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FUNDAMENTALS OF SHOT PUT TECHNIQUE

The glide shot put has increasingly become somewhat of a technical relic. The USA, which was the birthplace of the Glide technique, was for many years the sole proprietor of the newer rotational style in international competitions. However, as other countries continue to adopt the spin style technique of shot putting, many World Championships and Olympic medals are being won by foreign born spin shot putters. As a technical trend, the spin style of shot putting is increasingly popular.

Nevertheless the glide technique maintains relevance, and occupies a valid position as a competitive technique, as well as a technical progression. Developmental and High School throwers can learn the basic technique with relative ease. Many of the skill acquired within the glide can be utilized if the thrower is later converted to the rotational technique.

Glide Style Shot Putting:

1. The Grip and Placement of the Implement
    a. Place shot on upper pad of hand
    b. All fingers should be placed on the shot
    c. Gliders generally tuck the ball under the chin, forward of the point of the jaw below the ear.
2. Starting Positions
    a. Crouch Start
        i. Offers greater stability and consistency of performance
        ii. Requires a greater level of leg strength
    b. T & Slant T Start
        i. Offers an greater opportunity to convert the velocity of the mechanical potential, that exists via vertical displacement of CMT, into horizontal velocity across the ring
        ii. Requires a greater level of timing and skill to gain technical consistency
3. The Glide Sequence
    a. The Trunk should be actively, or passively as in the case of the T Start, lowered until the lower abdomen, and the upper thigh are in contact.
    b. The CM should be displaced/ un-seated to initiate the glide across the circle.
    c. Drive/ Support leg
        i. The drive leg should explosively and fully extend in a direction and angle that will project the CMT upward from the lowest point, at the back of the circle, toward a relatively middle level at the center of the circle.
        ii. The thrower should seek to maintain the contact of the lower abdomen with the upper thigh throughout the full extension of both the drive leg, and the extension leg.
    d. Extension/ Free leg
        i. The free leg should be used to balance the preliminary movements, and positions, of the thrower, during the initial single support phase.
        ii. The free leg should be drawn into nearly an identical position of flexion relative to the support leg.
        iii. Following the initial displacement of the CMT prior to the explosive extension of the support leg, and almost simultaneously, a full and rapid extension of free leg towards toe-board target must occur to aid in the shift of thrower across the circle.
            1. The elastic energy stored in the groin/ hamstrings, as a result of the complete extension of both legs, aid in the recovery of the support/ drive leg under the thrower in the center of the circle.

2. The height of CMT at the back of the circle, preceding the extension of the free leg, aids in determining the height of the free leg extension target.
3. Target of free leg extension should generally be between the bottom of the toe-board (0”) and about 18”.
4. The lower the CM at the bottom of the support stance in the back of the circle, the higher the extension leg target.

iv. The direction of extension leg determines throwing line of direction.
1. Standard treatment of the extension/ free leg includes an extension in line with the left sector line (*left as the thrower faces the throwing impact area).*
2. An optional treatment of the extension/ free leg includes driving the free leg straight across the circle, while moving the support/ drive leg foot across the centerline of the circle toward the right side of the circle (*right as the thrower faces the throwing impact area*).
3. Hip axis alignment, relative to the shoulder axis, and foot axis, remains identical although the foot placement is slightly different in the circle for each of the techniques.
4. In the standard technique the heel of the extension leg foot is aligned with left sector line (*for standard alignment*)
5. In the modified technique the toe of the extension leg foot is aligned with centerline of circle (*for non-standard alignment).*

Rotational Style Shot Putting:

1. The Grip and Placement of the Implement
    a. Place shot on upper pad of hand.
    b. All fingers should be placed on the shot
    c. Spinners generally place the ball into the neck behind the point of the jaw below the ear.
    d. This shot position counteracts the effect of centrifugal forces that tens to pull the shot away from the neck of the thrower.
2. Double Support/ Starting Position
    a. The initial position of double support in the rotational style shot put is much like the initial position in the discus.
        i. The goal should be to initiate the single support phase from a viable double support posture.
        ii. Requires a shift of CM over the single support base of support to create dynamic balance.
    b. Shoulder and hip axis should remain horizontal throughout single support phase.
3. First Single Support phase
    a. Drive/ Support leg actions
        i. As the thrower lines up in the throwing direction an abbreviated, bur explosive, drive phase off the support leg should be initiated.
        ii. This drive phase push off is markedly shorter than that of the discus technique.
    b. Swing/ Free leg actions
        i. An aggressive, and dominant, swing leg action should be initiated at the outset of single support (i.e. once the swing leg foot clears the ring).
        ii. The rotational shot put relies to a greater extent on the impulse provided by the swing leg to create force, as well as torsion, in the throw.
4. Non Support Phase
    a. The athlete should actively “heel tuck” and adduct the drive leg as the push off is completed.
    b. The Swing leg side should be actively inverted at the conclusion of the free leg swing/ kick in.
    c. The free arm should be shortened to aid in the rotation of the athlete in no support.
    d. Otherwise the position achieved at the conclusion of the single support phase should be maintained throughout the non-support phase and the re-contact of the second single support, and double support phase.
5. Re-contact Second Single Support Phase
    a. Re-contact of the swing leg foot axis in single support is earlier than the corresponding phase in the discus. The foot axis should generally be about 270- 315 degrees.
    b. A soft turning re-contact of the swing leg reduces friction, and sets up an short duration of second single support.
    c. This soft pivot also aids in the development of a stretch reflex action in the swing/ free leg for use in the delivery phase.
    d. The free arm should move out an away from the body to slow the upper-body to aid in maintaining the torsion between hip axis and shoulder axis.

6. Second Double Support Phase
    a. The double support is the initiation of the Power position
    b. Power Position comparison between the glide and rotational techniques
        i. The glide technique power position in the middle of the circle is relatively the same as that of the rotational technique.
        ii. The glide technique tends to have a less vertical posture of the trunk relative to the rotational technique posture of the trunk.
        iii. The glide technique has many different expressions; however they each tend to utilize a broader base than the spin style of shot put in the power position.
    c. The rotational technique generally uses a long drive phase out of the back coupled with a shorter base in the power position.
7. Delivery Sequence
    a. Thrower should turn in the direction of throw while maintaining torsion between the hip and shoulder axis
    b. When the hip axis is near perpendicular with the throwing direction the thrower should actively unwind the torsion, while still maintaining the position on the implement.
    c. The final movement is an active turning/ jumping from the legs, followed by the slapping action once the ball has been lifted to above the head from this action of the legs.
    d. Keep the hand moving behind the shot, and try to maintain pressure/ contact as long as possible
8. Free Arm Actions Cont.
    a. Generally the novice to intermediate thrower should be instructed to keep the free arm long, relaxed, and away from the body through throw. This aids in maintaining torsion during the throw.
    b. The exceptions to this would be the non-support phase of the throw, and the delivery sequence.
    c. Shortening the free arm lever during non-support, while maintaining shoulder axis torsion, aids in angular/ rotational velocity.
    d. Free Arm axis should not be "broken" to a large extent at shoulder axis to maintain torsion (i.e. dragging a left arm).
9. Skill identification, and support (through drills, and parallel movements should be primary in coaching technical introduction, and instruction of Shot Put
    a. Teaching Considerations
        i. Seek to create specific learning periods with objective emphasis
        ii. Introduction *(skill, drill, instill)*
        iii. Stabilization- occurs through repetition of learned movements
        iv. Habituation - through repetition of stabilized movements
    b. Create general to specific motor learning
    c. Utilize visual aids early
    d. Still frame, or digitized figures offer a simpler input than video for beginners
    e. Video aids in creating spatial/ rhythmic awareness
    f. Advanced level training partners
    g. Control outside input during teaching, and introduction period
    h. Pick appropriate technical models for throwers
    i. Limit outside coaching (includes other athletes)
    j. Duration of Non-Support phase/ Second Single Support

<u>Developing an Efficient Discus Model:</u>

The discus throw allows for a wide range of individual expression of the technical fundamentals. Current successful technical expressions of the discus cover a wide variety of styles and philosophies of throwing. The physical parameters of successful discus throwers, on the world stage, indicates the necessity for well above average size. For example world class male discus throwers tend to be about 1.95m/ 115kg. However exceptions to these physical parameters readily exist on both the national and world levels. The athletes who comprise these exceptions typically compensate for physical deficits with a particularly exceptional specific physical talent(s), and/or an exceptionally well adapted technical model.

The dynamic nature of the discus movement has historically witnessed a variety of successful technical expressions. Many of these utilize large and sweeping movements to accomplish mechanical advantage within the throw. Those technical models will continue to be successful. The technical model should seek to maximize the athlete's particular physical attributes (I.E. system of levers, range of movement, bio-motor capabilities). **The technical model to be presented and discussed in this article is meant to pare down the movements of the discus thrower to a bare and essential minimum.**

The objective in restricting the variables of the technical movement within the discus model is meant to create a system of throwing which is efficient, and easy to replicate as a model. The efficient technical model promotes consistency of expression via repetition, faster progression toward habituation of movement, and offers the opportunity of lower degradation of the quality of movement due to competitive stressors. In addition, this type of model can offer coaches a simple and precise task oriented teaching progression. The successful lowering of the minimum physical parameters necessary for high level success, offered by an efficient technical model, may also offer coaches a greater population with regard to athlete selection.

ESTABLISHING SYSTEM AXIS

A key and central element of the technical model being presented is a stable and consistent axis of the thrower-implement system. This system axis must be established and maintained throughout the throw. Athlete posture is the basis of this efficient dynamic axis. **The development of an efficient axis can be accomplished by stabilizing the trunk axis in an upright posture with the hips tucked under the athlete during the preliminary wrap of the discus.** This vertical posture should be maintained throughout the entire throw, with the exception of the axis tilt in the power position.

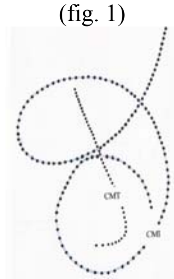
> ***Coaching Cue:*** The coach should introduce, and consistently cue, the athlete to maintain an erect posture with the hips stabilized and tucked underneath throughout the learning process. Posture precedes balance.

The objective of establishing this axis is intended to minimize head radius of the athlete throughout the entire movement. The error of excessive lateral deviation of axis is best observed when viewing the athlete from the back of the circle and towards the throwing direction, or 180◦ . The goal is to minimize any lateral deviation (I.E. wobble) of the axis. This stable and efficient axis allows forces imparted to the system, such as the push in the direction of the throw off the single support base out of the back of the circle, to result in a corresponding increase in forces available to be applied to the discus during the delivery phase. If the axis remains efficiently stable, the treatments of the free leg, drive leg, and CMT displacement can be organized to create effective resultant forces for the discus delivery. An efficient system axis allows for effective maintenance and use of separation/torsion, in the form of stored elastic energy, within the throw delivery.

PATHS OF CENTER OF MASS

An additional technical goal of the athlete during the discus throw should be the creation and use of dynamic / directional displacement of the center of mass. **An efficient technical model should seek to align those forces generated parallel with the intended direction and angle of projection of the throw.** This aim should be achieved while creating a dynamic and specific directional balance of the thrower-implement system about an efficient axis. Direction, paths of the thrower/implement system, and angel of implement projection should be taught early and often within the teaching progression of the discus throw. Paths to be covered should include the paths of Center of Mass of the Thrower (CMT) and Center of Mass of the Implement (CMI) and with intended angles of projection and orbital considerations. Development of the awareness of these paths by novices, early in the learning progression, can be effective in the development of spatial and kinesthetic awareness of the athlete. At the outset of the discus movement the transition from double support to single support necessitates a shift of the CMT toward the single support base. The degree of this shift over the base of support is relative to the degree of Center of Mass displacement / counter in the direction of the throw (i.e. hip counter). In order to create an effective throwing direction the necessary path of the CMT is roughly as follows (see fig. 1)**.**

(fig. 1)

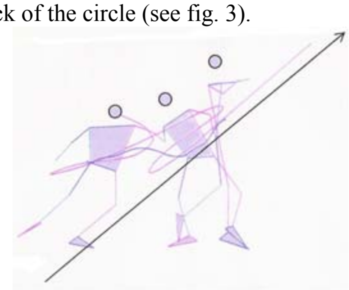


ALIGNMENT OF FORCES

The actions of the swing/ free leg and the push off of the drive / support leg aid in establishing the intended path of projection of the implement. The CMT and the forces established by the swing/ free leg and drive/ support leg out of the back of the circle combine to create a resultant which is ideally parallel to the discus projection path. Those forces should be directed as closely as possible to align with both the intended angle of projection, as well as the directional path of the implement. The direction of the push out of the back of the circle should be aligned with the path of the CMT (see fig. 1). The push direction may require modification, due to the actions of the free/ swing leg, so that the resultant system direction is accurate to the intended path. Reduction of deflected forces makes it easier to apply those forces generated during the throw into an efficient delivery sequence. This efficiency of movement offers either higher performance for a given level of forces generated or equal performances with less force required, relative to a less efficient model of throwing.

The discus orbit is a resultant of the system axis and the forces applied to the thrower-implement system. The push off of the first single support establishes the direction of CMT, as well as the pitch angel of the orbital plane. When viewing the throwing movement from 90◦ to the side in the throwing direction, **the angle of the push off of the single support leg should be applied parallel to the desired angle of projection of the implement** (see fig. 2).

Coaching Cue: Single support push angel alignment can be determined by checking to see that the angle of the lower leg (tibia) is parallel to the angle of projection of delivery, when the athlete executes the push out of the back of the circle (see fig. 3).



(fig. 2)

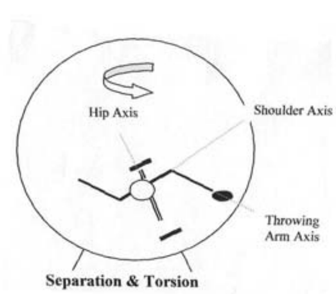
The discus orbit should be symmetrical. A symmetrical orbit is evident when the implement is neutral, relative to horizontal, at both 90◦ and 270◦. There should be minimum roll of the orbit on the longitudinal axis. Applying forces within a symmetrical orbit aids the efficiency of the thrower + implement system upon delivery.

Coaching Cue: Orbital mistakes, such as late high point or "scooping", should be addressed by developing proper axis, and proper alignment of forces with regard to both direction of CMT and angle of projection.

SEPARATION AND TORSION

Separation and torsion are distinct skills that are required in the discus throw. **The elastic energy that the combined movements of torsion and separation provide serves as the primary engine for the acceleration of the discus in the delivery.** A technical model that stresses the maintenance of an efficient axis offers the athlete the ability to maintain and utilize separation and torsion to a higher degree.

Coaching Cue: Torsion can be defined as the positive angle, or space, created between the hip axis, and the trailing end of the shoulder axis. Separation can be defined as the positive angle or separation of axis between the shoulder axis and the throwing arm axis as it extends through the CM of the implement. For the purposes of this article, and to better distinguish between the aspects of these energy storage systems, the terms total lead/ Space will be used to define the cumulative amount of torsion and separation (see Fig. 3).



(Fig. 3)

Separation & Torsion

In the case of each of the skills of separation, and torsion, the thrower can pre-stretch the agonist active muscle groups, and thereby facilitate and maximize the storage of elastic energy. In addition to creating the ability to exploit the stretch reflex, the throwing side arm/ lever, and trunk, range of motion are maximized through these actions/ movements. Proper delivery timing will generate the conditions optimal for the efficient summation of forces and delivery sequence.

SEPARATION

When properly executed both separation and torsion offer the thrower an opportunity to maximize bio-motor and mechanical components of the throw. Separation can be achieved if the athlete contracts the triceps, and cocks back the throwing side shoulder.

The contraction of the rear throwing side (*antagonistic*) musculature causes a relaxing of the chest deltoid area (*agonistic*) musculature that increases both the range of motion of the throwing arm lever, and the storage of elastic energy.

> ***Coaching Cue**: The coach should introduce, and consistently cue, the athlete/ thrower early in the learning process to actively contract the antagonistic to the throwing side musculature. Active cues such as "squeeze the backside muscle", or "cock & lock" the rear shoulder and inside head of the triceps aids in maximizing separation. Lowering the throwing side arm increases rang of motion and contributes to proper discus tilt on delivery.*

Over time and as throwers progress in the skill of creating and maintaining separation, it is likely that passive cueing of the skill of separation can be used. This is especially true for those throwers who have gained stabilization of the skill. The passive cueing of separation would be achieved by instructing the thrower to relax, and leave the discus trailing behind the system during the movement as far as possible. The goal of this passive cueing is meant to maximize the total lead in the system.

National and world-class discus throwers can at times lose their separation levels during high intensity throws. The most common cause of this fault is related to an inefficient axis. The problem can also be the result of an especially effective push off of the single support / drive leg out of the back of the circle. The stretch created by an effective push creates stretch through the chest and may cause the discus to "bounce" forward and thus creating slack in the system. While the creation of this negative separation is not a goal of the technique, the cause can be a positive sign of the effective translation of force to the thrower-implement system. The skill of regaining position and the necessary separation level with the corresponding elastic energy can be taught through effective use of drills.

> ***Coaching Cue**:* The Cast & Catch style of the South African drill can be effective for this purpose. This drill can be practiced with balls, puds, pipes, or just about anything that would typically be thrown in training. It may be advisable to use the standard style of South African drill, with a constant total lead, when throwing the discus as the primary drill. This will reduce confusion within the athlete regarding the differing goals between the drills,

The lack of separation of the throwing arm axis relative to the shoulder axis can be simply described as "slack" in the system. Slack becomes evident to the coach by observing the relationship between the throwing arm axis relative to the shoulder axis. A negative separation angle is easily noted as the discus seems to lead the thrower as the thrower-implement system move in the direction of the throw toward the orbital high point. **The negative/ neutral separation angle effectively inhibits the opportunity of the thrower to impart any force to the implement until the slack is removed from the system.** If the separation angle is reduced to any extent, during the conclusion of the first single support or non-support phase, it should be regained prior to the re-contact of the second single support in the center of the ring.

TORSION

Torsion can be defined as the positive angle, or space, created between the hip axis, and the shoulder axis (see Fig. 4). Torsion affords an opportunity to store elastic energy in the torso of the thrower for use during the delivery sequence. The counter wrapping of the free arm in non-support can be an effective means of re-establishing and maintaining torsion. **Actions of the free side arm and shoulder, when combined with active counter rotation and contraction of the torso musculature, will maximize the torsion level between the shoulder axis and the hip axis.** It is possible to establish a torsion position upon the preliminary wrap of the discus movement by "setting" the left shoulder inside the left hip in the initial wrapping movement of the throw. Some athletes are sensitive to the tendency of this early torsion to somewhat inhibit rotation within the throw. However if the axis is efficient, then additional rotational forces can be added via the swing/ free leg inversion, as well as shortening the free arm, to counteract this inhibited rotation. An early establishment of torsion greatly reduces the opportunity for later mistakes that may result in the loss of torsion.

Coaching Cue: The torsion position can be set from the back of the circle by setting the shoulder axis behind and inside the leading side hip axis. Cue the athlete to hold this left shoulder inside the leading side hip until delivery sequence is initiated. Free arm can aid in re-establishing torsion in non-support by casting it in a subtle counter wrap motion.

SECOND SINGLE SUPPORT

The second single support contact phase is a critical phase within the throw, because it represents a major opportunity for the loss of angular velocity of the implement due to thrower-implement system friction. This friction tends to reduce the separation/ torsion level via system deceleration. The loss of separation can be avoided if there is an active cueing of squeezing the throwing side arm/ shoulder back to maintain separation level. This can be achieved by cueing the contraction of the antagonistic/ backside musculature, and/ or an active inversion, or pivoting ahead, of the second single support side both prior to and subsequent to the second double support re-contact (I.E. left foot re-contact for a right handed thrower).

The loss of angular velocity of the thrower-implement system, due to the second single support friction, can also be mitigated by reducing the time between the second single support contact and the second double support contact. **Delaying the re-contact of the second single support in the center of the ring will reduce friction, and shorten the time interval between the second single support contact, and the second double support contact** (I.E. the time between right foot, and left foot touch down for a right handed thrower). This delaying of the re-contact of the second single support foot can be accomplished by lifting the knee of the swing / free leg (right leg for a right handed thrower) during the non-support phase following the swing invert action. The re-contact of the second single support can also be delayed by the active dorsiflection of the swing leg foot. These movements serve to delay the re-contact and shorten the time interval between single support and double support. They also have the added benefit of creating knee flexion and an ankle lock position which aids in the storage of additional elastic energy in the leg for use later in the delivery sequence. The recontact of the second single support should be with the foot axis oriented at, or around, 315 degrees. However, a case could be made for delaying re-contact even later to reduce the negative impact of friction on implement velocities.

Coaching Cue: The athlete should be instructed to turn in the air, not on the ground. The desired angle of the foot axis upon re-contact of the second single support should be approximately at 315 degrees. It is important that the thrower does not stay on the first single support beyond the line of direction of the CMT out of the back of the circle. This error leads to the technical fault of “over-rotation” and results in a poor heel tuck/ heel recovery on the drive leg.

TILT OF AXIS IN POWER POSITION

When observing the axis of the system, from the perspective of 90° in the throwing direction, there should be a tilt of the axis away from the throwing direction when the athlete is in the Power Position (see fig. 4). However in order to maintain effective summation of the system upon delivery, there should still be minimal deviation of the axis (I.E. head radius) in the system axis. The axis tilt aids in establishing the angle of projection of the implement. The axis tilt maximizes the force path of the implement, and thereby the opportunity to impart forces in the delivery of the discus. In addition the axis tilt delays the transition of the CMT in the direction of the throw, which results in a more effective use of forces generated. **The tilt/ orientation of the axis is achieved during the Non-Support phase of the throw.** As the free leg is inverted, and lifted, a center axis of rotation is established. The free arm, and shoulder, is counter wrapped away from the direction of the throw. This wrapping of the free arm side maximizes torsion between the hip axis and shoulder axis, and initiates the tilt of the axis away from the throwing direction. The lower body travels toward the front of the circle, and the tilt is complete. The tilt of the axis is relative to the desired angle of projection of the implement, and the technical proficiency of the thrower (i.e. throwers with greater technical mastery can achieve, and utilize a greater axis tilt).

Coaching Cue: During the learning phase athletes should be instructed to maintain a more erect vertical posture throughout the throw until technical mastery allows the use of greater system axis tilt. Axis tilt should be introduced as the novice thrower becomes more adept at achieving the fundamentals of the standing throw position.


Fig.4

COACHING CONSIDERATIONS

Teaching progressions should be based on task/ skill identification and should develop the athlete toward mastery of necessary skills. The coach should seek to create specific learning periods with an objective emphasis towards specific skill acquisition. The process of skill introduction should follow the following process:

> ***Coaching Cue:*** Repetition of an introduced movement creates a learned movement. Stabilization of a learned skill occurs through repetition of the learned movements. Habituation of a movement skill occurs through repetition of stabilized movements.

- Introduce the skill
- Drill the skill
- Instill the skill *(via repetition)*

The goal of the teaching progression should be to move motor skills along the continuum from learned movements to habituated skills/ movements. Related/ parallel movements and task oriented drills should be used, in conjunction with cueing within the throw, to aid in the learning progression of identified skills. For the aid of developing an appropriate skill progression the following is a non-exhaustive list of skills related to the discus technique:

Task/ Skill Identification

1. Double Support Axis/ Balance/ Posture
2. Hip/ Pelvis stabilization
3. Pivoting in Single and Double Support
4. Transferring/ Countering of CM
5. Single Support Axis/ Balance/ Posture
6. Use of Focal Points
7. Establishing and Maintenance of Torsion & Separation
8. Free Arm Mechanics
9. Swing/ Free Leg Actions
   a. Sweeping
   b. Inversion
   c. Knee Drive/ Lift
   d. Dorsiflection (*ankle lock*)
10. Drive Leg Actions
    a. Sprint/ Push
    b. Heel Tuck/ Recovery
    c. Adduction
11. Maintenance of position Axis/ Balance/ Posture during Non-Support Rotation
12. Recontact Stabilization
    a. Single Support
    b. Double Support
13. Effective Transfer of CM
14. Use of Torsion & Separation in Delivery Sequence
15. Blocking Mechanics
    a. Upper body
    b. Lower body
16. Recovery Mechanics

COMMON ELEMENTS OF SUCESSFUL TECHNIQUE IN THE THROWS

I. BALANCE

The thrower must develop proper static as well as dynamic posture. Posture is the basis for static and dynamic balance in the throws. Balance is crucial to the final result of the throw. An unintended loss of balance inhibits the proper rhythmic acceleration of the thrower/implement system, and reduces the application of force during the delivery sequences. Close attention must be given to the alignment of the body's system of levers and joints. In particular the throwers center of mass (head, trunk, arms, legs, hips) relative to the thrower's base of support and desired direction of travel is an element of any successful throwing technique.

II. DIRECTION

"You ain't going nowhere, if you don't know where you're going". Efficiency in setting up forces in the throwing direction will aid the development of the athlete's spatial/kinesthetic awareness. The athlete should have a clear understanding of the desired direction of travel through the circle. It is not enough to know where the implement is intended to land. The athlete must develop a basic understanding of the direction of the athletes' center of mass, in addition to the desired path, angle and direction of the implement that is necessary to make the implement go where it is intended.

III. ACCELERATION / VELOCITY

The thrower should be encouraged to seek smooth and continuous acceleration of the thrower/ implement system. Acceleration and velocity are not identical, however for the purposes of this presentation may be considered relatively equal. The final distance thrown is largely a result of the velocity of the implement at release. An emphasis should be placed on the smooth and continuous acceleration of the implement to reach maximum velocity. Focus on smooth acceleration to attain velocity results in a more efficient use of elements of throwing, and therefore offers a corresponding improvement in performance. If velocity/speed is stressed exclusively, the other necessary elements of the throw and the performance will often suffer.

IV. RHYTHM

The thrower should learn, establish, and utilize, consistent rhythmic structures, or patterns within the movements of the throwing actions. This pattern is to remain constant regardless of the tempo/speed of the throw. As the tempo/ speed or intensity level of the throw is altered, either faster or slower, the rhythm structure should stay constant. Motor learning theorists have established that movement patterns learned and reinforced through repetition, and while using rhythmic and temporal cueing, suffer a much lower rate of degradation of quality due to stress (competition). Corresponding research also supports that such movements are learned at a faster rate with the use of rhythmic cueing during the learning, and movement stabilization process.

V. RANGE OF MOTION

The thrower should maximize use of the range of motion of involved lever/ joints, appendages during the application of force on the implement. This concept is closely related to acceleration. Typically the longer the force path, the better the result will be. The longer force path will give the thrower a better opportunity at a maximum acceleration of the implement during the throw. In addition the throwers joints, levers and muscular system can be utilized most effectively while using the widest range of motion allowable, within the technical parameters of the throw.

VI. KEY TERMS: PARAMETERS AFFECTING DISTANCE THROWN

a. Implement at release

1. **Height of implement at release**
   Technical flaws can negatively influence height of release; however the height of release is positively limited by the physical characteristics of the thrower.
2. **Direction of implement at release**
   - A. Angle of attack
   - B. Angle of projection
   - C. Resultant of directional forces
     - i. Vertical & Horizontal
     - ii. Deflection/ Lateral deviations
3. **Velocity of implement at release**
   This is the single most important factor influencing the distance thrown.
   - A. Horizontal velocity of implement
   - B. Vertical velocity of implement
   - C. Lateral velocity of implement
   - D. Resultant velocity

b. Definition of Physical Considerations

1. Elastic Energy

For the purposes of throwing the throwers body should be seen as an ***Elastic Energy Storage and Delivery System***. The antagonistic relationship between forces applied to muscles and the muscles attempt to counteract these forces results in the storage of elastic energy. This stretch reflex results in an increased firing efficiency at the level of individual muscle bands and positively affects power output. Plyometrics for the upper body, torso, and legs will improve this response.

2. Anaerobic Power/Explosive Potential

Anaerobic power is the physiological pathway being utilized in the throws. In order to improve this ability, one must rely on specificity of training. Sprints of 80 meters and under, work the anaerobic power system. However the throws require that anaerobic power be available in a variety of areas of the body that sprinting alone cannot isolate. (Plyometrics, general throws, medicine balls, throwing various weight implements, etc…)

c. Definition of Key Mechanical Terms

1. Conservation of Momentum

A mass in motion will tend to remain in motion, at the same velocity, and in the same direction, until acted upon by an outside force.

2. Summation of Forces

The sum of forces applied in a movement can be cumulative. This is the concept that explains the cracking sound of a bull-whip, which at its culmination breaks the sound barrier. The concept of blocking with regard to angular force/ velocities relies on this concept of summation of forces. The efficient blocking of velocity/ force on one side of the CM of a body/ system, causes the velocity/ force from that side of the system to be added to the opposite side, or the next sequential segment in a uni-directional lever system, such as a whip.

3. Displacement of Center of Mass

The displacement of the CM precedes all movement in the throws. The goal in throwing should be a controlled displacement of the CM in the desired path, culminating in establishing the CM path the direction of the throw. Achieving this at times requires shifting of the CM over and around the axis of rotation when shifting to/ from single to double support. Displacement of the CM should result in the establishment of a balanced movement while setting up forces parallel to the direction of the throw.

4. **Torsion and Coincidence of Hip/Shoulder axis** (torque)

Torsion/torque or separation refers to the perpendicular relationship of the shoulder/hip axis. The hip axis should lead the shoulder axis throughout most of the throw, until the finishing sequence is initiated. Coincidence of the axis occurs during the conclusion of the finishing the axis occurs during the conclusion of the finishing movement when both axes are parallel to one another. This unwinding or, firing of the elastic “engine” in the torso culminates when both axis become parallel to one another.

5. Axis’ of rotation

The axis on vertical plane, which may pass through CM, this axis of system rotation is out side the thrower in hammer, and at times in the discus throw. The axis of rotation originates from the base of support about which point the system rotates.

6. Radius and Angular Force

Radius is the distance from the axis of rotation to the distal end of the lever. The shortening of the radius of a lever in angular/rotational movement will result in a corresponding increase of angular/rotational velocity, whereas the lengthening of the radius of a lever will have an opposite effect on angular velocity. This concept can be used to develop torsion (storage of elastic energy) between the Hip and Shoulder axis.

7. Resultant

The sum or consequence of all forces applied. For example, an application of an equal application of forces in horizontal and vertical direction on an implement, with no lateral deviations, will result in a 45° direction of projection. The direction of all forces created throughout the throw, linear, angular, vertical, horizontal, and lateral combine to determine the final distance and direction of the throw.