However, Best, Bartlett & Morris (1993) found that the best thrower in their study, despite having the highest horizontal speed of the center of gravity at final support, was able to be closest to the foul line than any other thrower, Komli & Mero (1985), as well as Ikegami, Miura, Matsui & Hashimoto (1981), found no significant correlation between run up velocity and distance thrown. On the other hand in a more recent study, Murakami, Tanabe, Ishikawa, Isobe and Komli (2006) concluded that world class javelin throwers obtain higher release velocities by employing a faster approach than other throwers. It may not be entirely clear however, whether higher run up speeds necessarily lead to longer distances. It is possible that there is an optimal interaction between run-up speed and the impulse imparted on the javelin. There must be a trade off between run-up speed and impulse imparted to the javelin that can be optimized. This trade off will result in an optimal run-up speed to impulse relationship and it will be individual specific (Best et al., 1993).

MAINTENANCE OF FORWARD MOMENTUM

The potential lack of relationship between the run up speed and the distance thrown, mentioned above, may necessitate a compromise between the maintenance of a large forward momentum during the approach run and the forces exerted on the javelin to increase its speed during the penultimate stride. With greater emphasis placed on release speed for the current javelinists along with greater angles of release required, it is possible that minor increases in “lean back” may be needed in order to increase the acceleration path with the ultimate aim to increase the release velocity (Bartlett & Best, 1980). Indeed, in the past a long flight time achieved by jumping up off the left leg (impulse step), has been considered beneficial because it allows the thrower to advance the right leg in front of the center of gravity before foot strike thus, enabling the thrower to achieve the lean back position. On the other hand, this kind of reasoning does not account for any reduction of the forward momentum of the thrower, which is simply caused by the shock of landing on the right foot. In addition, a high flight may cause a premature throw as the throwing arm is flexed and lowered resulting in shortening the acceleration path (Morris, Bartlett & Fowler, 1997). Indeed, many world-class throwers nowadays exhibit minimum or no “lean back” as they make the transition from the impulse to the soft step as they arrive in the penultimate step. Titow (1996) mentioned that an accentuated lean back cannot be realized at high approach speeds. Ihalainen (2006) has proposed a rather upright orientation of the torso (Figure 1) during the landing on the back leg by describing as optimum position a position that will have the throwing shoulder approximately in line with the foot of the back leg at the moment of right foot landing in the penultimate step. In doing this, the thrower may be able to better maintain the velocity gained from the run up right into the final stride as he attempts to impart as great velocity to the javelin as possible. Implied here is the possibility that a “lean back” position (Figure 1), may allow the thrower to increase the acceleration path while at the same time it may also decrease the horizontal velocity of the center of gravity of the thrower at the moment the front (block) foot hits the surface. Indeed, data from elite throwers who employ one or the other pattern show that those who maintain a more upright torso orientation during the soft step also achieve a higher velocity of the center of gravity right at the conclusion of the penultimate stride (Ihalainen, 2006). Of importance in figure 1, is the position of the left leg during right foot contact. That leg should be already advancing forward during this phase in preparation for a quick left foot strike. Therefore, to maintain the forward momentum generated in the run up, the right foot must be active during its landing after the impulse step.
Figure 2. The “getting out of the way” of the right knee during the penultimate step. At right, note the tendency of the right foot to invert, an action which implies that a push off from that foot is unlikely to occur.

THE ACTION OF THE RIGHT LEG

The horizontal translation movement, which should be quite obvious during the final stride, has two possible sources (Tidow, 1986). The first source is the velocity that has been developed during the approach run, although it may have been reduced somewhat during the landing on the right leg (soft step) following the impulse step. The second possible source is by a horizontal push of the knee of the right leg. Because of this possibility, many coaches stress the drive of the right hip into the throw. However, it is a fact that the majority of top-level javelin throwers these days demonstrate a more passive right leg “tilt” during the delivery phase. This tilt looks like if the already pointing forward, knee “gets out of the way” (Figure 2). In this fashion, the right knee does not push off upwards but rotates rapidly forward and downwards. As Gorski (2003) pointed out, trying to drive or push off with the right leg implies a slowing down to feel the body weight and the subsequent thrust of the right leg, an action that results in losing forward speed. This way, the eventual throw is the product of a willful forced action as opposed to a (desired) reactionary reflex as the thrower speeds into the plant. With a higher speed carried into the plant, the thrower does not strive for an accentuated hip strike but presses the pelvis right into the bow tension position, an action which requires less time. It seems that this can better be achieved if the thrower keeps the right knee and foot pointing diagonally forward. In both styles the common elements are that the thrower should strive to land the plant foot as quickly as possible and because of that, the right leg should show no knee extension with no attempt to lift the whole system but work in a forward direction only. In so doing, it is preferable that the right heel not touch the ground at any moment during the final position and release. In this fashion, the thrower is enabled to essentially “run” into the plant leg instead of waiting for the back leg to help push him into it. Similarly, the thrower’s aim during the impulse step should be to “get off the left (the impulse) to get on the left (the plant),” a cue that emphasizes the transient role of the back leg (right) as the thrower assumes the final position just before the actual throw commences.

THE ACTION OF THE BLOCK LEG

A fast arrival at the final stride will not guarantee a high velocity of release. This high velocity of the center of gravity must be used so that the torso also effectively rotates forward fast (Murakami et al. 2006). To achieve this, two important elements must be observed. First, the block (front) leg should be “firm” and “unyielding”, if not perfectly straight, the latter being a task very difficult to achieve even by top throwers. Essentially, the function of the block is to accelerate the larger body segments to begin the delivery of the javelin. In this fashion, the block serves as the spark that initiates the transfer of kinetic energy from the lower body to the upper body (Morris, Bartlett, & Navarro, 2001). This is supported by findings of an observed inverse relation between block leg knee flexion and throwing distance (e.g., Murakami et al., 2006). Whiting, Gregor & Halushka (1991) suggested that there is a flexion/extension mechanism during left leg planting. That is, there is a flexion of the knee, which is allowed by a controlled and active lengthening of the quadriceps that has the potential for energy absorption, and that there may be an optimal amount of flexion, in the longer throws, before the final extension of the knee, leading to the release of the javelin. Second, the placement of the left foot in front of the center of gravity is a factor that will determine not only the total reduction in horizontal speed but also it will affect the rate of the deceleration of the center of gravity. Throwers who are able to reduce the horizontal velocity of the body’s center of gravity by the greatest amount during the period between front foot planting and release may have the advantage and throw the furthest (Morris, Bartlett, Navarro & Viitasalo, 1995). A rapid deceleration (see Figure 3), immediately after the front foot landing, will probably affect the amount of stretch placed on the abdominal and trunk muscles, the aim being to evoke a more dramatic reactionary reflex from those same muscles. It is believed that the desired reflex will help the shoulder achieve its highest speed, right after the front foot strike, as a result of a rapid rotation and lateral flexion of the trunk (Morris et al., 1997).

Moreover, after the left foot is planted, approximately 38 percent of the total delivery time remains. At that same moment the javelin has achieved only 30-40 percent of its final release velocity. Given that this phase lasts between 0.11 to 0.14 seconds in elite javelin throwers, the process of the transfer of the kinetic energy is critical to the success of the throw. In this respect, a rapid increase in kinetic energy occurs via the blocking process and it is the magnitude of the kinetic energy values that differ between elite and other throwers, that difference being primarily due to the greater level of conditioning of the former throwers (Morris et al. 2001).
EFFICIENT TRANSFER OF ANGULAR MOMENTUM

There are two main elements to be considered as the thrower attempts to generate force to be imparted on the javelin. The first has to do with strength. The other more important technical element in javelin throwing is the orderly activation of the limb movements. This somewhat complex throwing skill consists of coordinated accelerations and decelerations of the various body segments in a way that maximum angular velocities of segments occur in a timed sequence from left foot to right arm with the aim being to produce maximum throwing speed at the moment of release. To make the delivery as effective as possible, throwers accelerate the larger body segments so that the smaller segments such as the wrist and the hand have adequate momentum towards the end of the movement. Indeed, major differences in technique between throwers occur in those distal segments, i.e., the elbow and the wrist, during the latter stages of the delivery (Morriss & Bartlett, 1996). This is logical given the fact that for a top thrower, more than 60 percent of the javelin release velocity can be achieved in the 60 ms before release. For this to occur, the thrower must create both large muscular force and at the same time accelerate the distal segments by following a very coordinated pattern. As hinted above, a properly firm left leg is of great importance in transferring the run up momentum to the other parts of the body. As the throwing arm and the javelin are relaxed and are left as far back as possible during the impulse step leading to the final stride, there is no impulse available form the right foot which tends to "flop" over after the planting of the left foot (Figure 4). Data analysis show that the basic order in which the peak velocity of the involved body segments occurs is: hip, shoulder, elbow, javelin. Peak velocities of the various segments are reached earlier for the larger and closer to the center of gravity body segments and later for the smaller and further out from the center of gravity segments. The optimal timing of this order could be individual-specific for the hip-related element. Some throwers may reach top velocity of the hip before front foot plant while some others continue to experience an increase in hip speed after front foot plant. Best et al. (1993), found that those throwers who reach top hip velocity after front foot planting, achieve higher values of percentage of speed of the center of gravity remaining at release as well as higher values of horizontal speed of the center of mass at release. This finding seems logical since the left leg, in the better throwers, is braced firmly, thus enabling the thrower to maintain a high horizontal speed at release as well as the ability to generate high impulse. Therefore, as the left leg braces, the right knee and hip would tend to rotate rapidly using the left leg as a pivot. It seems then that the capacity to generate hip speed cannot be examined separately in this kinematic chain and it is precipitated by other more important technique elements. However, top velocity for the right hip should precede that of the right shoulder. This can occur easier if the right foot plants on its toes and has a rather vertical positioning. If the positioning of the foot is sideways, both hip and shoulder will tend to move forward at the same time thus, losing all or part of the deliberate asynchrony of the activation of the body segments. Generally, a large hip angular velocity brings about, a) a hyperextension and, b) a rotation of the trunk about the vertical axis (Tsarouchas & Giaouroglou, 1986).

THE ACTIONS OF THE THROWING ARM AND SHOULDER

During the penultimate stride, the throwing arm should be extended but still relaxed and have a mostly horizontal alignment. If the arm drops it will be difficult or impossible to achieve the necessary hyperextension as described above. In seeking an extended position of the throwing arm as the left foot plants, the thrower is theoretically attempting to elongate the acceleration path of the javelin. Although this may be advise many coaches advocate, many top throwers have not followed such a pattern and they seem to have their elbows more or less flexed. That flexion has been observed to be as much as 123 degrees for an 89.06 m. throw, with 180 degrees being a completely straight arm. An earlier flexion of the throwing arm elbow may suggest a muscle recruitment pattern that is not optimal (Morriss et al., 1997). This may seem logical but the fact is that the final release action in javelin throwing is characterized by a “pulling” and a subsequent “striking” action, and that it is the highest release velocity that the thrower is after. If a thrower with a flexed elbow manages to achieve the all important delaying arm position before the striking action, which is characterized by a throwing arm that is flexed around 90 degrees and is positioned well back ready to “strike”, then the amount of the initial flexion of the elbow (at left foot planting) may not be as significant (Tidow, 1986). That is, it is inevitable that an initially extended arm will have to be flexed any way in the ensuing “bow” phase that follows the left foot planting. The difference between many beginner javelin throwers, who prematurely involve and flex the throw-

![Figure 3. Changes in speed of the center of mass (%) from the time of left foot planting (left side of chart) to the moment of release (right side of chart) for two different throwers. Adapted from Morriss et al. 1997.](image-url)
ing arm during the final stages of
the throw, and an experienced
thrower is that the former throwers
never manage to go through the
"bow" phase and the throwing arm
continues to move to the front
without achieving any "delaying"
striking action.

Once the "bow" position has
been achieved, the right shoulder
flexes and abducts horizontally
while at the same time the elbow
flexes, an action that reduces the
inertia about the shoulder axis and
allowing for a faster movement.
As the humerus also rotates laterally,
this position is characterized by an
elevation lead (Figure 4) which refers
to the lead of that joint ahead of
the javelin's center of mass and not
ahead of the shoulder axis as some
may propose. This assumed posi-
tion is of paramount importance
to help produce the response of the
rotators of the humerus which will
in turn cause a rapid rotation of
that segment accompanied by a
rapid elevation extension. Whiting
et al. (1991) suggested that one of
the most critical parameters appears
to be the maximum elevation velocity,
which has been found to be closely
related to release velocity. The elevation angle at release has been
shown to be quite small in elite throwers (Murakami et al.,
2006). Ariel, Pettito, Penny & Terauds (1980) observed maximal
humerus angular velocity right at the moment of release in an
elite javelin thrower as opposed to less experienced throwers
who released the javelin with the humerus at zero angular
velocities. Interestingly, high javelin release speeds can be
achieved by relying on different shoulder, humerus and elevation
action pattern. The gold and silver medalist in a world
championship achieved the same release velocity. However, the gold
medalist relied more on a lateral rotation of the trunk with a
powerful medial rotation of the humerus and elevation of the
elevation joint. The silver medalist relied more on extension of
the shoulder joint accompanied by a moderate degree of
medial rotation and elevation of the elbow joint. Observations
like this address the possibility of individual variations in the
emphasis of the various limb movements in javelin throwing
also suggesting the possibility for different training regimens
to facilitate those individual patterns of execution (Morris &
Bartlett, 1996).

THE "UNDER THE JAVELIN" POSITION

Another action that should be observed during the final
strike, as the thrower attempts to release the javelin, is the of
positioning of himself "under" the javelin (Tidow, 1996). During
this movement (Figure 4) the flexed elbow joint of the right arm
is at approximately shoulder level with a tendency to move
upwards. This upwards movement of the elbow is the moment
when the "bow" phase eventually "unwinds" and "strikes" the
javelin to its maximal acceleration. From a mechanical point
of view, this is possible when the javelin is in a vertical position above
that bow. In this fashion the thrower (the bow) can act squarely on
the center of gravity of the javelin in the direction of the throw. This positioning
of the thrower under the javelin is characterized by a sideways
movements towards the left, leaning of the torso
to facilitate the javelin release over
the plant leg. This lateral leaning is
caused by the limited anatomical
function of the shoulder joint. If the
sideways leaning of the torso were
not present, the throwing arm would
not be able to be in a position closer
to the top of the stretched bow. The
amount of this sideways leaning of
the torso has been the subject of
plenty of speculation as far as advising
a thrower to actively bend side-
ways or not. Murakami et al. (2006)
found no relationship between the
amount of lateral rotation of the
trunk and distance thrown, while it
was found that a positive relation-
ship exists between forward rotation of
the trunk at release and distance
thrown. Another mechanical ele-
ment as the thrower goes "under the
javelin" is that of the positioning of
the right flexed elbow at shoulder

STABLE THROWING BASE

The javelin leaves the hand roughly when the latter is
approximately in line (vertically) with the foot of the plant leg.
Since release velocity is the most important aspect of the
throwing action, the thrower should maintain full contact with
the ground using the whole left foot and the upper toes of the
inverted right foot. This is because a slinging movement can
occur only if there is a stable, fixed base to sling the javelin off
from (Figure 5). More specifically, once the back leg is off the
ground, the "stretched bow" position is compromised and the
resulting "whip" of the bow is considerably less effective. While
angular momentum of the system is generated during both single
and double support, the transmission of angular momentum
to the throwing hand and javelin occurs only during double
support (LeBlanc & Dupena, 1996). Consequently, it should
be considered a serious error when the right foot loses contact
with the ground before javelin release.
CONCLUSIONS

Since release velocity is a strong prerequisite for long throws, strength and power are very important in javelin throwing. Still, the importance of finesse in javelin throwing cannot be underestimated. With this in mind, the javelin throw is not just an arm throw but a whole body endeavor. The approach run allows the thrower to obtain a proper velocity and accelerate the athlete-javelin system. Following, there is an orderly, active, even violent, positively and then negatively accelerating process of the various body segments, which is greatly facilitated by the bracing left leg and foot. This process propagates from bottom to top and during its duration, less and less mass needs to be moved while at the same time an increased acceleration of each successive body segment is observed. This results in a considerable increase in the velocity of the distal end of the whole movement, namely, the throwing hand and the javelin. Such is the nature of the “whip” in javelin throwing and it is in the heart of an effective throwing ability. Obviously, a well-executed throw needs to occur effortlessly with the thrower working consistently on finesse until it becomes a regular part of the execution of the javelin technique.

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REFERENCES


