SPECIFICITY IN PLYOMETRIC TRAINING FOR THE DISCUS THROW

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Methods of artificially manipulating the athlete's body into an ideal technique for competition in the discus event in track and field has not been firmly established through research studies. Although McLaughlin (1981), Jarver (1980), Moynihan (1983), Woicik (1982), Gambetta (1981), and Wilt (1976) stated their athletes obtained better throwing patterns by using plyometrics than by using traditional training methods, their training methods have not been tested through critical research. McLaughlin (1981) used a platform four inches to six inches in height at the back of the circle and had his athletes land in an exaggerated bent-leg position prior to the drive off the power leg. Jarver (1980) and Gambetta (1981) had their athletes land in the center of the circle from a 30 to 40 centimeter elevated position and then perform a normal delivery. Wilt (1976) established 12 to 18 inches as his elevation height for throwers to use with five repetitions of six to eight sets.

Since an athlete first threw the discus 200 feet in 1962, the world record has improved over 35 feet in 20 years. The major reasons for the increase in distance are the larger competitors utilizing a technique which emphasizes using the lower body to generate power into the implement. It has not been determined whether using an alternative method training, specifically plyometrics, would aid the athlete in realizing the ideal technique in the discus throw by developing power in the lower body.

PURPOSE

The purpose of the study was to describe the biomechanical components of the discus throw; and more specifically, to investigate the altering effects of plyometric training within the discus ring.

METHODS

The subject selected for the study was a senior female discus thrower for the University of Kansas women's track team. She was a former state high school champion in the discus, and held the national high school record in that event for her age group. Her career best throw at the collegiate level was 159'7".

The subject had training sessions five days a week for a total of eight weeks. During this period she participated in a weight training program Monday through Friday. Two practices were used for aerobic conditioning and a prescribed discus throwing practice.

The throwing portion of the practice consisted of throwing two sets of ten repetitions from a plyometric platform within a discus circle. The wooden platform was constructed to raise the thrower five inches above the ground at the back of the circle. It sloped downward at a seven degree angle to permit proper body movement throughout the circle. A third set of ten repetitions was thrown from a conventional circle.

Films of the subject's throwing motion were taken before, at the mid-point, and after eight weeks of plyometric training. Six successive trials were taken at each filming session. The activity was filmed at 200 frames per second using a LOCAM camera set perpendicular to the plane of action. All 18 trials subsequently were used for computer analysis.

SUMMARY OF RESULTS AND DISCUSSION

The results of the study reflect the kinematic data collected from a one-camera angle. Only those paramters which can be assessed in a plane perpendicular to the camera were used for analysis.

Step Lengths

The average step lengths of the first and second steps for each of the three trials are presented in Table I.

TABLE I. FIRST AND SECOND STEP LENGTHS

Session	First Step (cm)	Second Step (cm)	Length of Throw (m)
Pre	116.0	84.0	41.0
Mid	104.2	72.6	43.6
Post	96.6	76.0	39.6
All	105.0	77.2	41.4

Longer throws occurred in the trials with longer step lengths. After plyometric training the length of the first step diminished.

Temporal Factors

The time taken for the first step, second step, second step to the release of the discus, and for the entire throw for each of the three trials are presented in Table II.

TABLE II. TEMPORAL FACTORS DURING VARIOUS PHASES OF THE THROW

Session	First Step (ms)	Second Step (ms)	Second Step to Release (ms)	Total (ms)
Pre	.180	.296	.178	1.438
Mid	.178	.316	.166	1.410
Post	.173	.273	.193	1.434

The time elapsed for the first step remained consistent for each trial, yet the distance of the step diminished. After plyometric training the driving action of the left leg in the back of the ring diminished.

The time elapsed for the entire throw during the mid-session shortened while the distance improved. The subject's training with plyometrics enhanced reaction time to the eccentric contraction in the middle of the ring.

Linear Velocities

The resultant average linear velocities of the right ankle, right knee, and right hand during various phases of the throw are presented in Table III.

TABLE III. LINEAR VELOCITIES OF THE RIGHT ANKLE, RIGHT KNEE, RIGHT HIP, AND RIGHT HAND.

Session	Segment	Resultant Average Velocities (m/s)		
		Prior to Release	Release	After Release
Pre	Ankle	2.3	3.1	3.4
	Knee	2.7	2.6	2.5
	Hip	2.4	1.8	1.6
	Hand	13.0	24.0	19.1
Mid	Ankle	2.1	2.8	3.0
	Knee	2.4	2.7	2.8
	Hip	2.2	1.9	1.9
	Hand	7.4	21.2	12.9
Post	Ankle	1.7	2.4	2.6
	Knee	2.8	3.0	3.0
	Hip	2.3	1.6	1.7
	Hand	7.5	18.7	9.8

The subject's linear velocity of the right ankle and right knee increased prior to the release of the discus. The right hip did not increase, however, breaking the sequential chain from the right ankle to the right hand.

The linear velocity of the right ankle and right knee did not decrease after the release of the discus. This indicated that the subject did not stop the rotation of these joints, thus the transfer of sequential movement to the right hip did not occur. The cause was the poor base created by the amount of time required for the second step.

Path of Center of Gravity

The height of the center of gravity through various phases of the throw is shown in Table IV.

TABLE IV. HEIGHT OF CENTER OF GRAVITY THROUGH VARIOUS PHASES OF THE THROW

Session	Backswing (m)	Left Foot to Middle of Ring (m)	Right Foot in Middle of Ring (m)	Release of Discus (m)
Pre	1.1	1.46	1.01	1.19
Mid	1.0	.88	.83	1.11
Post	.99	.89	.93	1.13

The peak of the subject's center of gravity was during the backswing, while the lowest point was during the pivot over the left foot at the back of the circle. The subject was able to pivot with a lower center of gravity after plyometric training. A lower center of gravity was maintained since no driving action was necessary to propel the subject to the center of the circle.

The center of gravity settled in the center of the circle and then rose to its greatest height with the release of the discus.

Path of Discus

The height of the path of the discus throughout various phases of the throw is presented in Table V.

TABLE V. PATH OF THE DISCUS DURING VARIOUS PHASES OF THE THROW

Session	Left Foot Pivot to Middle of Ring (m)	Right Foot in Middle of Ring (m)	Release of Discus (m)
Pre	1.49	1.34	1.77
Mid	.91	1.13	1.72
Post	.96	1.22	1.75

The discus was at the same height as the subject's center of gravity while the subject pivoted over the left foot. Only before plyometric training took place did the discus rise to aid in the drive to the center of the circle. The plyometric training seemed to inhibit the driving action from the back of the circle.

The discus was brought up gradually throughout the throw. It trailed the subject's axis of rotation except during the pivot over the left foot in the post-session. The discus remained low too long, increasing the speed of rotation and creating improper body position.

Angle of Trunk Inclination

The angle of trunk inclination for various phases of the movement are shown in Table VI.

TABLE VI. ANGLE OF TRUNK INCLINATION

Session	Back of Circle (deg)	Center of Circle (deg)
Pre	96	112
Mid	90	108
Post	96	102

The angle of the subject's trunk inclination to the horizontal with both feet on the ground at the back of the circle was in the erect (90°) position. The angle of the subject's trunk inclination to the horizontal as the right foot was placed in the center of the circle was well above the ball of the right foot. The angle of the right knee at its height stepping to the center of the circle shortened the radius of the right leg, enabling a quick step. The angle of the subject's right arm at the release of the discus insured optimal rotary momentum.

Angle, Height, and Velocity of Release

The angle of release, height of release, and velocity of release are shown in Table VII.

TABLE VII. ANGLE, HEIGHT, AND VELOCITY OF RELEASE

Session	Angle (deg)	Height (m)	Velocity (m/s)
Pre	34	1.77	22.96
Mid	32	1.72	22.61
Post	32	1.75	22.98

The subject's angle of release (32° - 34°) was within the optimal range suggested by the literature. The subject released the discus slightly higher than shoulder level. The subject's velocity of release (22.61-22.98 m/s) was slightly below the literature's recommendation for elite male throwers.

CONCLUSIONS

After plyometric training, the subject's lower center of gravity at the back of the circle indicated a more flexed left leg. The greater the left leg was flexed, the greater the contraction of the muscles of the leg, or the greater the potential available to be used by extending the left leg. Even though the subject assumed this superior position, the potential energy was not used by the thrower. Powerfully extending the left leg would have driven the lower body of the thrower to the center of the circle, while the trailing upper body remained relatively passive to develop torque (or more potential rotational energy). Instead, the subject had been trained to merely step passively with the entire body to the center of the circle by descending a given height. This left leg drive to the center of the circle which is vital to subsequent phases of the throw was negated.

The time elapsed for the entire throw decreased after plyometric training. This was due to the improved reaction time to eccentric contractions during the throw, a primary objective of plyometric training. The subject had been trained to immediately drive vertically with the lower body after the forced contraction of stepping to the center of the circle from the plyometric platform.

Because of the longer amount of time taken to place the left foot down on the last step, a proper throwing base was not established. The left foot did not aggressively travel to the front of the circle during the final step of the throw because of its passive drive from the back of the circle. The left foot should be set down quickly to halt the forward progress of the body. Since the left foot placement was delayed, the right leg continued to use the stored energy, traveling forward. Ideally, the energy should be transferred upward through the body. Due to poor timing on the left foot placement, inefficient energy use occurred. Therefore, the entire body was not used to lift the discus prior to the release.

Although the angle of release was within an accetable range, it did not produce optimal throwing distance considering the subject's inferior velocity of release. The low release angle, as demonstrated by the subject, provides optimal throwing distance only for throwers releasing the discus at a higher velocity. After plyometric training, the angle of release decreased due to the passive left leg establishing a block prior to the release of the discus. Since the left foot did not adequately transfer the body's energy vertically, the subject's right arm continued to travel forward, without a lifting force being initiated through the body.

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