2007 Critical Factors Research Update for the Rotational Shot Put

by
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Critical Factors Project

- The high performance division of USATF commissioned research to determine what variables were most critical to success in the shot put
- The objective of the project is to put U.S. throwers on the medal stand at World Championship and Olympic Games

Subdivisions of the Throw

- Previous research and coaching literature have used events in the throw as divisions for dividing the throwing action into several phases
- Using easily identifiable events aids in analyzing characteristics of the throw

Subdivisions of the Throw

- To facilitate interpretation of the data the throw was sub-divided using phases of support (single & double) and non-support
- Previous research has used the same approach (Grigalka, 1970; Kristev, 1971; McCoy et al, 1984)

Pre-Flight Phase

- All preparatory and extraneous movement occurring prior to the moment of takeoff

Takeoff

- Takeoff (T.O.) is the moment at which the thrower's support foot breaks contact with the surface of the throwing circle and the thrower enters a period of flight

Flight Phase

- The period following takeoff during which the athlete enters a period of non-support

Rear Foot Touchdown

- Rear foot touchdown (RFTD) occurs the instant the throwing-side foot makes contact with the throwing surface after the flight phase

Transition Phase (Early Delivery)

- The transition phase is the period between rear foot and front foot touchdown

Front Foot Touchdown

- Front foot touchdown (FFTD) occurs the instant the non-throwing-side foot makes contact with the throwing surface

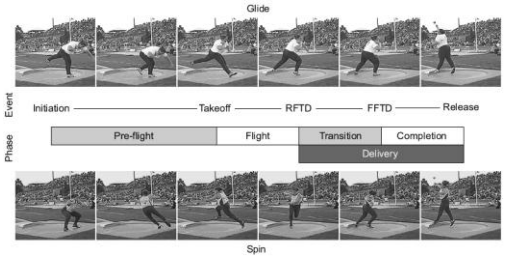
Completion Phase (Late Delivery)

- The completion phase is the period of time between FFTD and release

Release

- The instant the shot breaks contact with the thrower's hand

Phases of the Throw



Examined Parameters

- Implement Parameters
  - Velocities
  - Accelerations
  - Angles
  - Height
- Performer Kinematics
  - Joint and Segment Angles
  - Temporal Parameters

General Objectives

- Maximize implement velocity while releasing at an angle, height and horizontal release distance that are suitable for high level performance (while still permitting a fair throw)

Attaining Objectives

- Several mechanical and biological principles underlie attainment of this objective:
  1. Length of the implement acceleration during the delivery phase
  2. Speed of the performer's movement during the delivery phase
  3. Attainment of positions which allow the athlete to generate the greatest quantity of force in the direction of the throw
  4. Development of conditions which allow the athlete to produce a legal throw

Critical Factors

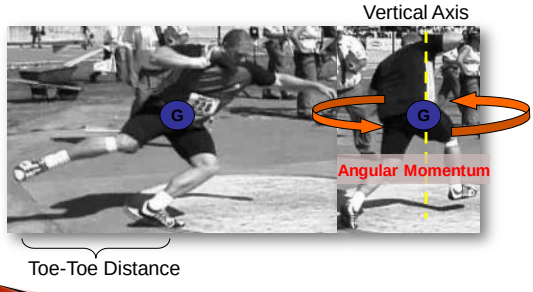
1. Long sweeping free leg
2. Greater vertical displacement of COM during flight
3. Greater rear leg knee flexion at RFTD
4. Optimal shoulder-hip separation during delivery
5. Short transition time
6. Maximized kinetic linking
7. Front leg extension at release
8. Optimal angle of release

Long Sweeping Free Leg

Long Sweeping Free Leg

- The further an athlete can increase the radius of the swing leg while still maintaining balance the better

Long Sweeping Free Leg



Long Sweeping Free Leg

- A long sweeping action of the swing leg increases the angular momentum at takeoff
- This will help to increase angular velocity when the thrower makes RFTD and brings the leg in closer to the body

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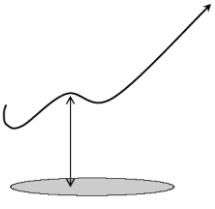
Greater Vertical Displacement of COM during Flight

- Contrary to previous theory greater vertical displacement of the athlete-plus-shot system can actually be beneficial

Greater Vertical Displacement of COM during Flight

- Plyometrically load the lower extremities for a more powerful delivery of the implement
- Athletes with lesser eccentric strength qualities may not be able to handle the loads on the rear leg



Intro for Critical Factors 3 & 4

- The trunk is more upright in rotational throwers when compared to their counterparts using the glide
- In theory this reduces the horizontal and vertical trajectory along which the implement could be accelerated in the final moments of the throw

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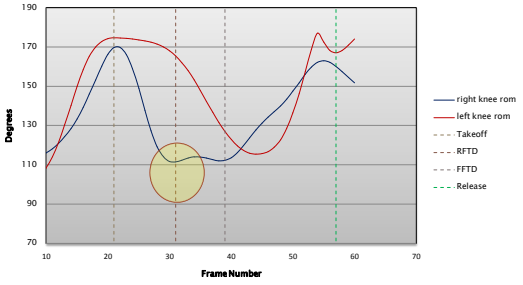
Greater Rear Leg Knee Flexion at Rear Foot Touchdown

- The best athletes make RFTD with a greatly flexed rear knee and grind the foot causing the athlete to both turn and lift while in single support
- The optimal degree of knee flexion is highly dependent on an athlete's strength

Rear Knee Angle

- The throwers make RFTD with between 105° and 115 ° of knee flexion

Rear Knee Flexion



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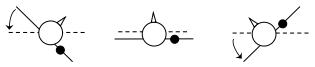
Optimal Shoulder-Hip Separation

- Refers to the differential angle between the shoulders and the hips at the RFTD



45 degree separation (positive) | 0 degree separation (neutral) | -45 degree separation (negative)

Optimal Shoulder-Hip Separation

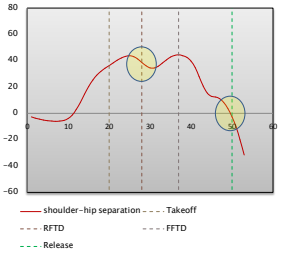
- Increased shoulder-hip separation creates greater pretension in the trunk musculature and increases the range over which the implement may be accelerated

Optimal Shoulder-Hip Separation

- Shoulder-Hip separation angles should be between 50 and 70 during transition phase
- For spinners, a long sweeping swing leg will assist in increasing shoulder-hip separation
- Separation should progressively decrease up until the point of release

Shoulder-Hip Separation

- The optimal angle for any given athlete will be somewhat dependent on the strength and power of the thrower



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Short Transition Time

- The shorter the time interval between RFTD and FFTD the better

Short Transition Time

- Shorter transition times are highly correlated with greater shoulder-hip separation during the transition and at FFTD
- This equates to greater pretension in the trunk musculature and allows the athlete to begin the double-support delivery sooner

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Understanding the Kinetic Linking

- The kinetic link is a combination of two principals:
  - Acceleration of distal segments by proximal segments
  - Conservation of momentum
- The kinetic link is a good indication of how well the athlete is appropriately sequencing the activation of joints to produce the most efficient movement pattern for performance

Maximizing Kinetic Linking

- After FFTD, sequential acceleration and rapid deceleration of the hips, then shoulders and then arm should be observed
- Summation of speed by each segment

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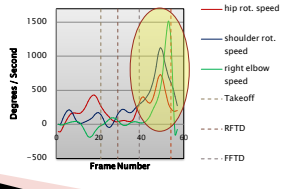

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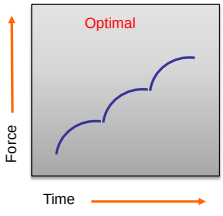
Front Leg Extension at Release

- Early or late front leg extension will create an inefficient summation of forces from each segment
  - This will result in decreased velocity at the moment of release and will produce less than adequate horizontal breaking forces

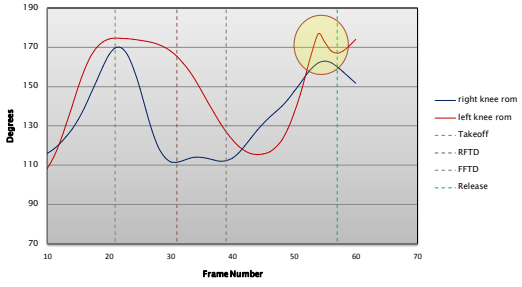
- The front leg should extend fully <u>just prior to the moment</u> of release

Front Leg Extension at Release

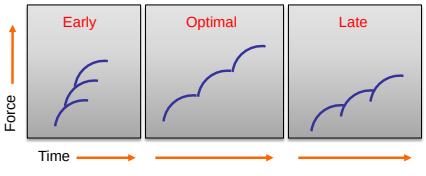
- Ideally, the forces generated from a given segment occur as the preceding segment action has reached its maximal force output
  - In doing so, the sum of all the forces will be greater



Front Leg Extension



Front Leg Extension at Release



- If forces are generated too early or too late forces will not summate to their greatest potential
- The front leg is key in developing optimal summation of forces at release

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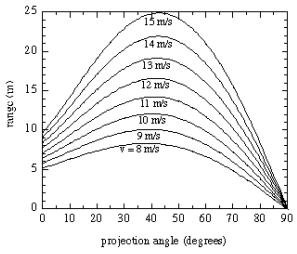
Optimal Angle of Release

- According to the mathematical model of projectile motion, the optimum angle of release for an elite level shot putter is about 42
- This however is not the case in the real world



(Maheras, 1995)

Optimal Angle of Release

- The predicted 'optimal' release angle assumes that release velocity and release angle are independent which they are not:

Release Angle ↑ = Release Velocity ↓

- Release velocity is by far the most important variable in the projectile motion equation → we want to MAXIMIZE release velocity

Why the Discrepancy?

- There are two main reasons for the difference between the mathematical 'optimal' and the real world optimal release angles:
  - As the angle increases the athlete must expend more energy in overcoming the mass of the shot and less effort is available to develop the release speed of the shot
  - The structure of the human body favors force production in the horizontal direction

So What is the Optimal Angle of Release?

- It appears that the optimal real world release angle is significantly less than the predicted 'optimal'
- A release angle that is within the range of 32-38 would be the best for maximizing the projected distance of the shot

THANKS