Plyometric exercise

A plyometric exercise is an exercise in which the athlete utilizes the force of gravity to store energy within the muscular framework of the body. The storing of energy is then immediately followed by an equal and opposite reaction, utilizing the natural elastic tendencies of the muscles to produce a kinetic energy system.

For example, an athlete steps from a box of specified height and drops to the ground. His body is accelerated over the distance he drops by the force of gravity. (Figure 1).

In Figure 2 the athlete is absorbing the force of landing within his body by flexing the ankles, knees, and hips. His entire body decelerates until his motion downward is stopped. This flexion of the lower extremity joints is rapid, brief and is known as a “counter-movement.” This can be observed in all individuals prior to jumping. There is a slight lowering or “cocking” of the body prior to the major movement. (Figure 3). The energy developed in this process is now largely stored within the elastic structures of muscles and tendinous tissue.

Figure 4 represents the utilization, or conversion, of stored energy to “kinetic” or energy of movement. Geoffrey Dyson, the eminent biomechanics theoretician of track and field, likens this activity to compressing a spring, and then releasing the downward force and letting it spring up. The reaction achieved is an explosive-reactive movement in the desired direction.

A short or brief support time on the landing surface is desirable in the plyometric exercise. This support time is known as the “amortization” phase. It occurs from the time the athlete makes first contact with the surface until the body actually leaves the landing surface. The shorter the support time (amount of time spent on the landing surface before rebounding) the greater the athlete’s Neuro-Muscular Reaction to the ground contact stimulus.

The second major component of the landing and takeoff is the amount of Elastic Strength the athlete possesses. The term elastic strength relates to those properties of muscle-tendon tissue which allow it to be stretched rapidly, thereby increasing internal muscular tension, and subsequently experiencing a rapid forceful shortening of the muscle. This capability is noted by the ability of the athlete to produce either exceptionally powerful single-leg takeoff jumps or rapidly repeated double-leg takeoff jumps.

Elastic strength, then, is the ability of the athlete to rebound from the surface upon which he lands, quickly and repeatedly with maximal distance or height. It is a major component of all skilled activities and is trainable within the individual differences of all athletes.

Plyometric activities can be found in many forms. The major ingredients are elevation of the body, followed by a return to ground surface with subsequent projection of the body, either vertically, linearly or some combination of the two. The effective absorption of impact forces from the ground are a direct function of muscles which have been properly strengthened. The strengthening process is one in which explosive lifts are emphasized after minimal strength standards are reached.

Once these minimal standards have been accomplished, the specific development of elastic strength can begin.

First and foremost, the amortization phase must be developed. The time spent on the ground may be looked at as the neuro-muscular reactivity of the athlete. In order to improve this reaction to the ground via the neuromuscular system, one begins with “jumps in place.”

Plyometric exercises can be categorized not only by type, but also by specific effect desired. This section of the article will deal with a breakdown of each category and the specific area of movement which is developed or affected.

The following exercises are to serve as examples of specific means of developing neuromuscular reactivity and shortened amortization phase.

Jumps in Place

1. Squat Jumps
Starting Position: The athlete stands, feet shoulder width apart.
Movement: The athlete squats to a position 135°, or 110° knee flexion and
Plyometric Exercise

moves vertically as rapidly and forcefully as possible. Immediately upon landing, he absorbs the force of landing until reaching the prescribed amount of knee flexion and attempts to come out of that position in a vertical direction as rapidly as possible. The system of sets and repetitions will be discussed in general at a later point in this article.

2. **Double Leg-Tuck Jumps**
Starting Position: As in Exercise #1.
Movement: Athlete springs from the ground, flexing hip and thighs until thighs are parallel with the ground. He grasps the knees, briefly, with both hands and then extends the legs to the ground surface and repeats the movement as prescribed.

3. **Single Leg-Tuck Jumps**
Starting Position: As in exercise #1.
Movement: Athlete springs from the ground, utilizing a single foot takeoff, until thighs are parallel with the ground. Again, he grasps the knees briefly and lands on takeoff foot, and repeats as prescribed.

4. **Pike Jumps**
Starting Position: As in exercise #1.
Movement: Athlete springs off of two feet. While keeping the upper body erect, the legs are brought up with no knee flexion (straight) by flexing the hips. The athlete touches the toes, and then opens up to return to ground surface and repeats as prescribed.

5. **Split Squat Jumps**
Starting Position: Athlete assumes a position with one leg in front of the body. This leg assumes a 90° angle of flexion at the hip and knee. The opposite leg is extended at the hip and knee so that it projects straight back.
Movement: The athlete bounces twice by moving the body up and down approximately six inches. He then explodes up vertically, attempting to lift himself from the ground. Upon landing in the split squat position, he catches himself and repeats as prescribed.

6. **Split Squats with Cycling**
Starting Position: As in exercise #5.
Movement: As above, however, the athlete cycles (interchanges) front and back leg while in the air. Upon landing, the athlete rebounds after two bounces and repeats as prescribed. Note: Advanced athletes may eliminate the bouncing between jumps and may also try a “double cycle” (exchanging front-back twice while in the air).

7. **Jumps over Cones**
This particular exercise requires the athlete to move vertically a prescribed height and repeat. The use of a 6”-18” cone is dependent upon the level of development and aptitude of the individual.

Starting Position: Both feet approximately shoulder-width apart. Toes on a definite starting point. Arms should be used to assist movement.
Movement: Athlete is allowed to use a “counter-move” to aid in achieving some elastic strength. He now leaps as far as he can in a forward, linear direction. The force of landing will be absorbed by the lower extremities. Distance traveled should be recorded for achievement and testing purposes. There are international norms against which the athlete’s score can be compared.

Note: An advanced variation is to perform this activity with a single leg takeoff.

2. **Standing Triple Jump**
Starting Position: As in Standing Jumps #1. Note that a two-foot takeoff with double leg push is the internationally accepted standard for starting this activity.
Movement: Athlete pushes from both legs, projecting himself linearly. He must land on one foot (hop). He immediately projects linearly to land on the opposite foot (step) and concludes by jumping from that foot to accomplish a two-foot landing (jump). Again, there are international score tables for comparison. Note: Advanced athletes may use a single foot takeoff or “rocker” step. These distances are NOT comparable to international norms.

3. **Jumps over Cones**
Starting Position: Athlete stands with both feet on takeoff surface and a cone or similar object approximately 18” in front of him.
Movement: Athlete explodes upward attempting to clear the cone and land on the other side. Heights of cones are varied over repeat trials so as to present a constant challenge.

**Multiple Jumps and Hops**

These activities now utilize the skills developed in the earliest stages of training and begin to combine them with repeated movement patterns. This is the first time the activity begins to take on the essence of “plyometric” training.

1. **Double Leg Hops**
Starting Position: As in Standing Jumps #1.
Movement: Double Leg Hops are repeated 3-5x for maximum effect. The more skillful the athlete, the greater the number of repetitions. Body position is erect, a double arm action is generally employed and the force against the ground is linear as well as vertical.

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Summary

Jumps in place are exercises requiring limited space and equipment, yet which may serve to develop neuro-muscular reactivity to the ground. The stimulation of ground contact followed by immediate takeoff, is essential to reduction of the amortization or “time spent on the ground” phase. Short support time on the ground has long been shown to be of priority to sprinters, jumpers in track and field, basketball and volleyball players.

The progression from “Jumps-in-Place” should then be to “Standing Jumps.” These exercises are employed to stress maximal effort with both vertical and linear components. These are very definitely one repetition, maximal efforts. The drill itself may be repeated several times.

Standing Jumps
1. **Standing Long Jump**

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NSCA Journal January 1984 58
2. Single Leg Hops
Starting Position: As in Standing Jump #1.
Movement: Athlete employs a two-leg push, landing on a single foot and repeating this movement 3–5x. Action is again more linear in nature than vertical. Note: An advanced form of this exercise employs a running start with repeat single leg hops over 25 meters for time.

3. Hurdle or Cone Hops
Starting Position: As in Standing Jump #3.
Movement: Athlete clears the first hurdle or cone and immediately employs a “touch and go” technique to move forward over the next barrier. The number of cones or barriers depends on the developmental and training level of the athlete.

4. Squat Hops
Starting Position: Athlete places both hands behind the head and assumes a proper squat position.
Movement: A double foot takeoff and landing is employed. Repetitions may again vary with 3–5x a recommended beginning. These may also be performed on boxes or stairs with 18” the recommended height elevation.

5. Repeat Triple Jumps
Starting Position: As in Standing Jumps #2.
Movement: As in Standing Jumps #2, immediately projecting into the next triple jump upon landing from the jump phase of the previous effort. Repeated 2–3x.
Note: This exercise is best utilized by those individuals who have effectively learned the technique of performing a standing triple jump.

In-Depth Jumps and Box Drills
In-depth jumps are exercises utilizing the body weight of the athlete and the force of gravity to exert force against the ground. The key to successful development of elastic strength is the proper grading and progression of these drills. The athlete is best served when he has developed the ability to convert the stored energy of landing into the kinetic energy of takeoff as rapidly as possible. In a practical image sense, the progression is similar to the difference between the rebounding of a handball and a tennis ball when dropped from the same height.

1. In-Depth Jumps—Double Leg
Starting Position: Double leg stance on top of specific height. (Note: Research regarding the height used for in-depth jumping were published by Verkoshansky in 1973 as 75 and 110 cm. These were claimed to produce maximum dynamic strength gains. Although subsequent researchers have used a range of heights from 50 cm to 3.2 meters, the results appear to indicate the crucial factor to be choosing a height which allows the athlete to rebound from the landing surface a distance at least equal to their standing jump and reach score.) Athlete steps, one foot leading, off of the box and attempts to drop that specific distance.
Movement: The landing is to be an “active-reactive” movement. The athlete lands on both feet, and explodes immediately from the ground, as rapidly as possible. The variations from this single start and movement pattern can be quite varied as follows:
   a. Land, jump vertically onto another box of equal height.
   b. Land, jump vertically as high as possible.
   c. Land, jump out linearly as far as possible.
   d. Land, jump vertically as high as possible.
   e. Land, jump out linearly as far as possible.
   f. Step from box backwards on land, jump up onto the same box.
   g. Step from box backwards and land, jump linearly backwards as far as possible.

2. In-Depth Jumps—Single Leg
Starting Position: As in In-Depth Jumps and Box Drills #1.
Movement: The landing contact is now made with a single foot. The athlete then immediately re-directs his momentum as before. The heights utilized for this drill are lower than In-Depth Jumps—Double Leg and should not be used with the novice athlete. The variations are as follows:
   a. Land, jump vertically onto a box of equal height.
   b. Land, jump vertically as high as possible.

3. Running In-Depth Jump
(advanced athletes only)
Starting Position: Athlete runs a few strides along a surface higher than the landing surface. At the end of the running surface he drops down to the lower surface and immediately propels himself into one of two variations:
   a. Alternate bounding (Bounding)
   b. Single leg hops (Multiple Jumps and Hops #2)

4. Box Drills
These activities require the use of low, multiple sets of boxes (5–6), set up and spaced so that the athlete can allow for forward movement, landing and the transitions between them. These activities are often considered to be multiple in-depth jumps although they are generally done at lower heights.
   a. Double Leg
Starting Position: Athlete faces a row of 12”–18” boxes approximately 2–3’ apart.
Movement: Athlete performs an in-depth jump with enough forward momentum to land on the next box and immediately repeat this until all boxes are covered. The athlete ends with either a strongly directed vertical or linear jump.
   b. Single Leg
Starting Position: As in Double Leg.
Movement: As in Double Leg, with the athlete landing on a single leg and projecting himself up and forward on the same leg.
   c. Single Leg—Alternating
Boxes are arranged so that the athlete moves forward, then laterally, then forward again.
Starting Position: As in Double Leg.
Movement: Athlete lands as in Double Leg, then immediately directs himself laterally, onto another box, and repeats for 4–6x.
Boxes may also be arranged so that the athlete tends to move in a largely forward direction by stretching the distance between boxes.
   d. Straddle Jumps
Starting Position: Hands on hips, feet shoulder-width apart.
Movement: Athlete steps and lands with feet together, then springs onto next box with feet apart. The movement is repeated for the prescribed number of boxes.

(Continued, page 61)
Plyometric Exercise

(Continued from page 59)

Bounding

These exercises are employed to improve both running stride length and frequency. They are exaggerations of the normal running stride in order to accomplish or stress a specific aspect of the run cycle. These exercises are performed at distances of 10–100 meters.

1. Single Leg Bounds

An activity performed with a running start in which the athlete bounds on a single leg over a specified distance. The nature of the bound is such that the athlete shortens the radius of movement of the leg by tucking the heel against the buttocks and rapidly moving the thigh forward. The lower leg then extends and reaches for the landing on the same leg. The landing is “active,” in that, the athlete pulls through and initiates another bound as soon as possible.

2. Alternate Bounds

Essentially the same “reaching and pulling” activity done during the single leg bound is utilized here with the exception that landings are on opposite or alternating feet. Landings are “active” and arm action may be single or double in nature.

3. Combination Bounds

The rhythmic coordination of alternate and/or single leg bounds. These activities may be arranged in various ways e.g. L-L-R, R-R-L, or LL-RR-LL patterns.

Plyometrics for Special Effects

1. Joint Strength

The concept of stressing and therefore strengthening the ankle, knee and hip joints via plyometrics requires the use of a special surface and controlled jumps in place.

Since the athlete must be capable of adapting to irregular landing surfaces or unbalanced body positions during activity, the specificity of training becomes paramount. The surface used for this training stress is an especially-made angle box of specific shape and dimensions (Figure 5).

The purpose is to stress the small musculature about the ankle, knee and hip joints. By using slightly angled surfaces, the proprioceptive receptors of the joints and muscle are constantly stimulated setting up the sensitization of the muscles stabilizing these joints to ever-changing surfaces, and thus preparing them for on-field stress.

Starting Position: The athlete stands on one side of the concave or convex surfaces with both feet positioned so they are approximately shoulder width apart and on good balance.

Movement: The following are variations to be used for increasing joint strength:

a. Jump in place, feet apart, convex surface.

b. Jump in place, feet apart, concave surface.
Plyometric Exercise

c. Jump in place, feet together, side to side, convex surface.
d. Jump in place, feet together, side to side, concave surface.
e. Jump in place, Feet together, ¼, ½, full turns, convex surface.
f. Jump in place, feet together, ¼, ½, full turns, concave surface.
g. Jump side to side, feet together, back and forth, concave to convex surface.
h. Jump side to side, feet together, ¾ turn, convave to convex to concave surface.

2. Lateral Change of Direction
The following is a list of plyometric drills useful for developing the ability to move and change direction laterally. The principles discussed earlier in terms of starting position and body movement apply to all of the change of direction activities.
a. Move laterally.
b. Move laterally over sticks.
c. Move laterally changing direction.
d. Lateral double leg hops over cones.
e. Lateral double leg hops on and off box.
f. Standing lateral single leg jumps.
g. Single leg lateral hops back and forth on the spot.
h. Single leg lateral hops.
i. Single leg lateral hops on and off box.
j. Step forward off of a box and on one leg and break laterally.
k. Single leg lateral hops side to side over cones.
l. Side to side lateral hops, alternating legs between two angle boxes or in a ditch.
m. Side to side lateral jumps, alternating foot that contacts the box.

3. Forward Change of Direction
a. Run forward, changing direction.
b. Bound forward zig-zag pattern, alternating legs.
c. Forward single hops in a zig-zag pattern.
d. Drive jumps moving forward same foot, contacts top of the bench each time.
e. Drive jumps moving forward over bench, alternating which foot contacts top of each bench each time.
f. Bounds forward in a zig-zag pattern between angle boards or in a ditch.
g. Double leg zig-zag hops forward over row of cones.
h. Single leg zig-zag hops forward over cones.
i. Run downhill, run zig-zag course.
j. Assisted run through zig-zag course.

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Physiological Basis

Summary

There is a preponderance of evidence to show that plyometric or “jump” training is a valuable adjunct to preparing the athlete for performance. This system of exercise not only influences the contractile and elastic properties of the muscle, but also adds to the proprioceptive mechanism, thus enabling the athlete to heighten his special awareness.

Training under these types of loads apparently allows the body to recruit larger numbers of motor units during eccentric work and consequently allows for the storage of energy to a greater degree than under other types of training (e.g., weights or running alone). The result is manifested in more powerful, explosive body movements of great magnitude and efficiency.

The bottom line of sport activity is the ability to run faster and jump higher. Plyometrics are the matrix for accomplishing the bottom line.

(Continued from page 40)

work relying primarily on anaerobic metabolism until exhaustion (8, 19). Muscular endurance largely depends upon the maximum strength level of the muscles in question (19). The advantage of higher strength levels becomes more apparent as the required force output increases (i.e., the strength advantage in AME tests is more apparent during high intensity work) (8, 19). Thus, one possible method of reducing the onset of fatigue associated with high intensity work (e.g., weight training) is by increasing maximum strength. Strength may be a key factor in the enhancement of short-term endurance.

As each motor unit becomes stronger with training, fewer motor units would be needed at a given submaximal workload, thus a greater motor unit reserve would be available for continued work (19). The increase in motor unit strength may be associated with an increase in the cross sectional area of the skeletal muscle being trained (14, 19).

Increases in lean body mass (LBM) accompanying weight training may be related to increased strength and to enhanced AME. In previously untrained men, O’Bryant (23) has shown strong correlations between gains in LBM and gains in strength and power. It should be pointed out that the correlation between muscle cross-sectional area and maximum strength is not r = 1.0 (18). Strength gains (and therefore AME gains) may be due, in part, to changes in the central nervous system (e.g., greater motor unit recruitment, synchronization, etc.) (18).

The skeletal muscle concentrations of ATP-PC and glycogen are crucial to maintaining high intensity workloads and work rates (19). Increases in ATP-PC, glycogen and the myokinase reaction (2 ADP → ATP + AMP) have been observed after strength training (21, 32). Therefore, biochemical adaptations within the skeletal muscle accompanying weight training may also contribute to increased endurance during...
Non-circuit weight training-periodization
(To be executed 4 days/week for first 5 weeks with 3 days/week maintained thereafter.)

Days: Monday & Thursday
for 4 days/wk or
Monday & Friday for 3 days/wk

<table>
<thead>
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<th>Preparation phase</th>
<th>Strength-power phase</th>
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<tr>
<td>8 wks 2 wks 3 wks 2 wks</td>
<td>1 wk 1 wk</td>
</tr>
<tr>
<td>4 days/wk</td>
<td>3 days/week</td>
</tr>
</tbody>
</table>

1. Full squats
   Main core lifts
   5x10 3x5 3x10 3x5 3x3 3x2
   (1x10)* (1x10)* (2x5)**

2. Bench press
   5x10 3x5 3x10 3x5 3x3 3x2
   (1x10)* (1x10)* (2x5)**

3. Hyperextensions
   Suggested optional exercises
   5x10
   (1x10)*

4. Bent over rows
   5x10
   (1x10)*

5. Sit-ups
   5x30
   (1x10)*

6. Lat. pulls
   3x15
   (1x10)*

practice begins

Tuesday & Thursday for 4 days/wk or
Wednesday for 3 days/wk

<table>
<thead>
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<td>3 wks 3 wks 2 wks</td>
<td>1 wk 1 wk</td>
</tr>
<tr>
<td>4 days/wk</td>
<td>3 days/week</td>
</tr>
</tbody>
</table>

1. Clean pulls (from mid-thigh)
   Main core lifts
   5x10 3x5 3x10 3x5 3x3 3x2
   (1x10)* (1x10)* (2x5)**

2. Clean pulls (from floor)
   5x10 3x5 3x5 3x3 3x2
   (1x10)* (1x10)* (2x5)**

3. Shoulder shrugs
   Suggested optional exercises
   3x10
   (1x10)*

4. Behind neck press
   3x10
   (1x10)*

5. Weighted dips
   3x10
   (1x10)*

6. Bent arm pullovers
   3x10
   (1x10)*

Weight exercise

Program 3: Pyramid weight training and interval running (for football)

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Wednesday

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<th>Strength-power phase</th>
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<td>1st Set 2nd Set 3rd Set 4th Set 5th Set</td>
<td>**********</td>
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<tr>
<td>10 RM 8 RM 6 RM 4 RM 2 RM</td>
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</tbody>
</table>

Program 3 is cited here as an example of a popular method of conditioning used in past years but which may now be considered undesirable, as it does not provide for maximum gains in anaerobic capacity nor does it include a specific preparation phase. Furthermore, this type of training, where the volume of exercise is kept constant while simultaneously increasing the intensity over the duration of several weeks, may lead to overtraining (1) and a reduction in strength-power gains, if not a loss in absolute strength and power. Consequently, such a loss of strength and power could also result in an overall reduction in short-term endurance as discussed previously by Stone and others (4).

Summary

Program 1 represents the overall best approach presented here to improve anaerobic capacity without violation of the principles outlined in this article and previously discussed by Stone and others (4).

References


Running Program
(to be executed Tuesday, Thursday, Saturday)

10 week protocol for each session

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<td>220 yds</td>
<td>110 yds</td>
<td>50 yds</td>
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<td>1 to 4 secs. faster than avg. 440</td>
<td>5 secs. slower than best 220</td>
<td>3 secs. slower than best 110</td>
<td>1½ secs. slower than best 50</td>
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67 NSCA Journal January 1983