CHAPTER - II
REVIEW OF RELATED LITERATURE

2.0 INTRODUCTION

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REVIEW OF RELATED LITERATURE

2.0 INTRODUCTION:

Sincere efforts have been made by the researcher to locate literature but he has found no reference to any study done to determine the effectiveness of Box Jumping Exercises in the improvement of performance in triple jump. From the references it is found that a few authors have recommended the use of Box Jumping Exercises in the training of the triple jumpers. A brief review of such articles reported in professional journals and in books is given below.

2.1 REVIEW OF RELATED STUDIES:

Yoon¹ says that leg strength and co-ordination are important like the speed, in triple jump. According to him Box Jump Exercises can produce strong legs. If the legs are not strong enough, they will collapse on the landing. This method of training will help the hoping leg to develop strength in the tendons of the knee so that it will not collapse in a full effect jump and also to take the landing jar. As the strength increases, the athletes will find that he can land from the hop, flex the knee and take off for the step.

ACCORDING TO HOUSDEN² A triple jumper should have good leg strength because he must be strong enough to absorb body weight from the

²Fred Housden, "Land and triple jumping Questions and Answers" Track Technique, 40 (June, 1970), 1265
heights and he must have sufficient power to drive that body weight forward and upward. Therefore he safest plenty of activities in which body weight has to be driven upwards after having come from heights. This means vaulting on the off horses and boxes, hopping from the low box over bars and ropes, hopping with weighted belts, hopping down steps occasionally trying to drive upwards etc.

ADAMS\textsuperscript{3} study provided an analysis of triple jump, movie film was projected and body parts were platted by dots. The distances from the dots to baseline were measured and the distances were placed graphically. He reached the following conclusions.

1. The last step was both lengthened and shortened.

2. The take off full landed hell first.

3. The third take off angle was greatest, the second was smallest, except for our object.

4. The load extremities were elevated most in the third take off, and least in the second take off.

5. Forward can changed constantly, and increases more in successive flights.

6. Parallel co-ordination of the arms and the lead leg was recommended. Transfer of momentum from the lead extremities was enhanced by a high posterior starting position, and a high anterior elevation that was terminated suddenly at the end of take off.

\textsuperscript{3}Larry T Adams, "Cinematographic Analysis of The Triple Jump," Dissertation Abstracts Internationals, 36-12 (June 1976), 1926
7. Newton's third law of motion was used twice to place the legs in landing position in the third flight.

Besen\textsuperscript{4} concluded from his experience that in triple jump event, strength and a certain amount of mobility of the knees, hips, back, abdominal muscles and particularly that at ankles, need special development so as to withstand the tremendous stress placed on the body parts when performing an all out effort on any types of surface and more so on hard packed runway. Though weight training is useful to develop certain aspects of strength, it is the combination of weight training exercises and special multiple type jumping exercises that really prove most beneficial to achieving top class performances in the triple jump event. He emphasizes the need of 'stop boxes' 40 cm. high and 40 cm. square for performing special jumping exercises. He also advises to use a protective heel cup or sponge padding in both soes at heels and as far as possible do these exercises on soft grass.

It is a fact that training methods differ from one coach to other within the same country, and that there is a wide variation on the ideas of training among the leading countries in track and field athletics. Nevertheless, all types of training must be governed by some fundamentals which are nearly the name in all bases, in our own country or abroad.

An attempt has been made by the research scholar to locate literature related to this study. The relevant studies of specific importance are cited below.

FISCHER\textsuperscript{5} Compared three resistive exercise methods in the developments of muscular strength. In isotonic method the prescribed weight was lifted through full range of motion. Isometric methods involved maximum contraction of the muscle against an immovable resistance and in power method a maximum load was lifted through a range of 6 to 8 inches and held for a 5 second count on the last repetition. 99 physical education subjects were divided into three groups & engaged in their respective exercise programmes five times a week for nine weeks. Results revealed that both isotonic and power exercise programmes increased strength significantly more than the isometric programme. Isotonic and power programmes were equally effective for all muscle groups those used in arm. Flexion in Isometric Contraction, for which power movements were move effective. Power movements also appeared to be more effective than isotonic exercises in Isotonic Contraction for subjects with high initial scores.

GIRARDI\textsuperscript{6} compared the effectiveness of Isokinetic exercises in the developments of strength and endurance with isotonic and isometric exercises. A control group and their experimental groups - Isokinetic, Isotonic and Isometric, were assigned twenty three subjects each within the limitations of this study it was concluded that no treatment was significantly superior to all other treatments in improving muscular strength, powers, endurance or circular respirators endurance.

\textsuperscript{5}Harold Loc Fischer, "Comparison of Isotonic, Isometric and Power Training in the Development of Muscular Strength" Dissertation Abstracts International 39 (April 1979) . 3443
\textsuperscript{6}George Junior Girardi, "A Comparison of Isokineti Exercise with Isometric and Isotonic Exercises in Development of Strength and Endurance." Dissertation Abstracts International 32 (May 1972) . 6147
BOLING\textsuperscript{7} studied four methods of training:

1. Isometric exercise
2. Isotonic exercise
3. Running of stadium stairs and
4. Heavy resistance running using penny power pull in developing planter flexion and strength of the lower leg. This study revealed that all four methods would significantly increase the planter flexion strength. However, the isometric method proved to be the best method for improving flexion strength.

Huntinger\textsuperscript{8} compared three different methods of developing strength and their relationship to speed in swimming the crawl stroke. Isokinetic of strength developments for increasing speed in swimming pre-test and post-test were applied on one control group and three experimental groups. The finding of the study showed that there was no significant difference between the treatment groups. Isotonic group did not have significant gains in swimming speed but did have gains in strength. Isometric group had significant gains in both strength and speed in swimming.

Hickenbottom\textsuperscript{9} selected 45 boys studying in grades six to eight and divided them into three groups to determine which method of exercise

\textsuperscript{7}Robert B. Baling, "The Investigation of Four Method of Training in Developing Planter Flexion and Strength of the Lower in College Males." Dissertation Abstracts International 33 (October 1972) 1483.

\textsuperscript{8}Paul willard Huntinger, "Comparison of Isokinetic, Isometric and Isotonic Developed Strength to Speed in Swimming The Crawl Stroke" Dissertation Abstracts International 31 (March 1971) 4522.

Isometric or Isotonic, would develop arm strength more quickly. The groups exercised three days per week for nine week period and were tested before exercising each day by a cable tensiometer. Both Isotonic and Isometric flexion and extension exercises increased strength of the elbow. Isotonic and isometric flexion exercise produced significantly gains in strength within the first three week period, and isometric exercise tended to produce strength faster, although not significantly and no significant difference existed between the rate of strength gains for isotonic and isometric exercises involving flexion and extension at the elbow for a nine week period.

COLEMAN\textsuperscript{10} Divided forty-eight subjects randomly into four groups which participated in difference programmes consisted of differential isometric or isotonic training of contra-lateral arms. Both method utilized a weight load of 5 Rm and total contraction time of 40 sec. per exercise session. Isotonic and Isometric Strength was measured before during and at the end of the training period. Analysis revealed no significant difference in the strength developed by either method in the exercises or unexercises arm.

BOBBY\textsuperscript{11} Conducted a study to determine the effects of isometric and isotonic contraction on muscle strength, body weight, muscle weight and fiber diameter.


\textsuperscript{11}Lee Beasley Bobby, "Effects of Isometric and Isotonic Training on Skeletal Muscle Hypertrophy" Dissertation Abstracts Internation 30 (August 1969) 565
Harris\textsuperscript{12} studied the effects of Isometric and Isotonic training methods on leg extension strength, leg extension power. Sixty volunteer male students from the physical fitness classes of the University of Southern Mississippi were divided into three groups, two experimental and one control. After pre-test scores were converted to $Z$-scores and placed in rank order. In Isometric exercise the subjects applied maximum pressure against the bar for six seconds with a two minute rest between each repetition and in isotonic exercise six repetition for each set. Post tests were applied on same test items. It was concluded that both the training methods increased strength. The shuffles the indicated that the isotonic training method made more significant contribution to leg extension strength than did the isometric training or tumbling exercises performed by the control group.

Marley\textsuperscript{13} in his study to compared the effectiveness of Isometric and Isotonic exercises in the development of strength divided 36 subjects into three groups. One group trained with isometric exercises, the second group with isotonic exercises and the third (control) group participated in regular Physical Education activities. Subjects were tested several times before and after ten weeks training programme Isometric and Isotonic exercises appeared equally effective in developing strength but isotonic exercise was more effective in developing muscle size, although size as measured was not necessarily proportional to strength.

\textsuperscript{12}Irvin David Harris, \textit{"The Effects of Isometric and Isotonic Training Programme on Selected Variables."} Dissertation Abstracts International 30 (Dec 1969) 2359

\textsuperscript{13}William P Marley, \textit{"The Comparative Effectiveness of Isometrics Exercise and Isotonic Exercise in the Development of muscular strength. Endurance and girth."} Completed research in Health, Physical Education and Recreation 5 (1963) : 57
Mathews and Kruse\textsuperscript{14} Examined the effects of Isotonic exercise of the elbow flexor muscles on the ergograph (load of three-eight strength at 30 repetitions per minute continued to exhaustion) and Isometric exercise of the same muscles (three consecutive 6 second maximum pulls on a strap) the training periods were for four weeks. The exercise concluded that individuals react to exercise in a manner peculiar to themselves. A common regression line did not occur within either of the two exercise regimens and individual regression equation exhibited lack of uniformity as related to increase of strength.

SENTILLES\textsuperscript{15} selected seventeen female inter collegiate volleyball athletes as subjects and randomly assigned them to either and isotonic or isokinetic group. Subjects were pre and post-tested by using clark's cable strength tests. Both groups followed eight weeks weight programme the isotonic group using a Universal Trainer and the Isokinetic group a ‘power’ machine. Exercise stations consisted of bench press, shoulder press, hamstring curl and quadriceps lift. The study revealed that isotonic training measures were superior to isokinetic procedure in developing or maintaining strength fitness in elbow flexion, shoulder flexion and shoulder press quadriceps lift, hamstring curl within the isokinetic group and significant improvement on the quadriceps lift mastering cult and bench press for the groups. Isotonic training

\textsuperscript{14}Donald K Mathews and Robert Kruse, “Effect of Isometric and Isotonic Exercise on Elbow flexor muscle groups.” Research Quarterly 28 (March 1957) 26-37

\textsuperscript{15}Pamela K Sentilles, “A Comparison of an Isokinetic off Season Weight Programme to an Isotonic off Season Weight Programme in Developing and Maintaining Strength Fitness in the Female Athletes.” Completed Research in Health Physical Education and Recreation 22 (1980) 200
procedures were concluded to be superior to isokinetic methods for maintaining and developing strength fitness in female athletes.

Jacobson\textsuperscript{16} studied the effect of two types of Isotonic weight training techniques on strength and movement time in a specific limb movement. One treatment consisted multiple sets and repetitions method the other new untested technique consisted single set with manual resistance. Forty-five college males were divided into three equal groups, out of which one was control group. Training involved three 40 min. work bouts per week for a ten week period following the ten week training period strength improved significantly in both treatment groups. These was no significant difference between the two treatment groups. Reaction time did not change significantly in either group after treatment. It was concluded that either method of training will produce. Similar significant improvement in strength and movement time.

O'SHEA\textsuperscript{17} studied the effect of six weeks progressive weight training programme on the development of strength and muscle hypertrophy group-A trained with three sets of 9 to 10 repetitions, group-B with three sets of 5 to 6 repetitions, and group-C with three sets of 2 to 3 repetitions. Individuals in each group handled maximum weight loads for the number of repetitions each was required to perform. No significant differences were found between the

\textsuperscript{16}Bert Hans Jacobson, \textit{"The Effect of Two Types of Isotonic Resistance Training on Strength Movement Time and Reaction Time in the Knee, Extensor Muscle."} Dissertation Abstracts International (September 1984) 785

\textsuperscript{17}Patrickl O’shea, \textit{"Effect of Selected Weight Training Programmes on the Development of Strength and Muscle Hypertrophy."} Research Quarterly 37 (March 1966) 95-102
three systems of training. All training procedures resulted in the improvement of static and dynamic strength.

BERGER\textsuperscript{18} used seventy nine male subjects in his study to determine which proportion of maximum strength used in training was as effective for increasing strength as training with the 1 RM. Three groups trained twice a week with 66, 80 or 90 percent of 1 RM plus one weekly effort with the 1 RM. A fourth group trained three times weekly with 1 RM. A fifth group with 66 percent of the 1 RM a sixth group with the 1 RM only once a week and the seventh group acted as a control. After six weeks at training the group that trained with two-third of the 1 RM three times a week and the control group had mean strength scores which were significantly less than the means of the other groups.

Thorson\textsuperscript{19} compared the effect of selected exercise programmes involving force strength training and weight training in the development of leg power. Thirty-six male students were randomly assigned to the forced-stretch group, weight training group and control group. Data were collected before and after five weeks of training. An ANOVA was used to determine the significance of differences between the groups and a 't' was used to determine significance of change within the group. No significant differences were observed in leg strength among the members of the forced stretch group and weight training groups.

\textsuperscript{18}Richard A Berger, "Comparison of The Effect of Various Weight Training Loads on Strength." Research Quarterly 36 (May 1965) 141-146

\textsuperscript{19}Edward K Copen, "The Effect of Systematic Weight Training on Power Strength Endurance." Research Quarterly 22 (May 1950) 188-194
MCKETHAN\textsuperscript{20} studies the relative effects of a training programme involving isometric, isotonic or a combination of isometrics - isotonics on quadriceps strength and vertical jumping ability. Male subjects (N-24) were assigned to 1 to 3 experimental groups or to a control condition. Vertical jumping performance was evaluated by the jump and reach procedure and cable tension tests were used to measure quadriceps strength. The training for the isometric group involved 16 seconds max. isometric boat at each of 900, 1100 and 130 of knee extension. The isotonic group trained by utilizing max knee extensions. The combined group trained by performing an isometric contraction at 900 and then completing the knee extension against isotonic resistance. The results were: At the conclusion of training the quadriceps strength of the isometric exercise group was greater than that of the control group. Other among groups comparisons were non-significant, within group gains in quadriceps strength occurred for each of the 3 training procedures and there were no differences among or within the groups in relation to vertical jumping ability.

BURNHAM\textsuperscript{21} investigate the comparatives effect of isotonic and isometric exercises in the development of muscular strength for individuals with different levels of strength. College men (N-148) participated 3 days a week in one of the following programs: Isotonic exercises for 2 weeks,


\textsuperscript{21} Stanley Burnham, "A Comparison of Isotonic and sometric Exercises in the Development of Muscular Strength for Individuals with Different Levels of Strength." Completed research in Health, Physical Education and Recreation, 9 (1967) 118
isotonic exercises for 5 weeks followed by 5 blocks of isometric exercises, isometric exercises for 10 weeks, or isometric exercises for 5 weeks followed by 5 weeks of isotonic exercises. The multiple length regression analysis revealed no significant differences between isometric and isotonic programs in developments muscular strength of the arms or legs for either the group as a whole or far the different initial strength levels.

JONES\textsuperscript{22} investigate inter individual Isometric strength training variability by camping training effects with specific isometric propensity test deviation partners. The study used two physical Education Classes of male high school students as subjects. The distribution of isometric training responses was not peculiar to any one isometric propensity test deviation pattern.

ZANGRA\textsuperscript{23} studies the comparative effects of isotonic and isometric exercises upon muscular strength. Male high school students were divided into a control group (N-20) an isotonic exercise group (N-21) using one 6-sec maximal isometric elbow flexion at 900 for the game period. Elbow flexion strength was measured at 550, 900 and 1220 with a push pull manometers. Test reliabilities were 85, 91 and 92 respectively. The isotonic exercise

\begin{itemize}
\item \textsuperscript{22}Robert E Jones, \textit{"A Neurological Interpretation of Maximum Isometric Training and It's Relationship to Individual Training Variability."} Completed research in Health Physical Education and recreation 9 (1967) : 137
\item \textsuperscript{23}John Francis Zangra, \textit{"Comparative Effects of Isotonic and Isometric Exercise Upon Muscular Strength."} 21 Stanley Burnham, \textit{"A Comparison of Isotonic and Isometric Exercises in the Development of Muscular Strength for Individuals with Different Levels of Strength."} Completed research in Health, Physical Education and Recreation 9 (1967) 118
\end{itemize}
program increased elbow flexion strength significantly at 1250 but not at 550 or 900. The isometric exercise program did not increase elbow flexion strength significantly.

GIRARDI²⁴ evaluated the effectiveness of isokinetic exercises and to compare the effectiveness of isokinetic exercises in the development of strength and endurance with isometric and isotonic exercises. Subjects (N=92) fresh and coph boys were assigned to 1 or 3 experiment groups and 1 control group. The criterion measures were the vertical jump, chins, Dips, Right grip, left grip, back lift, leg lift and 12 mm run walk. The ANOVA for repeated measures was used to determine if change has occurred between pre-test and post test scores for the groups and the ANCOVA was used to test the different treatment effects upon the variance criterion measures. The isokinetic treatment, treatment group improved significantly in muscular endurance and strength, isokinetic treatment was superior to control treatments in improving back strength, muscular endurance power and circular respiratory endurance.

SILVESTER²⁵ conducted a study to compare the effect of variable resistance to free weight training programmes on leg strength, vertical jump and thigh circumference. 19 male students were assigned randomly to 4 groups as follows group (did squats with 80% of the 1 RM group N exercised the squats with 80% of the 1 RM. Their exercise routine was one set of 6
repetitions followed by 1 set of repetition of failure. Group U exercised on the Universal Dynamic variable resistance leg guess station. Pre-mid and post tests were administered on various muscle groups. Through an ANOVA and Newman Kuale sequential range test significant difference were found and the following conclusions drawn: all training systems caused significant strength gain in all strength measure group C gained significant more right hip extension strength then group N, group C, O and U improved in vertical jump while group N Did not and thigh circumference of the treatment groups was not significant difference over the experimental group.

GROGORY\textsuperscript{26} conducted a study on comparative effects of isotonic, isokinetic and negative resistance strength training programmes for the improvement of strength. Ninety one male students were assigned randomly into seven treatment groups. There groups did three sets of three repetitions and three groups did three sets of eight repetitions. The seventh group served as the control. All the three programmes brought about significant improvement in strength isotonically. No significant differences were detected among the three programmes when measuring the isometric strength gains. Non-experienced lifters improved in strength isotonically more than experienced lifters.

Jones\textsuperscript{27} investigate the effects of the use of different numbers of repetitions of isotonic exercise on strength going produced through

\textsuperscript{26}Shepard Ralph Gregory, "A Comparison of the Effects of Isotonic, Isokinetic and Negative Resistance Strength Training Programme." Dissertation Abstracts International 36 (September 1965) 1376 - A

\textsuperscript{27}John W. Jones, II, "The Effects of Repetition on Strength Increases Produced by Repetitive Resistance Exercise." Completed Research in Health, Physical Education and Recreation 7 (1965) 56-57
progressive Resistance exercises. The equipment used consisted of dumbbells, weights, exercise tables, metronome public address system, tensiometer, pulling assembly goniometer and measurement table. Subjects were 65 volunteer men without previous weight training assigned at random to treatments. No significant increases in strength was obtained.

DIETRICK\textsuperscript{28} studied the effects of isometric, isotonic and isokinetic training programme upon push up achievement in high school boys. Twenty-eight High school boys were selected and assigned to 4 treatment groups. Each subject pretested for the number of complete push ups executed at 3 different push up rates. A 5 weeks training programme was initialed with the control group attending regular Physical Education Classes daily and the experimental groups training using group technique on a bench press exercise for 3 days and attending regular Physical Education Classes the other two days. After post tests a 2 way ANOVA indicated a significant difference between the 4 groups of treatment but neither the push up rate effect nor the interactions were significant.

COLEMAN\textsuperscript{29} compared isotonic and isometric exercises performed on contra-lateral limbs. Subjects (N-48) divided randomly into 4 groups participated in different training programs for developing strength. These programs consisted of differential isometric or isotonic training of contra-

\textsuperscript{28}Frank L Dietrick, \textit{"The Effects of Isometric, Isotonic and Isokinetic Training Programme Upon Push up Achievement in High School Boys."} Completed Research in Health Physical Education and Recreation 15 (1973) . 80

\textsuperscript{29}Alfred E Coleman, \textit{"A Comparison of Isotonic and Isometric Exercises Performed on Contralateral Limbs."} Completed Research in Health, Physical Education and Recreation 12 (1970) 233
lateral arms. Both methods utilized a weight load of 5 RM and a total contraction time of 40 sec. per exercise session. Isotonic and isometric strength was measured before during and at the end of the training period. Analysis revealed no significant difference in the strength developed by either method in the exercised or unexercised arm.

BOWERS\textsuperscript{30} compared Autosuggested muscular contraction to isometric and static contraction. The cross transfer of strength and size development to the contra-lateral unexercised limb was also investigated. Sixty-one male subjects assigned to one of four groups performed five contraction of the elbow elixir muscles on 3 days a week for 6 weeks. Either isometric, static or autosuggested muscular contraction significantly increased muscle strength but not muscle size.

2.2 THEORETICAL PERSPECTIVES OF THE STUDY:

After reviewing the past research studies in the field of physical education, the investigator studied the theory of plyometric and weight training programme.

2.2.1 SCIENCE IN PLYOMETRICS

Plyometrics is a method of developing explosive power; it is also an important component of most athletic performances. As coaches and athletes have recognized the potential improvements plyometrics and bring to performance, they have integrated it into the overall training program in many sports and made it a significant factor in planning the scope of athletic development.

\textsuperscript{30}Louis A. BOWERS, "An Investigation of the Effects of Autosuggested Muscle Contraction on Muscular Strength and Size." Completed Research in Health, Physical Education and Recreation 7 (1965) 64.
Power

Although the exact reasons that plyometrics works may still hold some mystery, it is a fact that the training brings results. Yuri Verkhoshansky, had stated in the late 1960s that individuals could significantly improve jumping and sprinting ability by progressive jumping exercises. The suggested training and performances of athletes such as Olympic sprint champion Valeri Borzov helped to substantiate those statements in the early 1980s. Researchers Russ Polhemus, Ed Burkhardt, and others offered substantial evidence that combining plyometric training with a weight-training program enhanced physical development far beyond that of weight-training programs alone. You can enhance strength and speed, and avoid injury with good combined programming. People have probably always valued physical power, and, at least since the times of the ancient Greeks, athletes have sought methods for improving their speed and strength. Power, after all, is the combination of strength and speed, force times velocity. Power is the application of force through a range of motion within a unit of time.

Power is essential in performing most sport skills, whether tennis serves or a clean and jerk. Not surprisingly, then, specific exercised have long been designed to enhance quick, explosive movements. Yet it is only in the last few decades that several programs have been developed to systematically emphasize explosive-reactive power. It is still more recent that training to develop explosive power has been refined.

Progress in these areas of knowledge now hinges on two complications. First, several methods exist to develop explosive or reactive power (or both). Some are general, is that these methods have been researched, developed, practiced, and interpreted in several different
Review of Related Literature....

countries, languages, and structures of society. In this chapter we will give a
broad view of the interpretations to help you understand the system of
training. Rather than go into depth here about the scientific area, we will
discuss the most important principles and refer you to scientific research
available elsewhere.

At the foundation of the comprehensive training you will find in this
study are a few principles whose effectiveness is clear from experience. One
is using to full advantage the power from eccentric contractions. A second is
the advantage you gain from exploiting the stretch-shortening cycle and the
explosive power available from the elastic components of muscle. A third is
to adapt to plyometrics programs the underlying soundness of the training
principles of progressive overload and specificity.

> Muscle Contractions

The human body is continually subject to external forces and impacts,
against which muscles contract. Their contractions (or Actions, a term
preferred by some physiologists) are both negative (eccentric). In eccentric
contractions, the muscles undergo tension and lengthen or stretch (called
negative work); in concentric contractions they undergo tension and shorten
(called positive work). Any external force a muscle experiences that is greater
than its internal tension force allows it to lengthen in an eccentric contraction.
This type of contraction enables the muscle to break skeletal movements, in
other words, to decelerate. An eccentric contraction allows a muscle to sustain
greater tension than it can develop in an isometric position. Because the load
applied to the muscle causes it to work by lengthening, it is called negative
work (in contrast to the positive work done in concentric contraction to
overcome resistance). That is, when muscles contract eccentrically, they
lengthen as they simultaneously produce force. The external load is greater than the internal muscular force it can apply. Basically, every movement in the direction of gravity is under the control of an eccentric contraction.

What is significant here is that the energy cost of the negative work is less than that of positive work. The body requires less motor-unit activation and consumes less oxygen in eccentric contraction and exercise compared with concentric contractions. Thus, there is a different relationship between input and output of energy—a higher mechanical efficiency in eccentric than in concentric exercise.

In economic actions performed at moderate to high speeds, the muscles call on fast-twist motor units to work; these fast-twist muscle-fiber units are thus preferentially recruited. They have higher firing frequencies and larger and are larger fibers, production during eccentric contraction is greater than concentric contractions because the body generates a higher tension at the point of the muscle’s insertion. The tendon at insertion receives larger loads during eccentric than during concentric exercise.

In summary, because of chemical, mechanical, and neurological factors that influence the force and stiffness of the contracting muscle, eccentric lengthening (before rapid concentric shortening) produces the greatest force and power capabilities in skeletal muscle. It is therefore the central type of contraction to plyometrics.

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Loading and the Stretch Response

A muscle's initial length when it is stimulated influences the magnitude of its contractile responses to a stimulus. Applying force against a muscle, or loading, causes a reaction to the stress. When you apply this load, the amount of deformation (called strain) is the change that occurs in dimension. An internal liquid within the muscle resists these deformations during stretching and shortening, and this resistance to flow is known as viscosity. It is because of the viscosity that muscles must move in the direction opposite the desired force application (this is called pre-stretch). The property of muscle tissue that enables greater muscular tension is known as the stretch response. Not to be confused with stretch reflex (a basis neural mechanism to maintain active muscle tonus using impulses discharged from muscle spindles), the stretch response involves parallel muscle fibers exerting maximal tension at stretch length slightly greater than resting length.

Elasticity

Muscle strength is the maximum force or tension that a muscle can generate. This is the force or tension a muscle group can exert against a resistance in one maximal effort. An important component accompanying strength is the muscle's elasticity, its ability to lengthen and increase in tension, which resides in the contractile elements of skeletal muscle. Naturally, there are limits to these abilities.

The range of elasticity, or strain, is directly proportionate to the ability of the tissue to resist forces and return to its original shape upon releasing a load. It is this elastic property that plyometric training plays on.
Elasticity lends the ability to use the strain or tension to return to or react in the original direction with greater force, more efficiency, or both. It is the basis for resilience, or the ability to absorb energy within the elastic range the muscle works. When a load is removed and the tissue returns to its original shape, resilience causes the release of energy.

Studying elasticity has led to the concept of stored elastic energy, which is the recoverable energy the viscoelastic tissue deformation generates in the eccentric phase of the movement. This energy is available for reuse in the following concentric phase of muscle activity. Elastic energy has been explained as mechanical energy that the muscle does not dissipate as heat, but rather absorbs and stores for reuse during its subsequent, active, shortening cycle.

Exploiting the stretch-Shortening Cycle

Eccentric and concentric muscle actions usually occur simultaneously in combinations of muscle function otherwise known as the stretch-shortening cycle. The eccentric contraction stretches a muscle's length, and the concentric action proceeded by an eccentric countermovement. Defining the principles of the stretch-shortening cycle will help us understand not only what is occurring within training and performing but also how to apply these principles. This understanding is useful in planning polymeric training.

In analyzing and applying training that uses the stretch-shortening cycle model, remain aware that performance of human athletic skills is never merely the sum of such factors as strength, velocity, loading, and stretch. Performance of any movement pattern, plyometric or otherwise, is holistic in nature. It is an integration of all such factors. In developing human power, many mechanisms drive and coordinate the skeletal musculature. Enhancing
muscular control and reactive power associated with the stretch-shortening cycle exercise relates to changes in complex neuromuscular structure and sensory-motor pathways.

Perhaps the most accurate term to describe the time from the eccentric or stretch portion of the cycle through switching to the concentric or stretch portion of the cycle through switching to the concentric or shortened portion is elastic-reactive, a concept that Vern Gambetta described in 1986\textsuperscript{32}. What is important in elastic reactivity is the impulse, or the force that starts a body into motion, and the motion this force produces. Greater impulse relates to better efficiency. Called portion, the mechanics explain synergistically augmented energy levels and heightened effectiveness.

The basis of both the voluntary and involuntary motor processes involved in the stretch-shortening cycle is the so-called stretch reflex, which is also called the muscle spindle reflex or mitotic reflex. This spindle apparatus and the stretch reflex are vital components of the nervous system's overall control of body movement. In executing most movement skills, the muscles receive some type of kick. The rapid stretching (loading) of these muscles activates the muscle spindle reflex, which sends a strong stimulus through the spinal cord to the muscles. This stimulus causes them to contract powerfully.

Let's now look briefly at how the stretch-shortening cycle works. Various terms have been suggested to describe phases of the stretch-shortening cycle, which includes the stretch or eccentric phases, the brief period between, and the stretch or concentric phase. Basically, the cycle

\textsuperscript{32}Gambetta Vern- \emph{Plyometrics: Myths and Misconceptions}
combines an eccentric contraction, in which the involved muscles undergo tension through lengthening or stretching (negative work), and a concentric contraction, in which the muscles shorten (positive work). The cycle in its clinical form of muscle function and as it appears in its natural form.

2.2.2 PLYOMETRICS PLANNING

Certain principles of athletic training apply especially to the stretch-shortening cycle and plyometrics. The first is a basis and widely accepted training principle: progressive overload.

> **Progressive Overload**

Using the principle of progressive overload successfully develops strength, power, and endurance. The relationship between increasing muscular strength and resistive overload using weights is well known. Repetitions of work at less than an overload emphasize endurance of the muscle—not strength.

Because we are emphasizing power development, and because power is the function of force times distance over time, you can use several overload methods. However, rather than the traditional definition of power, strength times speed, the principle of overload exploits the true formula of power in planning your training sessions.

A term often used instead of power training is speed-strength. It indicates the ability to reach the maximum of strength during the movement in a brief time—a ratio of maximum strength in a movement and the time to reach it. Many sport scientists use the term to describe several correlating processes.

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components of strength, primarily, these are absolute, explosive, starting, and reactive. Perhaps a breakdown in a more definitive formula is appropriate, so let us take another view of power. A basis physics lecture for power always gives the following formula, with these applications:

\[
\begin{align*}
F &= \text{application of force} \\
D &= \text{application through the greatest distance} \\
T &= \text{application in the least amount of time}
\end{align*}
\]

Let's put into words what we are really after:

\[
\text{Power} = \frac{\text{Force } \times \text{ Distance}}{\text{Time}}
\]

\[
\begin{align*}
F &= \text{force application (this is strength and impulse)} \\
D &= \text{distance transition (this is agility and coordination)} \\
T &= \text{time reduction (this is speed and acceleration)}
\end{align*}
\]

Few coaches would disagree that to apply more force (f) you must have improved strength. Also, few would ignore that reducing the time (t) factor takes accelerated movements. However, surprisingly many coaches neglect to incorporate the formula's other equation—the agility and coordination you need to make appropriate distance transitions (d). The body's characteristics (its size and shape, for example) always set certain limitations, of course. Because you need all three components (each is an important piece) to make up the pie, in plyometric training you must plan to involve overloads that can accomplish what you want in all these areas.

The types of overloads available to plyometric training are shown in the box below.
Plyometric overloading

<table>
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<tr>
<th>Resistive Overload</th>
<th>Spatial Overload</th>
<th>Temporal Overload</th>
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<tr>
<td>Gravitational</td>
<td>Range</td>
<td>Operating rate</td>
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<tr>
<td>Inclination</td>
<td>Saggital, transverse, frontal</td>
<td>Impulse</td>
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In training the stretch-shortening cycle, resistive overloads usually take the form of rapidly stretching a limb or the entire body in an eccentric contraction, such as overcoming the increased forces as the result of falling from a height. You can place a spatial overload on the stretch-shortening cycle by increasing the range, within a desired plane of movement, that the athlete must perform the application of forces.

Movement can also have the effects of overload through range of motion. The concept is to employ the stretch reflex within a specific range of motion. An example here is of an athlete performing a vertical jump from both feet without any approach. The application of force is upward, with all parts of body summating forces in that direction. You can apply the same summation of forces form a position in which the legs are split in the capital plane, increasing the overloads placed on the system and the degree of difficulty. Many exercises-although specific to particular athletic skills in movement place of limbs and involvement of certain muscle groups- are executed in a spatially exaggerated manner; that is, limbs may move through much wider ranges of motion, even though the movement plane resembles that of the performance goal.

You can accomplish a temporal overload by executing the movement as rapidly and intensely as possible. The force the skeletal muscle produces
depends on the speed of shortening or lengthening and the absolute length of the muscle at any instant in item. In eccentric exercise, force increases as the velocity of stretch increases. Stant in item. In eccentric exercise, in which the force decreases as the speed of the contraction increases. One theory is that the faster the transition occurs from eccentric to concentric contraction, the greater the muscular tension produced and, potentially, the greater the muscle power produced\textsuperscript{34}. To develop in this area you can use decline pathways and spring like surfaces, as well as other variations.

2.2.3 GEARING UP FOR PLYOMETRICS

Any program dedicated to enhancing performance needs an ongoing method of evaluating the program’s direction, the participants’ fitness, and the performers’ accomplishments. To use the stretch-shortening cycle optimally, you should evaluate several components that you bring to the program. These include whether individuals’ age, fitness level, and understanding of safe procedures are suitable for them to participate, whether they are properly equipped (having appropriate attire and props to use), and whether they can design good exercise progressions. The Gambetta method can help you achieve your goals faster than ever before.

Verm Gambetta has helped numerous individuals and terms improve their performance by applying his principle-centered training programs. Based on scientific laws, functional movements and practical experience these programs are specifically designed to develop “The complete Athlete.”

Function is determined by analysis of the demands of the sport, the demands of the position or event, and most importantly, the qualities of the individual athlete. “The body is a kinetic chain that functions together to produce efficient movement.” Vern says. “Therefore, I do not focus on individuals parts in training-rather, I design programs based on how the parts function together as a whole.”

The resulting training and rehabilitation programs are based on the following principles: Postural alignment and dynamic balance are the foundation for all training rain strength before strength endurance.

- Train movements, not muscles
- Train fundamental movement skills before sport-specific skills
- Train core strength before extremity strength
- Train body weight before external resistance
- Train joint integrity before joint mobility
- Train synergistic muscles before prime movers
- Train speed before speed endurance
- The result is the systematic, sequential and progressive development of “The Complete Athlete.” GSTS Program goals
- Injury Prevention
- Performance Enhancement
- Education

The Gambetta Sports Training Systems Conditioning Program Process. During this five-step process we ask questions to gain insight into the athlete’s needs and condition. Based on the answers, a system and plan is

15 Gambetta Vern- *Plyometrics: Myths and Misconceptions*
developed to help the athlete reach their goal. Finally, the effects of the program are assessed for effectiveness.

**Step - 1 : The Sports**

What are the demands of the sport? Most games require quick starts and quick stops

The performance Paradigm- constant interplay of force reduction and force production.

**Step - 2 : The Athlete**

What are the qualities of the individual athlete relative to the demands of the sport?

This is highly age dependent, therefore, it is important to carefully consider."

- Development Age – Biological Age
- Training Age – Position or Event

These demands change as the athlete’s training age increases.

**Step - 3 : The System**

- Speed – Strength/ Power
- Stamina – Suppleness

All these components have a different emphasis based on the sport and individual. Facilities or equipment should not be a limiting factor

**Step - 4 : The Plan**

Periodization –

Timing of the application of training components.

Phases Of The Year
1. Transition
2. Off season
3. Early Season
4. Mid Season
5. Late Season

Progression
Basic Conditioning
Basic Skill

Step – 5 : The Evaluation

Assessment of the effect of the program. Find out where you are to know where you are going.

– Criteria Tests – Progress Check

2.2.4 APPLYING THE METHOD TO THE ATHLETE

Kinetic Chain Concept

To maximize results, you must condition and prepare the whole body. The body is a link System.

With all parts working together.

Theme.

The Gambetta Method uses multi-plane & multi-joint movements, which are functional and Synergistic.

2.2.5 ASSESSING ABILITY

Is serious plyometric training a good option? Before getting too far in planning the specifics of a program, the prudent approach is to look honestly and carefully at various factors that could affect safe participation in such intense training. If you are a trainer, you must determine a participant’s status
as to age, experience, health, fitness, levels of strength, and genetics. If you are planning a program for yourself, you should treat assessment at least as seriously because you are your own trainer! What you are looking for are any limitations that might inhibit proper progressive development in explosive power training.

2.2.6 AGE FACTORS:

Chronological age is an important consideration. Carmelo Bosco and Paavo Komi (1981) conducted research to demonstrate that the maturity or immaturity of both the nervous system and skeletal system affect tolerance to plyometric training. Youngsters who have not yet reached puberty, for example, should not participate in plyometrics, especially at the intense levels. The continual growth of the skeletal system, cartilage at the epiphyseal plates, joint surfaces, and apophyseal insertions make the extreme forces of some plyometric exercises inappropriate.

The inability of young age groups to tolerate the high loads of the stretch-shortening cycle can cause confusion. Youngsters are exposed to forces during play and sports that may equal or exceed the forces tolerated in plyometric training with a proper progressive system. Kids are vulnerable to excessively hard play, yet not as vulnerable to excessively hard play, yet not as vulnerable as to consistent repetitions of excessive overloads.

We contend that 12-to-14-year old participants can appropriately use plyometric training as preparation for future strength training. This has been corroborated by researchers including Valik (1966) and McFarlane (1982)36

36Valik B. Strength Preparation of Young Track and Fielders. 1966, Physical Culture in School 4.28 In Yessis Translation Review (1967) 2.56-60
However, we suggest moderate jump training with youths. Use early progressions of low impact and small dosages, as the guidelines in chapter 3 and the continuum in chapter 4 suggest. There does not appear to be any significant response to explosive strength training in the adolescent until after the onset of puberty; therefore, prescribe training programs cautiously. This makes using planned progressions all the more worthwhile, so indicatively. This makes using planned progressions all the more worthwhile, so that individuals may receive the many other benefits (mechanics, coordination, structural integrity, etc.) until maturity and mastery develop.

As age increases, the ability of the nervous system, muscle and joint pliability, and energy production decrease, which makes plyometric training less attractive to older athletes. On the other hand, evidence suggests that a decreased explosiveness is only partly due to the natural aging process. Increases in endurance training, a lack of such training, and lifestyle also influence how much explosive power a person maintains at older ages. Continued use of stretch-shortening cycle training in proper progressions and moderate intensities can be effective for aging athletes, as evidenced by the growing numbers of masters athletes in explosive sporting events (track and field, weightlifting, etc.). As we will address in chapters 3 and 4, we can evaluate anyone's capabilities and adjust the training to accommodate both the immature and mature participant.

2.2.7 PLAYERS' PHYSICAL CAPABILITIES AND HEALTH LIMITATIONS

Several physical areas merit your evaluation, to assess not only for training but also for limitations. Look at flexibility, especially as it exists (or
fails to exist) in the ankle joints and calf muscles for proper foot mechanics and in the shoulders, hips, and spine for the proper hip set and segmental cushioning. Examine posture, noticing especially the proper use of torso mechanics; pelvic tilt; and positioning in cervical, thoracic, and Lumbar spine. Check out balance in equilibrium, torso tilt, and each appendage’s joint alignment. Assess the stability of the foot, as it is in contact and positioned on the ground, the firmness of stance, joint tension, and coordinated control.

Past injury may be a factor, and you must consider any that might be limiting. Look at joint stability and balance for assessing past knee, ankle, or shoulder injuries. As we will address in chapter 3, these forms of training are useful in rehabilitation from injuries. Limitations on explosive training may arise from health problems occurring in the back and spine. Excessive trauma to these or any areas that cause improper landing capabilities can present problems.

**2.2.8 PLAYERS' GENERAL FITNESS**

Having a god level of overall fitness is helpful in all areas of exercise, and training for explosive power is no different. Successfully completing a doctor’s physical exam is helpful. You should have good body-weight control and body composition, enough cardiovascular fitness to exercise continuously for several minutes or more, the strength to handle your own body weight in movements in all planes and directions, and the flexibility to handle movement positions in several ranges of motion.
2.2.9 INDIVIDUAL DIFFERENCES

Not all athletes will respond alike to particular prescribed training regime. Coaches need to be sensitive to individual differences, and participants must have some self-awareness. For example, differences between males and females show up both in training and performance. In addition, the genetic makeup of an individual dictates, to a large extent, his or her ability to improve. Factors, which as limb length and muscle fiber type distribution, have a direct effect on performance. You need to be aware of certain limitations that can arise in training and development. Although they may affect the rate of an athlete’s progress throughout a program, they should not influence the basic design of the training regime.

2.2.10 CONSIDERING EXPERIENCE

The training age, or level of experience, a participant brings in working with stretch shortening cycles can be more important than chronological age. Some athletes who have had several years of experience as competitors, for example, have still never trained for competition. It is common to begin working with maturing athletes who have been extremely skilled in their athletic endeavors, who possess enormous talent, and yet who bring only an infantile level of training as a base. Such participants can be at high risk if they attempt to use poor technical and developmental qualities, adding quantities of exercise that their body structures are not ready for. So, as a coach, you must realistically determine a person’s technical and developmental practice by quality training assessments (posture, balance, flexibility, and stability as described previously).
2.2.11 JUDGING STRENGTH

Sport scientists have raised some interesting questions about the amount of strength and stability necessary to successfully perform eccentric training, the effects of slower isotonic strength training on eccentric performances, and whether relationships exist between more ballistic (plyometric) training and isotonic training. Traditional weight training basically enhances muscular strength. Plyometric training, on the other hand, enhances muscular power. Recently, Greg Wilson (1993) and other have suggested that athletes use dynamic weight training (a form of stretch-shortening cycle exercises that are externally loaded) to maximize mechanical output.

It is important to continually evaluate the level of strength a plyometric participant has. There are several ways to assess strength:

- Absolute strength, or the maximum level, is measured regardless of body weight.

- Relative strength, or maximum level, is measured regardless of body weight projecting your center of gravity away from, across, or over the ground.

- Dynamic strength involves both eccentric and concentric contractions, with a degree of speed (used, for example, in squatting and single-response jumping movements).

- Elastic strength is speed involving the elastic and contractile components and reflex contractions (such as multiple response or rebound jumps).

- Core strength is discussed less often but may be the most basic and important of all.
Core strength centers on the core of the body. We will define it as the control over the muscle and joints of the trunk or torso. It is responsible for all postural stability in movements in all planes and directions. Core strength is a component of all the other forms of strength. In handling any external loads or any speed of movement, core control influences the beginning, maintenance, and completion phases.

Being to demonstrate and assess different strength qualities (such as starting, maximal, explosive) makes an athlete more aware of the essential power qualities athletic performance demands. All forms of strength have a place in evaluation. You should prioritize them by the progressive goals and objectives of the program. For, example, an athlete (Jack) may exhibit good or even great strength as tested in a barbell squat. He might be weak, however, in a vertical jump test, possibly indicating a lack of speed in the training load and poor response movements, which indicates low levels of elastic strength. Dietmar Schmidtbleicher (1992) suggest that even different rates of force development are necessary to overcome differing loads, both internal and external, as well as the movement time involved.

2.2.12 LOADING CORE STRENGTH

Body weight vs. Gravity

Absolute strength overloads regardless of condition
Relative strength overloads % of bodyweight
Dynamic strength overloads/degree of speed
Elastic strength overloads / degree of rebound ability
2.2.13 EVALUATING THE EXERCISE OBJECTIVES

You can use the stretch-shortening cycle in most parts of the training regime. It will be part of the warm-up, the weight-rom workout, the speed portion, and the agility segment; sometimes you will use it specifically and others times generally.

In the quest for more efficiency in movement, minimizing the time lapse between eccentric and concentric contraction is extremely important. Two periods of delay exist. One delay is between the signal from the brain for muscle contraction and the onset of muscle activity, and the other is between that appearance of muscle electric activity and the development of tension in the muscle, the electromechanical delay (EMD). This second delay is shorter in eccentric contractions than in concentric ones. This shortened response time further supports the concept of producing the greatest force in the least amount of time. The stretch-shortening mechanism enhances force production by contributions from the series elastic component (SEC) during the stretching. Eccentric efficiency, in other words, is improved by using the stored elastic energy of the SEC.

Evaluating the factors involved with strength-shortening cycle exercises helps determine timing, volumes, and intensities. I. King (1993) outlines these factors:

- The rate of eccentric action, known to many as the amortization phase (the stretch)
- The rate of concentric action, the recoil, or summation phase (shortening)
The delay time between the cessation of the eccentric and onset of concentric muscle action, also known as the coupling time.

The amount, if any, of external load involved.

These elements take only approximately one-half second to occur, yet can change the scope of the training form you are using. We often need to

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C

"Sprintening"

"Squat jumping" (W/10-20 kg)
Distinguish a rapid continuous stretch-shortening cycle movement, or intensive elastic and reactive method, from those of a speed-strength orientation) loaded and not as elastic or reactive) or, furthermore, from a shock methodology. Schmidbleicher (1992) consider these differences to be long or short stretch shortening cycles those greater or less than 250 milliseconds. In the following figures, the down portion indicates the amount of stretch, the up section shows the shortening, and the combination of the two and the delay if any, between (coupling). These are all in the contact portions of the chart. Notice the differences in time necessary for optimally executing minimal contact time and maximal flight.

Siff and Verkhoshansky (1996) suggest that, if the coupling time is longer than about 0.15 seconds when performing drills of high impact, intensity, or rate of force development, the action is not considered classical shock-method plyometrics, such as depth jumping. For our purpose, knowing how to measure these times is not as important as understanding the differences that individual exercises make, especially when incorporating greater movement magnitudes, such as bounding versus hoping, or greater gravitational overloads, such as higher drop heights or using additional weight on the body.
As a coach, you can evaluate performance based on awareness of what ground contact or coupling time in an athlete displays. You can determine the load by the response via ground contact time. It requires some theoretical understanding and conservation of posture, balance, stability, and flexibility to determine what is occurring with fast movements. Because a great deal of stretch-shortening cycle improvement depends on the rate of force development and the development of neuromuscular coordination, and specify of plyometric exercises. For example, training using squat jumps with 15 to 20 kilograms of external weight (a standing or weight vest etc.) is useful in certain phases and progressive times of training, as is bounding for certain prolonged cycle methodology doesn’t attend to the specific performance needs as does lower repetition bounding, hopping, or well performed shock training for quicker, more impulsive repetition of higher quality.

In considering repetitions of duration, external weight, and drops from height, it is better to wait to recommend them until an athlete is far up the skill proficiency scale. Avoid repetitions that sacrifice quality for quantity. However, you can fully use the stretch shortening cycle throughout a continuum of exercise and load factors. Evaluating the specific goals for each training phase and the session within those phases will indicate where (along the continuum) the majority of stretch shortening cycle volume can fall.

2.2.14 SELECTING EQUIPMENT

Performing exercises involving the stretch shortening cycle is simple, easily located and inexpensive. Participants can execute great plyometric training skills using backyards, parks, hallways, and even bedrooms. However, selecting the best situations for proper progressive training programs is essential to continued safe and effective training.
2.2.15 FACILITIES

When looking for a good facility or location for workout, you will discover that Mother Nature was thinking of eccentric-style training. Grass has, in our experience, shown to be the best surface as long as it is resilient yet cushioned. We do not recommend soggy, muddy grass or dead, dry, cement-hard grass surfaces. You can use cushioned hardwood floors, such as indoor gyms and aerobic studios, for early progressions of plyometric activities, or some rugged surfaces, trend tracks, and rubber weight-room floors. Resilient mats such as those used in gymnastic floor routines work well. Using mats with too much give or cushion digits the purpose of reactive landing; therefore, we do not recommend anything past that of wrestling matting.

2.2.16 EQUIPMENT

The equipment listed here isn't costly. Some facilities have most of the listed materials. We present the following equipment list so you can decide what to select, how to select it, then how best to acquire it.

2.2.17 ANGLE BOX

Made of metal, aluminum, or wood framing, an angle box is a set of angled foot placements for use in lateral movements. The precise angles of the box are not crucial. What is important is that each angle be slightly different from the other three. The bottom of the board must have enough weight, or the ability to be secured, so the box will not move during use. The boards must be of solid construction, durable, and of non-slip texture.

You can construct the angle box using the dimension we give, or purchase similar designs through specific conditioning product catalogs.
2.2.18 ANGLE BOARD

The angle board is made of wood or plastic, with a metal, aluminum, or solid wood frame. The sizes of several boards differ in height and top length according to the box size you want to use. Standard sizes are a 12-inch base by 6, 8, or 10 inches in height. The boards must be of solid construction, durable, and of non-slip texture.

You can construct one using the dimensions we give, or purchase it through specific conditioning product catalogs.

2.2.19 BARS

Bars range in size from five feet long to seven feet long, weighing anywhere from 10 to 50 pounds. They usually measure one to two inches in diameter for Olympic style. Purchase lead pipe, steel rods, lifting bars from weight sets, or construct them from pipes, PVC, or wooden dowels.

2.2.20 BOXES

Choose a variety of sizes, ranging from 12 inches high and wide to 42 inches high. You can use a combination of sizes and shapes, including rectangular and multileveled (drop, jump, and bound). Purchase boxes of wood or metal framework; you can construct boxes and cover them with rug, artificial turf, or antislip rubber.

2.2.21 CONES

Select rubber or plastic cones in four sizes: 6 to 8 inches, 10 to 12 inches, 16 to 18 inches, and 22 to 24 inches. Buy them from sporting goods stores, catalogs (Outlets),
2.2.22 DUMBBELLS

Choose closed bells weighing 10 to 40 pounds each. They are best when solid handled. Dumbbells can be made of a solid one-piece construction, welded, or bolted. You will not use them as much for dropping as for swinging. However, some advanced methods will call for you to release the dumbbell before completion. You can buy dumbbells from any sporting goods or weight equipment outlet.

2.2.23 HEAVY BAGS

You should have a selection of heavy bags, stuffed with different combination of foam rubber, sand, or soft pellets, and covered in canvas or durable vinyl. They can be tube or bell shaped, and they can range in weight from 20 to 120 pounds, as with many blocking dummies or boxing heavy bags. Purchase them from sporting goods outlets carrying boxing equipment or outlet catalogs of physical education equipment, football equipment, and so on. You can also construct bags with towel, shot, or sand stuffing in large laundry or carry-all bags.

2.2.24 HURDLES

Select hurdles that are adjustable, lightweight for carrying, and a combination of aluminum, PVC, plastic, wood, or metal. You should be able to range them in height from 12 to 36 inches.

You can purchase hurdles from track and conditioning catalogs or construct them of scraps from plumbing, building, or used furniture locations.
2.2.25 LANDING PITS

You can find landing pits outside at tracks or conditioning areas that use sand and sawdust in the dirt, or indoors, placed into or on top of ground, as landing boxes of foam padding or raised cushions.

Foam pit sizes range from 8-to-15 feet square. Sand pits can range from normal long or triple-jump pits to large ones of 5-by-30 yard rectangles.

You can purchase foam padding from sporting goods stores or outdoor and furniture repair outlets. You can get sand from rock and gravel quarries or landscaping suppliers.

2.2.26 MEDICINE BALLS

Having assorted sizes of rubber or elastic balls is best, although you can use leather types if a partner aids you. The size and weight, for our purposes, range from 3 to 4 pounds, for single-limb work, to 12 to 15 pounds for total-body exercises.

It is best to purpose balls from manufactures through a catalog or wholesale outfitter. You can also construct them from old playground or sports balls and stuff, fill, or sew them, and even wrap them in plastic or melt them in rubber.

2.2.27 STAIR STEPS

Look for stairs that are closed faced (no open space exists between steps) to prevent the toes from becoming caught underneath, no more than 6 to 8 inches high, 8 to 12 inches deep, and at least 3 feet wide.

You can find suitable steps in stadiums or indoor stairwells or can construct them of wood or cement.
2.2.28 TUBING OR BANDS

You can use elastic tubing to assist with accelerated movements or to provide safe obstacles for incremental jumping. Select assorted sizes and dimensions of surgical cord to solid core rubber cord. We recommend the thicker, more solid styles. Dimensions range from one-eighth-inch to three-quarter-inch thickness (inquire whether that is the total diameter or the width of the tubing wall). Size ranges may come in light, medium, and heavy specifications also, as with some wider styles of rubber bands.

You can purchase tubes and bands at hospital or pharmaceutical supply outlets, catalogs, or conditioning product catalogs.

2.2.29 ATTIRE

There isn't any special attire necessary for explosive power training. The comfort, stability, and design of the shoe does play a part, especially with continued and constant training. However, the main issue is proper foot, ankle, and lower leg-landing positions. These mechanics should be the most important emphasis. Experience and clinical evidence indicate that barefoot or thin-soled footwear may be safe and reliable from the standpoint of decreased tendency for pro-nation, minimizing excessive heel contact, and other landing improprieties. The proper blend of exercise surface and footwear that fosters attention to mechanics is what we should strive for.

2.2.30 WEIGHTED APPAREL

All styles of weighted apparel (vests, belts, anklets, etc.) have undergone clinical and practical evaluation, many with successful results. We do not recommend prolonged use of any particular style and advise against any use in the progressive beginning and intermediate areas of programming.
Once in the advanced stages of training, base your use of weighted apparel on what will produce the best results for optimal hip projection. Use any piece that exhibits the best fit, contour, and efficiency of use and does not detract from the ultimate goals of hip projection and prospective augmentation. You can purchase suitable attire in many sporting goods outlets and conditioning equipment catalogs.

2.2.31 BUILDING A FOUNDATION

Before getting a progressive 12-week program, you should assure that a participant has a proper foundation. This involves a general level of strength, continual testing to be able to select appropriate exercises, exercising with good fundamental techniques, avoiding risks of injury, and knowing how to recuperate from workouts.

2.2.32 STRENGTH TRAINING

Because a strength base is advantageous in plyometric and stretch-shortening cycle training, you should design a general strength-training program to complement, not retard, the development of explosive power. However, you don’t have to overdo establishing a strength base before plyometric training. An often prescribed recommendation in much of the layman’s literature is the once-used Russian suggestion of maximum squat of 1.5 to 2 times the body’s weight before attempting depth jumps similar shock training. This criterion is still useful as a safety protocol for the extreme end of the stress continuum. However, you do not need to apply it to the successful performance and positive training effects of the other stretch-shortening cycle exercises that fall along the progressive criterion. In our more recent research (Radcliffe and Osternig 1995), we found that some trends exist between squat performance and depth-jump capabilities.
However, the significance was so low that any predictions about how well amount of weight squatted determined jump stress capabilities are negligible.

2.2.33 *ON GOING ASSESSMENTS*

Begin all progressions with testing the posture, balance, ability, and flexibility of each participant before you perform any training. Examples of simple evaluation indexes would be performing a body-weight squat with erect torso, through hip and knee flexion, full-foot contact with balance over the mid-floor, and relative strength throughout the movement. Vern Gambetta’s research (1989) suggests that for beginners, strength in the stabilizing muscles is primary, and you can easily test for it. The advantage of assessing posture, balance, stability, and flexibility is that you will have information to guide your planning for progression to the next training level on the continuum. These assessments are useful for all stretch-shortening cycle training movements (weights, plyometrics, speed and agility work, etc.). If progress in any area seems doubtful to you, drop back a level or maintain the current level until you meet the criteria. Then you can move onward.

2.2.34 *VERTICAL JUMP TEST*

Countermovement vertical jump height has been used as a test protocol to measure successful depth-jump performance. Researchers have used several practical testing conventions in this area. As long ago as 1974, Sergio Zanon suggested a protocol.

*An athlete is made to carry out a standing high jump after facing his legs and the maximum height is reached with his hand on a graduated board (vertical jump test). The highest reading of three jumps is registered. The athlete is made to carry out the same operation, landing on the same point*
from a height which is progressively higher by 20-40-60 cms. (depth jump test), and from each different height of fall, the maximum height is reached and the subsequent jump is read off of the graduated board. The value of the greater height reached in the subsequent jump (after landing) which should always be higher than that of the jump from level 'o' (standing jump) determines the optimum height of fall for that particular athlete at that moment of the training process.

Practical field work by Frank Costello (1984) supported this concept. He suggested that, by knowing an athlete's Sargent (standard) vertical jump, then testing in a depth jump from an 18-inch box, relatively weak athletes will jump several inches less than their vertical jump marks, as opposed to stronger athletes who will reach or exceed their vertical jump marks after a drop from the same height.

2.2.35 OTHER BASIC TESTS

In chapter 3 we will describe a basis testing procedure that we have identified and believe is helpful in evaluating power. It involves these tests:

1. 6x10 Shuttle Run
2. Medicine Ball Put
3. Zig-Zag Run
4. Vertical Jump
5. Standing Broad Jump
6. 800 MTS Run

You can also find normative data and ranked improvement progressions in chapter 3 as a way to interpret test scores and individualize
training programs. Testing at the beginning of certain training phases, then retesting at the conclusion of a training phase allows you to evaluate whether the intensity and dosage of the training are correct, too little, or too much. By conferring with the athletes and evaluating the intensity and volumes of the workload, you can systematically monitor the progress and develop a better basis for making adjustments in training. If you keep records and share normative data, as we have done in this book, we can collectively develop better prescriptions for training.

2.2.36 REMEMBER THE BASICS

Whether you are the participant reading this book or a coach who will guide others, you should keep in mind several components of the stretch-shortening cycle and plyometric training principles as you evaluate your teaching, learning, and testing: You want to teach others basic progressions and assessment procedures that provide good training and lead to more complex training methodologies.

- **Remind athletes of these rules:**

  - The toe-up rule, which is using locked ankles in dorsiflexion, with full mid-to forefoot ground contact upon landing.

  - The knee-up and hip-up rules, which promote maximum knee drive and hip extension or projection.

  - The heel-up rule for further projection of the hips and body flight by reducing the are and rate of the swing leg.

  - The thumbs-up or blocking rule of upper body posture and continued force expression.
Applying these rules in an accelerated manner during support leg coupling is known as transference of force (Jacoby and Fraley 1995).

Use sensible progressions in your teaching and working out. Here are a few guidelines:

- Teach exercise execution centered first around the lower leg (pogo, galloping, prancing, and ankle flip).
- Progress from lower-leg to full-leg counter movements (squat jump, split jump, and single-leg stair bound).
- Finally, progress to total torso counter movements (knee-tuck jump, bounding, hopping, etc.).
- With medicine balls, the execution should be passing, tossing, then throwing movements; next do the full multiple recoil movements of thrusting, swinging, and repetitive throws.

Educate athletes about relaxation, especially of the face and neck, to optically perform with postural control. Using proper breathing mechanics is crucial and can assist in structural support and execution:

- Inhale during descent.
- Hold breath during stretch phase.
- Exhale once you have executed shortening.

Teach, learn, coach, and train progressively along the stress continuum (see details in chapters 4 and

2.2.37 LANDINGS

As mentioned in chapter 1, specificity training in plyometrics is as important as in strength and endurance training. Generally, you should perform plyometric exercises at amplitudes and intensities corresponding
closely to the power movements and action sequences of specific sport skills. Sometimes, however, it’s useful to include purposeful temporal and spatial exaggerations as overload mechanisms.

Performing jumps with undamped (without delay) landings produces higher power and force values than those with damped landings (landings with a deed flexion, therefore more delay in coupling and contact times). The quicker the person switches from yielding work to overcoming work, the more powerful, and safer, the response.

In most cases, a good guideline to follow is that athletes should execute undamped landings in jumping exercises. All progressions and advancement in stretch-shortening cycle exercise execution should stress active tension upon landings. Both clinical and practical evidence exists about conditioning the participants in the art of preparing the musculature for takeoffs upon landing. In an effort to minimize ground time and promote undamped, high-tension, optimum-impulse takeoffs, you want to flex the joints and tense the stretch components upon loading. In an effort to minimize ground time and promote undraped, high-tension, optimum-impulse takeoffs, you want to flex the joints and tense the stretch components upon loading, rather than after contact with the ground.

2.2.38 FOOT PLACEMENT

Proper foot placement when doing the yielding and overcoming work is essential. To obtain as quick a release as possible, an athlete must maintain a locked ankle when landing on the ground. Rolling the foot from heel to tow or allowing movement along the ankle joint slows the response and displaces the force away from the overcoming portion. The best way to land on the ground is with a dorsiflexed foot and two-thirds to full-foot ground contact.
upon landing, emphasizing that the weight be balanced on the front half of the foot.

If you emphasize landing on the toes or even on the ball of the foot. On athlete might become confused, leading to poorly balanced landings and inadequate specificity in most leg and foot movements involving acceleration. As drill and execution techniques progress, the ability to reaccelerate the leg and paw the foot to grab the ground will be available, giving the optimal use of the least amount of ground contact time.

2.2.39 BLOCKING OR THUMBS-UP RULE

In all plyometric jumps, hops, leaps, bounds, skips, and ricochets, concentrate on the blocking (thumb-up) rule, by adding the arms in a forward and upward punching motion. The block occurs by abruptly halting the motion, to maintain upper body posture and continue force expression. When you bring the knees upward abruptly, as in hopping and tucking movements, the tendency is for the shoulders to drop forward. Holding the hands in thumbs-up position and executing the block technique counteracts this tendency by forcing the torso to remain more upright, thus aiding balance. In addition, the blocking motion of the upper torso can provide some 10 to 12 percent of the forces you apply.

2.2.40 FOLLOW-THROUGH

Follow-through is important in plyometric movements involving upper-body muscle groups. You should apply force continuously and emphasize quickness of action. In repetitive throws, such as the medicine ball chest pass or the heavy bag thrust, try to prevent the recovery or catch phase from going beyond the point of full extension or flexion. This will ensure that
limb and trunk musculature is properly stretched (loaded), initiating a more forceful, reactive explosion.

2.2.41 DILEMMAS OF ECCENTRIC EXERCISE

Eccentric exercise has been shown to produce damage in muscle cells and in motor performance. High-force eccentric exercise places considerable stress on muscle and connective tissue. It tends to produce delayed-onset muscle soreness. However, various sport scientists (Including Fritz and Stauber 1988; Frid' en 1984; Ebbeling and Clarkson 1960) have found data suggesting that damaged connective tissue and muscle relates to important regeneration process. The eccentric side of contraction also seems to cause increased intramuscular fluid pressure as a factor associated with delayed muscle soreness. This is significant for plyometric participants; some of this massage has a positive side connected with the regeneration process. It is helpful to understand these concepts to be able to better assess training, fatigue, overuse, and recovery.

Eccentric contractions cause more changes in certain muscle functions than do concentric contractions. These changes seem to be the result of trauma, initially in the mechanics. However, with time chemical changes also occur, due to the high tensions generated during eccentric loading. This type offloading has also been associated with some occurrence of tendinitis. Greater forces during eccentric contractions. According to Curwin and Stanish (1984), create greater stress on the tendons of the involved joints. Evidence of damage to the tendon microstructures seems to be the major factor involved.

The increased use of eccentric muscular exercise to augment performance and re-habitation has generated questions about optimal and safe
training loads. For practitioners, a great concern is that there is no consensus about what constitutes appropriate volumes and intensities of the stretch-shortening cycle or eccentric loading exercise. The type, duration, intensity, and dosage of elastic and stretch-shortening cycle training protocols needs continuous evaluation. Developments over the last 15 years, by study and by practical evaluation, have helped us greatly in dosage recommendations. This is another reason the progression tables in later chapters can be so valuable.

Eccentric action deserves special consideration from the physiological, adaptive, and training standpoints, because eccentric muscle contraction can absorb shock, a function different from other muscle actions. Training using only eccentric actions eliminates the inhibitory actions allowing for improvement in muscle strength and function. This shows us a further needs for examining the balance of eccentric and concentric muscle regimen and understanding the optimal use of eccentric and stretch shortening cycle training methodologies (Stauber 1989).

Therefore, continued damage to many fibers or connective tissue and continued repair and adaptation are long-term training effects of repeated eccentric muscle actions. Recovery from this form of exercise tends to be a slow process. Complete recovery can possibly take a week to 10 days, especially when an athlete does unaccustomed eccentric work. On the other hand, repeated bouts of eccentric exercise can produce adaptation, before complete recovery and restoration. Repeated, long-term eccentric tensions reorganize and re-coordinate muscle fiber structures, resulting in better stretchability and reduced mechanical damage. A fine line can exist in results from heavy exercise bouts with eccentric contractions; injury or microtearing of muscle fiber compared with helpful adaptations that improve power and
plyometric overloads that can become harmful compared with those that produce great results due to adaptation. The common denominator is the work-to-rest ratio, and we will explain this with more details later in the chapter.

We should now consider eccentric loading along with pre-stretch exercises and pre-landing postures. A major factor in treating (or rehabilitating) eccentric loading problems is initiating force-reducing techniques and use postural control during eccentric movements. The subsequent effects of a pre-motion silent period, a possible central-motor control system to stretch the agonist while reinforcing the dynamic forces that follow, seems to significantly reduce the forces in dynamic and ballistic movements (Aoki, Tsukahara, and Yabe 1989). Just as we will do in the different training phases of the stretch-shortening cycle, we can progress through rehabilitative phases using the same concepts.

In rehabilitative terms, this means slow, controlled, eccentric movements, developing to the point at which you can control much higher velocities with eccentric, contractile stopping abilities. Let’s take jumping in stretch-shortening cycle training, for instance. Landing technique is the primary issue. How well you land will dictate how well you next take off. By executing the proper pre-landing posture and give with the landing impact, the impulsive reversal of motion becomes the ultimate feature of the training.

Beginners should start with moderate drills, such as in-place jumps, and drills with both legs. As you see strength and explosive power increase, you can progress to movement drills and increasing intensity and complexity.
2.2.42 PROGRESSIVE OVERLOAD

A plyometric training program must provide resistive, spatial, and temporal overload. Overload forces the neuromuscular system to work at greater intensities. You regulate proper overload by controlling the height, distance, external loads or forces (or both), and the dosage (volume of work) of each variable. Improper overload may negate the effectiveness of the exercise or may even result in injury. Thus, using weights that exceed the resistive overload demands of certain plyometric movements may increase strength but necessarily explosive power. Resistive overload in most plyometric exercises takes the form of forces of momentum and gravity, using lightweight objects such as medicine balls or dumbbells or merely body weight. Later in this chapter we will deal more comprehensively with this concept.

2.2.43 VOLUME AND DOSAGE

Usually the number of sets and repetitions coincides with the type, complexity, and intensity of the exercises involving stretch-shortening cycle training. The amount should also reflect the planning strangest, the progressions, and levels of development that you have achieved. Usually the number of repetitions ranges from 8 to 12, with fewer repetitions for more complex takeoff and landing sequences and more repetitions for those exercises with lower stress. The number of sets may vary accordingly. Sport scientists in eastern Europe have suggested 6 to 10 sets for most exercises, whereas earlier Russian sport scientists recommended from 3 to 6 sets, especially for the more intense jumping drills. We emphasize that you plan all dosages on the continuum of progressive development as dictated by exercise complexity.
In the 1970s Russian scientists Verkhosnansky and Tatyan (1977) showed that, with high-volume speed-strength training, the sequencing of speed-strength training for preparing athletes is not statistically significant. This type of training is most effective when simultaneously used speed-strength preparation coordinates with the current functional state of the athlete's body. Sometimes the number of repetitions is dictated not only by the intensity of the drill but also by the athlete's condition, the execution of each repetition, and the value of the outcome.

2.2.44 SINGLE- AND MULTIPLE-RESPONSE DRILLS

Most stretch-shortening cycle drills fall into one of two categories: single-response (SR) or multiple-response (MR) drills. The single-response drills represent a single, intense effort. Good examples are takeoffs, initial bursts of motion, and releases. Multiple-response drills, though also intense, place more emphasis on elasticity, speed, and coordination by involving several efforts in succession. One major goal of true plyometric training is accomplishing high-impulse landings and takeoffs in succession. To properly progress to the advanced stages of the stretch-shortening cycle and plyometric training continuum, you must use both types of response. Even better, you should insert a third, which we call multiple response with a pause, working it into the educational setting of the training.

In the teaching and learning progression, perform single-response drills with a complete self-check and reset of the posture, balance, stability, and flexibility at each takeoff and landing. Successful performance then leads to executing the exercise in a single-response manner without resetting: takeoff, land, pause and check, then repeat. Therefore, because of the no-rest factor.
the drill becomes a continued set of responses, but with pauses. Continued success will lead to multiple-response repetitions and progressions.

You are performing these drills to improve nerve-muscle reactions, explosiveness, quickness, and the ability to generate forces in certain directions. An athlete will only benefit from the number of repetitions done well. For example, if he or she performs a set of hops, bounds, or throws correctly for eight repetitions, but begins to fatigue and performs incorrectly thereafter, then eight repetitions is enough. In the elastic-reactive nature of this training, little is gained with low effort, poorly executed exercises. Several coaches and researchers have used high-volume drills and exercises to investigate the effectiveness of high-endurance elasticity, but the nature of the exercises is low impact and intensity and low movement complexity. Referring to the basis progression guidelines section of this chapter, we see that training effects occur with quality before quality.

The number of sets, repetitions, and rest periods we recommended in the following chapters are based on our experiences of teaching and coaching plyometric training at the junior high, high school, collegiate, professional, and elite athlete levels, and on research literature for particular drills. They are not absolutes, but merely a basis from which you can begin, then evaluate, and progress. Adjust the values within the objectives to achieve the optimal training goals. Volume of plyometric training is an inexact science at this time, and we need much further research in this area.

2.2.45 HIGH INTENSITY

We can describe intensity two ways, both important to stretch-shortening cycle training. One description deals with amount of force at impact. We will address this in more detail later. The other use of the term
deals with the level of effort while executing the drills. Once you have implemented warm-up and progressive lead-up exercise, quickness of execution with maximal effort is essential for optimal training effects. The rate of muscle stretch is more important than the magnitude of the stretch. You achieve a greater reflex response when you load the muscle rapidly. Regardless of the level of progression, you must expend maximum effort projecting the hips, torso, appendages, or implement. Reducing impact, complexity, or flight is dictated by the technique and constraints of the exercise progressions themselves, not by diminished effort. Because you must perform the exercise intensely, it is important to rest adequately between successive exercise sequences.

2.2.46 MAXIMIZE FORCE AND MINIMIZE TIME

Both force and velocity of movement are important in plyometric training. In many cases the critical concern is the speed at which you can perform a particular action. For example, in shot putting the primary objective is to maximum force throughout the putting movement. The quicker you execute the action sequence, the greater the force you will generate and the longer the distance you will achieve. As we defined it in chapter I, the impulse of the movement is key. Movements must have a high impulse to genuinely train in the manner that the stretch-shortening cycle and plyometrics have suggested. The measure of impulsive action may truly dictate the effectiveness of training and performance.

2.2.47 REST

A rest period of one or two minutes between sets usually sufficient for the neuromuscular systems stressed by stretch-shortening cycle exercises to recuperate. Much depends on where the exercise exist along the stress scale.
Exercises of low impact and landing or catching intensity (medicine ball, heavy bag) may allow minimal rest periods of 30 to 60 seconds, enough time to walk back or change places with a partner or group of practitioners. At the shock end of the stress scale, exercise repetitions may require 2+ to 3 minutes or more for the systems to be available to produce and handle the forces necessary for optimal execution. An adequate period of rest between training days is important for proper recovery of muscles, ligaments, and tendons.

2.2.48 COMPLEX TRAINING

On some combined strength and elastic work days, an efficient method of time and facility use is strength, speed, and elastic complex. Our definition of a complex is when the sets of two different exercise styles follow one another, unlike combinations which we define as the repetitions of two different exercise styles following one another. For example, we consider a set of three repetitions of clean and jerk repetitions, this would be a complex (clean then jerk) exercise.

Complex training methods can also involve attaching two exercises that are similar in movement pattern and fall into the different labels of absolute or relative strength (speed not a factor), and those of elastic (speed and rebound ability). For further definition of these strength terms refer to chapter 2. Examples of complexes of absolute strength and elastic strength (weights and plyometrics) that have been tossing or throwing, and lunging then passing, pulling then tossing or throwing, and lunging then bounding or skipping.

Barbell back squat then squat jump 5x4 – do a set of 5 repetitions of barbell back squat, followed immediately by a set of 4 squat jumps, then rest. Increase the weight of the barbell; then repeat the sequence
for 3 more sets. You may perform the squat jumps with a light weight (25-pound sandbag, etc.) eventually. In the beginning use only body weight.

Incline press or bench press then medicine ball chest pass (for height) 5 x 5 began with a set of 5 repetitions of incline press, followed immediately by 5 repetitions of medicine ball chest pass with a 7-to 15-pound medicine ball, then rest. Increase the amount of weight on the barbell if necessary to intensify those repetitions, and repeat the sequence. The medicine ball weight does not increase.

2.2.49 INDIVIDUALIZING THE TRAINING PROGRAM

For best results, you will want to individualize the plyometric training program. After you have evaluated the participant, trained him or her in the basics, and observed some exercises, you should have a good idea of what each athlete is capable of doing and how fast to progress. Despite continuing research in the area of optimal training loads, as with so many other areas of sport training, individualizing the stretch-shortening cycle training program is more of an art than a science.

The intensity and amount of overload are two critical variable here. Views vary about the optimum intensity and overload for different stretch-shortening cycle exercises. Many coaches still recommend that athletes be able to squat 1 +to 2 times their body weight, for example, to train with certain plyometric exercises. However, as we mentioned previously, this does not apply to all exercises under the stress continuum of the stretch-shortening cycle. Not is it appropriate for every individual.
As we will discuss later, simple tests of progression and evaluation can provide a basis for individualizing the training, even if these tests are not yet based on a substantial body of scientific research evidence.

One notable area in which there is good evidence is the depth-jump exercise. Bosco and Komi (1979, 1981) and Verkhoshansky (1967) examined the optimal height for executing depth jumps and found that dropping from a height of 29 inches develops speed. Higher than 43 inches, the time and energy it takes to cushion the force of the drop to the ground defeats the purpose for this shock training.

More than three decades ago, Verkhoshansky first addressed the usefulness of depth jumps as an eccentric loading exercise. He searched for a shock method of nerve muscle reactive ability in a takeoff after jumping from a height. He demonstrated that isotonic weight training marginally improved speed of running and jumping takeoff. Verkhansky stated that “jumps in-depth come the closest to bridging the gap between weight or strength training and jump training for speed.” adding, “Takeoffs after a jump for depth was the leading method of improving the reactive ability of the nerve-muscle apparatus” (Verkhoshansky 1968).

Bosco and Komi (1982) reported improvements in jumping ability and increased tolerance to stretch loads in what they termed bounce training (drop jumps). After studying an athlete’s behavior under impact (depth jumps), Bobbert and others (Bobbert et al. 1986; Bobbert, Huijing, and van Ingen Schenau 1987 a, b), who also analyzed techniques of drop and countermovement jumps (and the force of their impact), recommended choosing drop height that do not require heel-to-ground contact. Athletes
should land with the weight distributed toward the forward half of the feet, because landing on a flat foot may excessively strain the Achilles tendon.

When eccentric training was introduced in the 1960s, it was assumed that high drop jumps (75-115 centimeters or 30-45 inches) were necessary to achieve maximum results (Verkhoshansky 1968). Later, studies recommended that drop heights should not exceed 40 to 60 centimeters or 16 to 24 inches (Komi and Bosco 1978; Scoles 1978; Viitasalo and Bosco 1982; Clutch et al. 1983; Bosco and Komi 1979, 1982; Adams 1984; Hakkinen, Alen, and Komi 1985). Our studies (Radcliffe and Ostimig 1995) and others (Bobbert et al. 1986; Bobbert, Huijing, and van Ingen Schenau 1987a, b) indicate that a further reduction in drop height may be appropriate (10 to 40 centimeters or 8 to 16 inches).

2.2.50 SPECIFICITY

As we mentioned in the first chapter, improving performance requires using the principle of specific training and development. The dynamic structures of a skill are located in the muscular components of force, contraction and recruitment. Training concepts in a spatial orientation can help this development, for example, using positions that mimic the same angles and degrees in performance. These increases become evident when, whether simple or complex, the movements you train are the same movements you evaluate in testing. The principles that put the body's postures into their movement planes include the patterns.

Regions, frequencies, and velocities of the performance movements (Bompa 1993; Siff 1996).
When you train for specific strength, speed, and endurance, keep in mind that stretch-shortening cycle exercises are useful for a variety of the phases and elements of the overload, intensity, and dosage principles. Different phases of training require various preparatory, technical, developmental, and transitional methods. Using different, multilateral, and specific aspects as you phase them in and out of the training development. Training age, rehabilitation, and closeness of a competitive performance each should influence the timing and dosages of specific plyometric movements.

We recommend that you continue using the progressive exercise methods to develop the general processes of strength (for example, the relative and dynamic portions) while you move reactive portions with shock methodology as in the advanced stages. The progressions are necessary to continue fostering greater neuro-motor (prospective) development. Then, with complete knowledge of your sport or activity, apply the stretch-shortening cycle principles to developing highly specific, neuromuscular improvements in performance parameters.

2.2.51 TRAINING AND REHABILITATION FUNCTIONS

Plyometric training and treatment regimes exist for different functions and methods. From a training standpoint, development from overloads might be:

- Resistive (forces of gravity, F);
- Spatial (range of motion, d); and
- Temporal (speed of movement, t).

These overloads exist as a menu of methodologies for improving power \[ F \times d / t \] (Radcliffe and Farentinos 1985).
Treatment regimes also exist for three corresponding methodologies:

- Lengthening, or increasing the resting length of the muscle tendon unit, stretching as a method of developing the tendons.
- Loading or increasing the stress on the tendons by progressive loading for basis physical development.
- Contraction speed, or increasing the speed of the movements, thereby increasing the loads on the tendon.

Several treatment programs exist that use eccentric exercise. As an example, Curwin and Standish (1984) suggest this rehabilitation treatment for tendonitis: static stretching. Followed by progressive eccentric exercise, determined by the amount of pain or discomfort (they give a symptom classification system), followed once again by static stretching, and concluding with ice massage applied to the inflicted areas.

You may notice that in the progressive development of the stretch-shortening cycle, or in a plyometric training program, some parts of the early drills and exercised, designed to foster correct technical and developmentally safe performance, do not adhere to the definitions of elastic, reactive, or plyometric exercise training. If the goals and objectives of the program are sincere, then we must get beyond this discrepancy so the final outcome—the elite level of progression—is truly explosive, impulsive, elastic-reactive, plyometric, and impressive. As sniff and Verkhoshansky (1996) have pointed out, we need to recognize that we can arrange plyometric training in many categories. Some examples are the distinctions between impact (no surface contact ends in contact with a surface). Distinctions also exist between maximal (producing rebound tensions and impulses of the highest intensities).
and sub maximal (exhibiting lesser impulses, lower intensities, and being less complex in execution) exercises. These distinctions fit along the stress continuum explained in chapter 4.

Many movements may be preparatory or supplemental before progressing to more classical plyometric movements. Again, it is understanding the concepts of the training, the proper lead-up progressions, and evaluating successful execution for advancement that are important to the overall development of the plyometric program.

The primary task in using stretch-shortening cycle and plyometric training is to fully understand the program you want to use it for. You can best accomplish this by establishing goals and objectives. Whatever the program, it's necessary to include certain objectives from the beginning. These objectives are defining the principles of this style of training, balancing and progressing the exercise movements, and applying the principles throughout, so they encompass the entire plan of the program.

Here are examples of these goals and objectives, as they might apply to establishing a program:

1. Develop a well-balanced, well-rounded, progressive training program.
2. Include the stretch-shortening cycle within all applications of basic training development (e.g., preparatory, technical, developmental, and transitional).
3. Use encompassing and individualized planning to safely and successfully progress beginners through to advanced or elite performers.
4. Create a system for evaluating the performance of the program.
Above all, keep in mind that the best training in itself is using proper progressions. If you always check the posture, balance, stability, and flexibility of each athlete throughout, then you produce a great deal more information. This feedback will go far in helping you apply proper dosages and load intensities.