

Plyometrics Roundtable

Track Coach editor Russ Ebbets prepared the questions for our panel-six leading American old hands of plyometric training application and theory.

THE PANEL

James c. Radcliffe. Jimmy Radcliffe has been the strength and conditioning coach at the University of Oregon since 1985. His books, including Plyometrics: Explosive Power Training and High-Powered Plyometrics are among the best-read in the field. He has also produced popular videos and DVDs on the subject of plyometrics. He has contributed to more than a dozen journals and is a frequent presenter/clinician at schools, clinics and conferences in the U. S.. and elsewhere.

Vern Gambetta. Vern Gambetta is the president of Gambetta Sport Training Systems in Sarasota, Florida. He was the conditioning consultant for the U. S. Men's 1998 World Cup Soccer team and has worked with MLS teams including the Tampa Bay Mutiny, the New England Revolution, and the Chicago Fire. He has also served as Director of Conditioning for the Chicago White Sox and Director of Athletic Development for the New York Mets. In basketball he worked with the Canadian Men's and Women's National teams and the Chicago Bulls. From 1977-1982 he headed the women's cross country and track program at UC Berkeley. His cross country teams won three Region 8 titles and finished in the top ten at Nationals four consecutive years. In 1982 his track team placed second at Nationals.

Vern served as the first Director of the TAC Coaching Education Program, an innovative program designed to upgrade the standard of track and field coaching in the u.s. He was the editor of Track Technique from 1980 to 1988, and edited the TAC Coaching Manual, Vols. I and II, and has authored six books and over 100 articles on training and conditioning.

Larry Judge, PhD, CSCS, Assistant Professor of Physical Education, Ball State University, is the USA Track & Field National Chairman for Coaches Education in the throws, and he lectures at various camps and clinics throughout the country. He has coached more than 100 NCAA Division I All-Americans, including eight Olympians. He can be contacted through his web site: www.coachlarryjudge.com

Dave Kerin. Dave Kerin coaches at Middlebury College. One of his athletes holds the NCAA Div. III record for the women's high jump. He is USATF Level III certified in jumping events, a Coaches Ed. Level II instructor, and carries a Masters Certification as an official. He also works for USATF High Performance & Women's Development groups.

John Cissik. John is the Director of Fitness and Recreation at Texas Woman's University. He consults on speed and strength training with various programs and is a prolific speaker, author of four books, including Strength Training for Track & Field, four DVD's, and approximately 60 coaching articles on strength and speed training.

Chris Polakowski. Chris Polakowski's primary job is that of a middle school physical education teacher, but for 20 years he coached track & field at the middle through college level. He is a USATF Level II Coach, and a CSCS and USA Weightlifting Certified International Coach. He coached a lifter to the Olympic Trials and several athletes in other sports to national (track) and international (bobsled, hockey) levels as their personal strength coach. He coached vaulters at the University of Vermont for several years.

1. What does the term plyometrics mean to you?

Gambetta: Plyometrics is the training of the stretch-shortening cycle of muscle action with hopping, jumping, and bounding activities to enhance the subsequent concentric muscle action. The goals are a) tolerate greater stretch loads-enhance stiffness; b) learn to attenuate ground reaction forces; C) enhance explosive power

Judge: Plyometrics was a training method thought to be developed in Eastern Europe for emerging elite athletes. Together, the Latin root words "plio" (i.e., more) and "metric" mean measurable increases. These "jumping" exercises have actually been around for decades and involve an eccentric contraction followed immediately by a concentric contraction.

The term "plyometrics" was first coined in the United States by track coach Fred Wilt. This particular training method involves simultaneous voluntary and involuntary muscle contractions. The goal is specific: to enhance the explosive reaction of the individual through powerful muscular contractions as a result of rapid eccentric contractions.

Results show this training method can improve force production at high velocities and cause an increase in maximum rate of force development. The effectiveness of plyometric training is well supported by research.

Kerin: 20 years ago, I understood it as dropping off a high box. More recently I would describe it as a potential means to improve an athlete's performance through stretch-shortening cycle enhancement.

Radcliffe: Plyometrics means a style of training utilizing exercises that are explosive and take advantage of the elastic-reactive components of the neuromuscular system. This includes any form of jumping, bounding, hopping, throwing, and tossing movements that combine the effects of eccentric loading and the rate of concentric execution.

Cissik: For the most part plyometrics involve using the stretch reflex to take advantage of elastic energy. Plyometric exercises are primarily done with bodyweight, though they may include an implement like a medicine ball or kettle bell. Plyometrics include various jumps, bounds/skips/hops, and throws.

Polakowski: Plyometrics are ballistic exercises, requiring the body to quickly change from an eccentric to a concentric contraction with as little time lapse as needed. The training protocol endeavors to better use both the stretch reflex and elastic properties of the muscle.

2. I have long felt (and taught) that the concept of plyometrics is often poorly understood and inappropriately applied by track and field coaches and coaches in other sports. My rule of thumb was that if you couldn't triple jump 40' (34' for females) or squat 1.5x bodyweight I shied away from plyometric work. At what point do you feel an athlete is ready for plyometric work? Is there safe plyometric work for a novice or Junior Olympian?

Gambetta: We must be careful with broad statements (like "triple jump 40' or squat 1.5x bodyweight I shied away from plyometric work"). Those constraints are the vestige of the misinterpretation of statements made in the literature on plyometrics from the former Eastern Bloc countries. Jumping, hopping and bounding are natural activities. Children do those activities in play naturally without training. If volume is strictly controlled virtually anyone can use plyometric activities as long as the objectives are clearly understood. Plyometric training for the young and developing athlete must be put in the context of the other components of training. With the young athlete it should be playful and game-like. Above all, good technical proficiency must be a prerequisite for adding greater complexity.

Judge: Most experts state that a thorough grounding in weight training is essential before you start. Although plyometrics have proven results, athletes without proper preparation, inexperienced athletes, or younger athletes can easily get hurt. Higher-than-normal forces are placed on the musculoskeletal system when performing plyometric exercises making these specific "jumping" exercises particularly dangerous.

If an athlete is not ready, is there safe plyometric work for a novice or Junior Olympian? Many experts in the field suggest that moderate jumps can be included in the athletic training of very young children. However, great care needs to be exerted when prescribing any training procedures for preadolescents. Because of the relatively immature bone structure in

preadolescent and adolescent children the very great forces exerted during intensive depth jumps should be avoided.

While specialized training like plyometrics provides great benefits to many athletes, any enhancement of power can be severely restricted if general strength parameters, mobility, and posture are not also addressed. I have found that highly specialized, event-specific training can be the source of tremendous frustration and recurring injury patterns if these foundational items aren't also developed in a variety of conditions, thresholds, and environments. It is important for the athlete to have a good sound base of general strength and endurance.

Less intensive plyometric exercises can be incorporated into general circuit and weight training during the early stages of training so as to progressively condition the athlete. Simple plyometric drills such as skipping hopping and bounding should be introduced first. Preparation phase plyometric exercises include various ground level plyo's including jump circuits, many types of bounding drills and bleacher / stairs work. This is a great starting point for a plyometric program.

An athlete must establish a fitness base before progressing to higher intensity work. For a novice athlete, I think it is important to learn the basics. Time needs to be spent on learning how to skip, bound, jump and land. Many of these exercises are used throughout the training program to build a base for later high intensity work that includes hurdle hops, benches and boxes of various heights. More demanding exercises such as flying start single-leg hops and depth jumps should be limited to thoroughly conditioned athletes.

Kerin: TJ as a measure would be falsely limiting in that there are very strong people who simply lack those specific skills. Running and jumping (non-plyo specific) are plyometric in effect. Start "slow & low" and look for positive adaptations before progressing with the prescription of plyos at any age. Do kids still jump rope? hopscotch? run? and if so, aren't those examples of safe plyometrics at an early age? With someone young, I would start to build from there. For HS coaches inheriting kids off of a basketball season, those kids have been "plyoing" all winter. Do they need time to recover from winter abuses or are they in prime shape and would be disadvantaged by changing over to too much slow/general prep type work?

Radcliffe: Researchers corroborate utilizing plyometrics in 12-to-14year olds as preparation for future strength training, suggesting moderate training progressions. The "1.5 times bodyweight criterion was initially suggested for depth jumps and shock training yet doesn't need to be applied to the successful performance and training of other plyometric progressions. In our research (Radcliffe 1995) such low correlations were shown to exist between squat performance and depth jump capabilities, that any predictions are extremely negligible.

Use posture, balance, stability, and flexibility assessments as a guide for progression to the next level of training. If any of the criteria are doubtful, maintain until the criteria are met, then progress.

Cissik: Technically, the triple jump is a plyometric exercise. So there are some flaws in this argument. After all-you cannot do the triple jump until you can triple jump 40'? Here's the thing, some plyometric exercises are clearly advanced. These are exercises that involve dropping from a height, jumping onto a height, purely one-legged jumps, etc. Those types of exercises require several qualities to be successful. First, flawless technique. Failing to land properly is going to cause an injury. Second, for advanced exercises a strength base is essential. The 1.5x bodyweight standard refers to depth jumps but certainly doesn't apply to jumping rope. Third, master the fundamental exercises. If you cannot jump from both feet explosively and land properly, then there is clearly no point in trying it off one foot or doing the exercise from a height.

Polakowski: Personally, I think a young body is ready early in the training career (10 or 11 years old), provided the training is done at the appropriate level and there's a high general fitness within this age group.

For example, these "fit" youngsters can be given a program that includes a few days a week of jump roping (two feet on the ground to start). Games that include jumping (e.g., volleyball) can add enjoyment and play to the young trainer. By 12, these same children can include stationary jumps (e.g., jump for height, straddle jumps, tuck jumps) as a next progression.

Be conservative in the number of contacts and days in the week that these exercises are done. This early training prepares the body for the next progression in explosive training. (As mentioned earlier, do not start any exercise, unless the athlete is physically prepared for it.)

3. Discus great Al Oerter attributed much of his throwing success to dribbling a heavy medicine ball against a concrete wall, what I've called "Talking Arms." What drills do you do for the arms?

Gambetta: What about everything else he did? Lets get real. Also remember that when he threw there were no medicine balls that bounced! By definition plyometric training refers to hopping, jumping and bounding activities. Let's not confuse terms. Medicine ball work is classified as core training or as multi-throws (maximum power training) if it involves throwing.

Judge: Because of the nature of the throwing, medicine ball training often comprises a large percentage of the auxiliary training. Medicine ball throws can be categorized as supplemental or specific training for the throws because medicine balls can be used for extraneous preparation exercise but also in the specific throwing pattern. Medicine ball preparation ,exercises are used to strengthen the abdominals and the torso.

During the peaking phase, medicine ball exercises are great for developing speed strength. Unlike free weight exercises like the bench press, medicine ball throwing involves no deceleration phase. Release work can be performed in all of the throwing events emphasizing the velocity of release. Specific medicine ball exercises are performed in the same way.

Medicine ball work is the foundation of a javelin thrower's training. A progression for a javelin thrower would include: standing throws, three-step throw, five-step throws, two-step walk-in full throws, and full throws.

For the shot putter, another means of increasing upper body strength popular with throwers is to lie on the ground face up. A partner then drops a medicine ball down towards the chest of the athlete, who catches the ball (pre-stretch) and immediately throws it back. This is a high-intensity exercise and should only be used after some basic conditioning.

Kerin: Not much for jumpers. My vaulters get their upper body work from the weight room and time on the pole, but there is a connection between the forces-plant through the "reverse C" position and training with repeat overhead throw and catches into / off a wall. I prescribe some work for throwers and multi-event folks and a quick answer would be that plyo / rebound throws are of value. Specifically with a javelin thrower as too many people forget the elastic requirements of the event. In the past I have prescribed rebound OH throws into a wall, overhead drop/catch & OHB's, rebound SP into a wall, twisting rebound throws, etc.

Cissik: Some medicine ball drills. Things like various chest passes (with partner or against the wall), tosses (to a partner or just for a distance), various explosive push-ups (clapping, "depth" push-ups, etc.), and medicine ball drops.

Polakowski: A progression I've used with push-up start with said exercise. Athletes change arm and leg spacing, as well as position of fingers during the first part of this progression. The next progression (athletes should be able to correctly perform 20 push-ups to move to the next progression), is to have one hand on a medicine ball while performing push-ups. The next phase is to perform a push-up, one hand on and immediately rising, switch the ball to the other hand. There are more progressions that I use from this point, but this is a good start (the first year).

4. Where do you use plyometrics in your weekly plan? Do the plyometrics come after weight work or before? On the day of weight work or the day after?

Gambetta: This is very training age dependent and also dependent on the work capacity base. It also depends on the phase of the training year. With younger training ages I recommend plyometrics before strength training. It should be sequenced on the same day as pulling (Olympic lifting) movements and leg work. With advanced training ages it is possible to mix plyometric and

strength training depending on the objective of the workout and the time of the training year. Greatest volume of plyo work generally follows the highest strength loading phase. Occasionally, with advanced training age athletes, we will do Olympic lifting movements on one day to open neural pathways and then do highest-intensity lowest-volume plyo work the following day.

Judge: The golden rule of any conditioning program is specificity. Plyometrics are performed twice a week. A thorough warm-up is essential prior to plyometric training. Attention should be given to jogging, striding and general mobility especially about the joints involved in the planned plyometric session. In the early season preparation phase plyometrics are performed at the track before weight training. These "jumping" exercises are performed on a high-intensity day that involves Olympic lifting movements.

During the competitive phase, high-intensity plyometrics can be performed in the weight room. Plyo's can be used in conjunction with exercises like the squat. The use of heavy and light loads in the same training session is referred to as the contrasting load method. Complex training has gained popularity as a training strategy combining weight training and plyometric training. Anecdotal reports recommend training in this fashion in order to improve muscular power and athletic performance.

Kerin: Keeping in mind the plyometric nature of sprinting and jumping, I have used all of the above. It depends on the theme of the day / cycle and where we are in-season. I tend to ramp up the volume of all work prior to the holidays as the break is a built-in recovery period. I have used weight room complexes with a DL or squat followed by a plyometric jump(s) done for sets. High amplitude/very low volume plyo's for neural activation or shock training.

Radcliffe: Depending upon the emphasis for the day/session the plyometric work can be 1) placed immediately after the warm-up and before the sprint or strength work; 2) "complexed" with the lifts and or sprint work within the body of the total training session; or 3) placed at the end of the training session, before the cool-down. Work the day of explosive, dynamic, intense work, not the day after, or the recovery day.

Cissik: I plan by the quality to be trained and by energy systems. In other words, if the sprinters are doing short, intense, all-out efforts addressing the immediate energy system on the track then the weight room and plyometrics for that day will emphasize those qualities. So, for example:

Track: 5x20 meter sprints, rolling start

Weight room: Power clean, clean pulls, split jerk

Plyometrics: Standing long jump, hurdle hops

As far as which comes first, this depends upon two things. First, what time of year are we in? Off-season the weights may come first, in-season it's always the track. Second, what are the athlete's needs. The quality the athlete needs to develop most needs to be prioritized.

Polakowski: I have no straight answer for your question. When I develop a plan for an athlete, I first consider the strength training (weight room). I don't do any formal plyometric work during a conditioning cycle (or with an unfit athlete at any time). During other cycles, I'll more than likely do plyometrics the same day before the weight work, when performing the Olympic lifts (snatch, clean & jerk and similar exercises).

5. Core strength, from a dynamic stabilization standpoint, is critical to power generation in the extremities. From either a general or specific standpoint what are some of the moves or muscles you concentrate on in your core strength program?

Gambetta: Emphasize training movements not muscles. No one or two muscles can stabilize the spine; it takes muscles working synergistically to achieve stability in motion. Stuart McGill states that stability is a moving target. Also remember all training is core training. The core is engaged in running, jumping and throwing activities.

Judge: The core also has a critical role in the maintenance of stability and balance when

performing movements with the extremities. It is the center of all body movements in throwing and can be critical in maintaining the stability of an anatomically correct body position. The objective of a core training program is to enhance the function of the critical torso muscles in a way that spares the spine from damage.

I use a multi-faceted approach to core training, which includes medicine ball work, bodyweight circuits, slow controlled movements, weighted abdominal exercises, dumbbell circuits, Olympic lifts, and ballistic release work. Strengthening the core requires forcing them to do more work than they are used to through overloading and working them from a variety of angles so that all the muscle fibers are used. Various training schemes using sprint drills, throws, and jumps are implemented with volumes, intensities, and rest-to-work ratios are influenced by training age, time of the season, and skill parameters.

The sprint drills emphasize horizontal movements through space where limbs are worked through various ranges of movement under varying thresholds of velocities and force. Multiple throw and multiple jump exercises involve various rotations, flexion/extension factors, and both intra- and intermuscular coordination.

Kerin: My kids are pretty good as far as doing core work. I allow them to drive their core work in part as compensation for my autocratic nature and also because we spend most of the year indoors and they can do core work away from the indoor track where facility time and my time is a valuable commodity. I do observe their core work and find that they hit all areas to a level I feel is sufficient. I also play posture cop and am always preaching "tall" to all my folks. In the weight room I prescribe exercises targeting hip-low back areas, working on targets like the sartorius with exercises like lying on back-extended leg, alpha/numero "tracings" at various hip angles.

Radcliffe: Our core conditioning focuses on the torso of the body, the torso being the trunk including the initial portion of the limbs (shoulders, hips, thighs). The concentration is on the proper execution of flexion, extension, and rotation of the torso, especially about the hips, utilizing proper posture, balance, stability, and mobility.

Cissik: I think this is the most over-used and over-hyped idea out there. I grant that core training is important for injury prevention, particularly in weight events and in people training with heavy weights. I also agree that it is important for posture. However, I think this can be addressed really simply in about 5 minutes a day without purchasing a whole bunch of unnecessary equipment.

Basically my core training is divided into three different types of workouts, which are alternated (e.g., today we do a workout from the first group, tomorrow one from the second, etc.). I organize them like this:

General core training: classic exercises like crunches, leg raises, sit-ups, back raises, etc.

Stability training: stability ball exercises, prone holds, side holds, etc.

Medicine ball training: various passes and tosses.

For the most part this is one area where I use circuit training. For instance, I'll select ten exercises in a group (say, general core exercises), have the athlete perform each for 30 seconds, with no rest between each exercise. Workout is done in about five minutes. I've included a sample below (a general core workout):

Crunch, feet on floor

Prone back raises

Sit-ups, feet free

Alt arm/leg, prone

Modified crunch

Oblique reach, feet on floor V-ups

Bicycles

Lying leg raises

Jackknives, right hand to left foot/left hand to right foot (alternate).

Polakowski: I look at the core as all muscles that surround the torso. Yes, the rectus abs are important (thus the need for crunch exercises), but only to a point. More importantly, the transverse abs (the stomach muscles you squeeze inward to have a stable torso) are more prominent to maximal effort during most athletic activities. Ab roller, planks (holding the body firmly forearm on ground surface in up push-up position) are exercises for the transverse abs. My athletes also perform Russian twists, side bends and back extensions on the Roman chair, as well as barbell exercises to work the core.

6. As a general statement-aside from the obvious rotary motions of the shot, disc and hammer all the events in track and field have a heavy linear emphasis in their execution. I fully realize there are joint or body torques in any movement but I think the average coach ignores the training for dynamic stability in the medial to lateral plane (coronal plane). How do you address this?

Gambetta: Always work in all three planes of motion. Recognize that even though sprinting is sagittal plane-dominant there is always a transverse plane component. Stabilization occurs in three planes of motion. Movement is triplanar, so training should be triplanar.

Judge: This is addressed in a variety of ways. Medicine ball exercises can be utilized for a wide range of functional movements that strengthen the core. We usually start with some very general non-ballistic medicine ball exercises and progress as the athlete advances in the training cycle. Dumbbell circuits are a great way to build core strength while also conditioning your athletes during the different phases of training. They offer great mobility and flexibility since they can be done almost anywhere, even when the athlete is traveling for games and events. Dumbbells are also less intimidating than other free weights and great for training through injuries.

Each dumbbell circuit is designed with a specific purpose and uses multi-joint total body movements that combine external resistance with bodyweight. Keep in mind that this type of training should be periodized and correlated with the other types of training.

I have designed four circuits that are cycled through the training program. Typically, I'll have the athletes perform two of the four circuits every other day and switch the circuits every three to four weeks as they adapt. These circuits include Olympic lifts and their derivatives, which are the best movements for developing speed and power. They also offer an opportunity for unilateral training, which is important in many sports activities.

The first circuit, named Coffee, is designed to be a morning conditioning circuit or part of a warm-up prior to other activities. The Nirvana circuit is designed to stimulate the nervous system while working the core. Included in this circuit are some ballistic Olympic movements that build speed. The Abzilla workout is a specialized circuit for abdominal emphasis. Arnold is a body building circuit. The weights of the dumbbells and number of repetitions should be adjusted for each circuit based on where

the athlete is in his or her season.

Kerin: Nothing trains a movement in-plane like the movement in-event. But first I'd go back to the point where the athlete enters training and remediate weakness observed before heaping a specific workload on him or her. At the Lane Symposium a fellow speaker gave a presentation on his athlete's needing to pass a Functional Movements Assessment, prior to full-on training. If they can't stabilize in the statics, then dynamics / rotationals are more likely to blow them up.

If you think back over past years you can see where on an athlete, the dynamic demands of an event has the potential to blow up them up. Follow the anatomy from the manifestation point to the actual weak link looking for cause not result. At the start of each fall assess the quality + / of the potential weakness areas and remediate prior to piling on dynamic demands.

Radcliffe: Within the general portions of the workout sessions care is given to encompass work in all planes and styles of movement. The warm-up includes dynamic form movements forward, laterally, and backward. The core routines will always include flexion, extension, and rotation in all directions. Within the strength training different lunge progression will employ steps out at 45 and 90-degree angles. Medicine ball multi-throw and toss progressions at similar angles are included.

Cissik: Stability training and medicine ball training (e.g., tosses to the side, etc.) that were mentioned above. In addition, I like one-legged stationary exercises (for example, stand on one foot and catch the medicine ball at knee height). These develop a lot of qualities; foot/ ankle strength, balance, multi-planar strength, coordination, core development, etc.

Polakowski: Some of the above exercises mentioned in number 5 address this. Warm-up activities also address exercises along other axes. For example, during warm-ups we'll do what I call moving jumping jacks. That is sliding the feet in a wide fashion, while swinging the arms in front of the body. Grapevines (Carioca), with an emphasis on the leg lifted in an exaggerated fashion when it comes across the front of the body.

7. It has been found that dynamic stability is more a product of endurance (red fibers) than of strength. How do you train these two important qualities that are physiologically at odds with each other?

Gambetta: You play the card you are dealt-that is a physiological fact. Because of the fact that the core muscles are antigavity muscles, primarily slow-twitch, they recover quite quickly. Therefore it is possible to train the core each day by varying exercise selection and volume and intensity.

Judge: The mid-torso musculature consists of postural muscles with a high percentage of slow-twitch muscle fibers. Part of their function is to maximize trunk stability by holding contractions for extended periods, so we first focus on training these muscles to do just that. This is often addressed in the warm-up. We emphasize the importance of keeping the body in perfect alignment while holding each position in a pedestal series.

After an athlete has developed the ability to maintain efficient postures while performing very simple motor tasks, we find he/she is able to develop more advanced skills at a quicker rate. At the same time, the risk of long-term repetitive injury patterns-many of which result from improper posture-is reduced. Once the athlete can perform acceptable slow isotonic mid-torso exercises, additional exercises that demand balance can be introduced.

For the beginner, I start the transition with bodyweight exercises and movements. A wide repertoire of activities can be used to enhance functional postural integrity and as a result latent power resources. One of my favorites is the pelvic tilt. In this exercise, the athlete lies on his or her back and contracts the abdominals until the low back presses into the floor. The contraction should be held for three to six seconds, followed by three to six seconds of rest and repeated for a total duration of a minute.

Kerin: Isn't endurance just a different expression of strength? In this case, force manifested as

tension? There are people, however, who will tell you that isometric is not an expression of strength. I had a self-styled expert recently tell me that "isometrics aren't really contractions because the muscles neither lengthen nor shorten." No, I don't believe the qualities to be at odds because stabilizers are enablers of movements, not prime movers themselves. No dual purpose of stabilizers so no conflict. However, force results in "unproductive" work when produced in stabilization deficit. Force is co-dependent on stabilization whereas stabilization can be trained in the absence of specific-intended dynamic actions.

Radcliffe: Using assistance exercises that have higher volumes (reps or distances). Lighter loads or bodyweight exercises that involve balancing on one limb or walking/ bouncing/ skipping certain distances twisting or with an implement locked out over the head. Dumbbell complexes have been used by numerous coaches as another way of attending to this. The alternation of pulls, squats, and pushes in a complex of certain rep schemes.

8. Progressive overload is one of the cornerstones of training. How do you quantify plyometric work? Is it by numbers of reps, time of reps or some other method? How do you know when the workout is over?

Gambetta: Know when enough is enough. First count reps, contacts. Intensity is the main stimulus for adaptation in high neural demand work. Nothing should compromise intensity. Time, measure, listen and watch. Have your objectives clearly defined. Know and understand good technique.

Judge: I usually count the number of foot contacts in a workout to track the volume. I usually quantify the intensity for plyometrics: heavy-depth jumps, medium-concentric jumps, light-sprint drills, easy-strides. It is wise not to perform too many repetitions in anyone session since a plyo session is a quality session, with the emphasis on speed and power rather than endurance.

I split the work into sets with ample recovery in between. As a general rule, two sessions a week with 48 hours recovery between sessions. I include them as part of the drills following warm-up.

I aim for quality NOT quantity. Carry out the plyometric exercises on grass or the track. The correct dose of stimuli must be provided. High intensity must dominate the plyometric training session as all exercises are to be performed at 95-100% effort. However, there must be a balanced relationship between stress and recovery. Insufficient recovery is the most common cause of injury in plyometrics. Generally 1-3 minutes between sets and 3-5 minutes between exercises is sufficient recovery within a single training session. I watch the execution of technique and will always discontinue an exercise or end the workout if technique breaks down.

Kerin: Volume, duration, intensity, quality of efforts. Particularly in single-leg support, when the quality drop-off is noticed that's a warning sign. Also, the asymmetrical single-leg activities, like say LLR, LLR contacts, are more a high-wire act by their nature. Go back to my earlier statement, Start "Slow & Low" and look for positive adaptations before progressing with the prescription of plyo's...

Radcliffe: The QUALITY of the execution should always be favored over the quantity. Utilizing repetitions, or contacts as some coaches like to refer to, is preferred over amount of time and/or distances. We like to give a range of repetitions for each set. The athletes learn that, with 8-12 reps, eight quality reps are more useful in elastic-reactivity than 12 sloppy ones. Observing contact time for "dead" landings or releases will be a good indicator for stopping.

Cissik: This is going to depend on the exercise. For example, vertical jumps will be by the number of repetitions. Single-effort horizontal jumps are also for number of repetitions. Horizontal jumps that are multiple-effort are done for distance or for the number of jumps. Bounds may be by distance, or it may be by the number of bounds.

Like with every other mode of exercise, I enter this with a goal. For example, two sets of 10 squat jumps. Each jump is maximal effort and should emphasize full recovery between each

jump. As with technical training in track and field, if technique and explosiveness begin to suffer then it is time to end the workout. Teaching someone to jump (or throw) slowly and with bad technique is counterproductive.

Polakowski: Every foot contact is counted and planned as part of training. If I see either an athlete struggling, or quality of effort (time it takes from eccentric to concentric contraction) is lower than expected, I've stopped athletes from continuing. A coach has got to understand, what plyometrics are for, before they use it as part of the training protocol. A coach should be monitoring the athlete during the entire process.

9. This is a broader question regarding overtraining. The "more is better" mantra when applied to plyometric work will rapidly negate any training effect only to produce acute bone, joint or soft tissue injuries. How do you know when enough is enough? You can answer from a single workout perspective or the density of plyometric work in a specified training cycle (i.e. -macro or microcycle).

Gambetta: See previous answer. Less is more.

Judge: You can answer from a single workout perspective or the density of plyometric work in a specified training cycle (i.e. macro or microcycle). As an athlete I made the mistake of "overtraining" plyometric work. I learned the hard way and the result was shin splints. My plyometric training program is broken down into phases. Throughout the training year, we sequence exercises from high volume to low volume and from less sport-specific to more. Following a basic preparation phase, we alternate accumulation, which emphasizes strength gains, and intensification, which emphasizes power and speed. Overload is a big part of the training program and is present in each phase. The body is adaptable, but will only adapt to a stimulus that it is unaccustomed to. The demands of training must increase over time if increased fitness levels are to be gained. But, I am careful to monitor volume. Plyo's are done sparingly with throwers and are used more as "special exercises" to build elastic qualities. Intensity for these exercises should be increased in a controlled progression.

Kerin: Years of mistakes lead to better understanding, I guess. Too many people drove kids to an early athletic grave with plyo's back in the day. Keep in mind other activities have a plyometric component (eccentric immediately switching to concentric). In that spirit, while plyo's have their application, they aren't something one can simply heap on the body of work without forethought. There is available information that groups plyo's into low, medium, high intensities. Progression thru or the combination of these is the art of the game.

Radcliffe: In keeping with the quality over quantity concept, per session is again a look at the quality of the take-offs, and the response time. Some jump coaches will take weekly jump measurements (standing vertical or horizontal) and if an athlete or group falls 5-8cm below the baseline or norm then they know progress and recovery needs to be altered. Over the course of a macrocycle volume increases slightly then must decrease as impacts (landing intensities) increase.

Cissik: With plyometrics, I err on the side of caution. I rarely do more than 2-3 different exercises per workout.

Polakowski: This question cannot be answered in the amount of words allowed in this roundtable. I will say, the nervous system is the primary system being trained during this protocol. A coach cannot look at nervous fatigue like they look at aerobic or muscular fatigue. Signs are more subtle. I'd suggest every coach study what plyometrics are before they formally use it as part of training. In number 8, I talked about not only counting contacts, but watching my athletes to determine if enough is enough.

10. How do your plyometric workloads differ from males to females?

Gambetta: Females seem to be able to better tolerate stretch loads than males. Anecdotally they seem to be able to handle a bit higher volume and recover. I emphasize that this is empirical, not research-based.

Judge: Plyometric training is very individual and must be tailored to the specific athlete it is intended for. Every athlete has different concerns and needs. Adjustments to fit the athlete's characteristics are always made. Because of individual variations, cookie-cutter plyometric programs are a sure way to hurt athletes. Medical history, training age, strength, muscle imbalances, the specific event are some of the variables that will dictate the specific design of the program. In my experience, females need more biomotor training in the area of strength development. I work more low-intensity plyometrics with my female athletes and hold off on high-intensity work until a large training base is established.

Kerin: In general: Men---less volume, greater amplitude; Women---more volume with lower amplitude. After that it's less gender specific and more strength/training age/health specific. In defense of the ladies, I had a female jumper here (went on to medal in the slalom at the 2001 Skiing World Championships for Norway) who was a rock.

You couldn't break her if you tried. My wife also built up her strength levels to where she could handle heavier plyo loading than some of my guys. To that end, improvement to one's max strength, functional hypertrophy, etc., provide greater resources to work with. People are caught up with working with percentages. How about giving more consideration to raising their 100th percentile to improve their 75th?

Radcliffe: Males in our program travel across our training progressions at a faster rate. The females train the same with the exception that their landing and takeoff skills---especially in terms of the aforementioned posture, balance, stability, and mobility protocols---need more development.

Cissik: They don't. Keep in mind that I'm very conservative with plyometrics, so I don't do one-legged exercises or depth/box jumps.

Polakowski: For me, it's individual to individual.

11. Most females have a larger quadriceps angle (Q angle) than men that posturally presents with an increased valgus (shin out) stress at the knee. How do you deal with this fact with your female athletes?

Gambetta: You address foundational and structural strength and train them. Way too much is made about what the female cannot do. If the female athlete is unable to do the activity with control then she will be put on a remedial program of exercise until she is able to achieve an acceptable level of control.

Judge: Female athletes must first develop the ability to maintain efficient postures while performing very simple motor tasks, after which we find they are able to develop more advanced skills at a quicker rate. A wide repertoire of activities can be used to enhance functional postural integrity and as a result latent power resources. At the same time, the risk of long-term repetitive injury patterns-many of which result from improper posture-is reduced.

Although plyometrics are great training for explosion and development of fast-twitch muscle fiber, they should be performed in moderation with throwers in general and should not be used by athletes with orthopedic injuries. The exercises involve direct impact and may cause injury if overused.

I have put more emphasis on gaining strength and power in the weight room with female throwers. I base exercise prescription more on a need basis. Females for the most part, are flexible and very elastic. The biggest challenge is improving their strength.

I emphasize plyometrics more with male athletes. They are part of our training program for

females but we use them sparingly. Because of their large body mass, throwers place a lot more stress on their structure (joints, ligaments and tendons) when performing plyometric training. The throws coach must carefully observe the technique, number of repetitions, and the intensity of each plyometric exercise. Single-leg activities, exercises involving hurdles and boxes of extreme height must be closely monitored and performed in moderation, if at all, with throwers.

Kerin: I worry more about this in the squat rack when I see toeing out. I speak to proper positioning and technique as well as have shifted to prescribing less squatting/loading of the spine, and more posterior chain work. One benefit is also a better balance between quad and hamstrings in deep knee angles. More plyo-specific, the concern I have for women is around possible joint laxity and potential for injury. I am very careful with single-leg contacts and over-jumping in the event-specific area. Someone did a study on NCAA women and their knee injury occurrence and, if I recall, they suggested that women may be more susceptible to ACL injury around days 10-14?

Radcliffe: There has been some considerable research out of Cincinnati, Ohio (Hewett, et al.) on this particular subject. The findings point directly to teaching them how to land. Use simple teaching and training progressions as to fuller foot landings, jumping straight, preparing to land as if to take off again, and progressing along a continuum of bounces, jumps, bounds, and hops, as to how well they handle the posture, balance, stability, and joint mobility of the landings. We like to do a good deal of our beginning progressions barefooted to stress these points.

Cissik: There are several parts to this. First, females need a strength training background to strengthen the muscles and ligaments of the lower extremity-especially squats and hamstring training. Second, females (and males) need to focus on good technique with plyometrics, especially how to land. Time should be taken in the beginning to work on the fundamentals. Third, plyometrics should be viewed as a progressive process so that the beginning skills are mastered before moving on to the advanced ones.

Polakowski: Although I've had a few males with such a problem, it does come up more so with females. I've found bands helpful to address this. I'll have (during warm-ups) athletes do all types of walking actions with bands around the ankles. I'll also have athletes (the athletes who want to put their knees together when the exercises get too difficult) go through a squat cycle with bands just below the knees. The focus is on pushing the knee out (keeping them in line with the knees when squatting) to have success in strengthening their weak area. Side lunges while holding dumbbells is another strength exercise we highlight with this athlete.

12. Plyometric drills can be used for various forms of fitness testing. What are some common plyometric tests you like and what information or correlations do you feel the test gives you?

Gambetta: Vertical Jump, Standing Long Jump (preferably into sand), Standing Triple Jump (into sand), Five hops + jump comparing difference left and right, and Five bounds + jump into sand. If you have a jump contact mat available use the stiffness jump test.

Judge: There are a number of noninvasive field and laboratory tests that can be used to evaluate the training state of track and field athletes. These tests can be used to measure biomotor qualities, analyze the pretraining state of an athlete and analyze training effects while a program is in progress. The two best tests of elastic properties are the standing triple jump and the standing long jump. The standing triple jump is a test of elastic strength, power, and coordination. The athlete, from a double-legged standing start, performs three jumps. The test begins with a double-leg takeoff, then a right-left or left-right contact pattern prior to landing. The standing long jump is a test of starting power and elastic strength. The athlete performs a single jump for distance from a standing start.

Kerin: I have to spend so much time teaching them how to perform a test and then the results

still are all over the board to the point I question their value for most on my level (NCAA Div. III). I will use a drop jump vs. a static jump from a 5 sec. hold to look for reactive strength deficit. Other than that I test OHB's, SLJ, timed 30's. But mostly I look to skill acquisition and event improvements over the course of the year. Our program deemphasizes the indoor season in favor of a longer buildup to outdoor April/May, so with the exception of NCAA indoor qualifiers, the immediate need to perform is more internal to the athlete than from me.

Radcliffe: Most coaches use standing counter-movement jumps (VJ, SLJ, and STJ) and they are good evaluations of power and if athletes are lacking in strength work versus speed. The original "Jumps Decathlon" created by Wilf Paish of Great Britain can still be utilized for many quality evaluations and the norms still fit well. Jumping sheds light on lifting, bounding on acceleration, and hopping evaluations (done correctly) can tell us a lot about sprint needs.

Cissik: Two tests I like, both are very simple. The vertical jump and the standing broad jump. Both test explosiveness. Both test your ability to apply your strength, which is an important quality for a track and field athlete. One may be more important than the other depending upon the event (e.g., whether the athlete is moving vertically or horizontally). Jimmy Radcliffe has got a great method for using the vertical jump test to monitor training effectiveness and overtraining.

Polakowski: I use the Vertical Jump test for start power.

13. When using medicine balls---how do you determine the appropriate weighted ball for the athlete doing the drill?

Gambetta: Training age, event and size of the athlete. Generally for most activities a 3 kg ball will suffice.

Judge: Balls come in a variety of sizes and weights. In most cases, athletes should start out with lighter balls, and as higher physical conditioning levels are obtained, increase the load of the balls. The standard "rule of thumb" is to always use a ball whose weight allows the correct technique of the drill to be performed. Using a ball that is too heavy will cause breakdown in skills. Sets, reps and recovery time are also important and are specific to the athlete's individual needs. Too many sets or reps, or not enough recovery time could cause fatigue and unacceptable skill performance.

It is also important to perform each drill with both sides of the body. Perform 5-10 repetitions per set of each exercise for 3-5 sets each. Medicine ball exercises can be performed by throwing the ball against a wall or with a partner.

Kerin: Start with the traditional men's shot/women's shot weights and work up or down as needs dictate.

Radcliffe: When using medicine balls, often it is the drill and objective that dictates the size of ball, other times it is a small percentage of the athlete's bodyweight (@5-15%).

Cissik: Unless working with throwers, I don't feel that you need much more than 2-5 kilograms for medicine balls. To me, the focus on these drills is to overcome some external resistance while focusing on speed of movement.

14. Leg drills can be done with double or single support. I once watched Tom Tellez's Houston athletes do a plyometric hurdle workout---all double support (two-footed landings). When I asked Coach Tellez why they only did double support he stated simply, "It's safer." How do you break things up?

Gambetta: I classify plyo's as to displacement of center of gravity. a) Supported---Slightly unloaded with some of the weight supported on the hands; b) In Place---Vertical displacement of center of gravity; c) Short Response---Horizontal displacement of center of gravity with 10

contacts or less; d) Long Response---Horizontal displacement of center of gravity with speed for 10 contacts or more. The emphasis of a particular response classification is dependent on the phase of the training year and the individual athlete. A, B & C can be done with either single or double support. The key is to progress to hopping and bounding activities that are more stressful.

Judge: Single-leg activities, exercises involving hurdles and boxes of extreme height must be closely monitored in training. I agree with Coach Tellez and keep activities in double support. I wait until the peaking phase to perform most high-intensity plyometrics. High-intensity plyometrics should be performed in moderation, if at all, with throwers.

Kerin: Safer, but there are no sprint or jump events with two-footed contacts. He may have felt that his athletes got plenty of single-leg plyo work from normal running and jumping.

Radcliffe: Our teaching and training progressions always begin with both feet landing and taking off, then progress to alternate (true bounding), and single (true hopping) leg drills. As shown by the following continuum:

Low-----Moderate-----High-----Shock----->

JUMPS

- 1-Pogo
- 2-Squat Jump
- 3-Box Jump
- 4-Rocket Jump
- 5-Star Jump
- 6-Butt Kick
- 7-Knee Tuck
- 8-Split Jump
- 9-Scissor Jump
- 10-Scissor Double
- 11-Stride Jump
- 12-Stride Crossover
- 13-Depth Jump
- 14-Quick Leap
- 15-Box Jumps(MR)
- 16-Depth Leap
- 17-Depth Jump Leap

BOUNDS/SKIPS

- 1-Prance
- 2-Gallop
- 3-Skip Progression
- 4-Ankle Flip
- 5-Lateral(SR)
- 6-Sng.Leg Stair
- 7-Dbl.Leg Incline
- 8-Lateral Stair
- 9-Alt.Leg Stair
- 10-Alt.Leg Bound
- 11-Lateral Bound(MR)
- 12-Alt.Diagonal Bound
- 13-Box Skip
- 14-Box Bound

HOPS

- 1-DbL.Leg Progression
- 2-DbL.Leg Speed(MR)
- 3-Incremental Vertical
- 4-Side Hops
- 5-Hops-Sprint
- 6-Angle Hop
- 7-Single-Leg Butt Kick
- 8-Single-Leg Progression
- 9-Single-Leg Speed Hop (MR)
- 10-Diagonal Hop
- 11-Lateral Hop
- 12-Divine Hop

Cissik: I don't like one-legged plyometrics, though I do like using modifications of certain lifting exercises and going to one leg or to a split style (like split cleans or one-legged Romanian deadlifts).

Polakowski: I start jump roping for beginners. I have them focus on keeping the knees in line with the toes. That's followed (depending on age of athlete-that could be a few months to years after) with more formal, double-support stationary plyo's. The next progression would be double support for distance. The next progression would be the same process while slowly introducing single support.

15. Do you do much box work? At what point in the season? How high are the boxes? What would be a sample workout? Do they land double or single support? Do they rebound or "stick the landing?"

Gambetta: Very little if any. The only use I make of boxes is for drop jumps. The height of the box is determined by the athlete's basic strength level and his ability to react off the ground. Weaker athlete = lower box, stronger athlete = higher box. Drop jumps are done both using single and double support. Obviously single-leg drop jumps are done off a lower box. I will change the response off the box to a vertical rebound or a horizontal rebound off the landing depending on the event and the training objective.

Judge: I prescribe low-level box work in the precompetitive phase and more intense box work in the competitive phase. The beginning height of the box should be relatively low and increased gradually. The optimal height of the box should not result in a landing where the heel is forced to the ground by momentum. The athlete should fall off the box in a relaxed state, not jump. The dosage of depth jumps should not exceed 2-3 sets of 5-8 repetitions for the lesser conditioned athlete and four sets of 10 for the well-conditioned athlete. I like to use boxes for concentric jumps in the weight room. I usually perform concentric jumps after squats in the weight room.

Kerin: I am a proponent of landings, but the strength and training age of the athlete is important, particularly if single-leg landings. However landings are not plyometric as there is no concentric rebound.

Radcliffe: Box jumps are different than depth jumps off of a box or platform. Along our stress continuum box jumps can be done early. Ground takeoffs onto a box at mid-thigh level can enhance landing mechanics and decrease impacts. Depth jumps were designed as "shock" training and landings are stressful. As with the continuum, we won't progress to this area until late in a macro or mesocycle. The teaching progression begins with landing only, then moves to elastic-reactive takeoffs. Our research (Radcliffe 1995) suggests that, to work the reactivity needed for short response landings (Schmidtbleicher), all you need is a drop from approximately knee level.

Cissik: I'm personally not a big fan of box work either. I think that if you are doing the stuff on the track (or the field) right, doing the weights right (strength and Olympic lifting), and focusing on fundamental plyometrics that you won't need these.

Polakowski: It depends on the athlete and the circumstance. Jumpers and sprinters with a good base of previous experiences can benefit. Just like anything else, start out low (about 4 inches and progress to about 16 inches). I'm a little shy about using boxes with throwers, because of their size; it really can put a strain on their joints I just don't want to see. Speaking of strain, I base a lot of what I do with boxes on what the effort looks like. I want to see little effort, good form (knees in line with toes, feet landing flat, not too much bend in ankles, knees and hips), and very little pause (amortization) between eccentric and concentric contraction.

16. You cannot run fast, jump or throw far unless you have a strong foot. How do you prepare the foot for the stresses of plyometrics? Do you do anything special for other "at risk" joint complexes (e.g., wrist, shoulder, knee, low back)?

Gambetta: Work barefoot on grass, also some in sand. Use foam rollers to roll fore and aft and pronate and supinate to work the intrinsic muscles of the foot. Use of a BAPS board is good. For the low back we do a mini-band routine daily, hip drops, and crawls. Stretch calves, hamstrings, psoas, IT band, adductors and lats.

Judge: The ankles and feet are often a weak link in technical execution. To combat this, we perform our warm-up, sprint drills, general strength circuits and jump circuits in bare feet on the grass. Warming up with no shoes on is a great way to build strength in the feet and ankles. We also perform low level single-leg hops and other special exercises to build up the feet and ankles. I prescribe exercises for these "at risk" areas as a part of our body building training.

Kerin: While plyometric work can be of great value, it can just as quickly end a season. Especially when intensity is ramped up, there needs to be a watchful eye on what is taking place in the moment. Where possible, train holistically with a view of the four year HS or college career.

Radcliffe: As mentioned previously, we really like to use barefoot training. It may be in the form of recovery strides, backward running, light changes of direction, and/or the simplified bounce, jump, bound, and hop progressions. These are also useful maneuvers for shoulder, elbow, and wrist-rudimentary work using either a wall, stairs, or ground as in push-up positioning.

Cissik: To some extent I've already answered this in several of the questions above. First, perfect technique should be demanded. Second, fundamental skills must be mastered before moving on to advanced ones. Third, the athlete's fitness base can be developed for the foot/ ankle as well as other "at risk" areas. I like taking 5-10 minutes during the warm-up to use exercises to address "at risk" areas. For sprinters these might include hamstrings, ankle/foot, and core. As with core training, I like to use circuit training (20-30 seconds per exercise, or 10-20 meters per exercise with no rest between exercises). Below is a sample warm-up circuit designed to address the hamstrings and the ankle/foot. Again, this would take about five minutes to perform.

- Leg swings, front/back
- Leg swings, side/side
- Bodyweight squats
- Lunges, step forward and step back (x10 meters)
- Inchworms (x10 meters)
- Walk on toes (x10 meters)
- Walk on heels (x10 meters)
- Walk on toes, toes in (x10 meters)
- Walk on toes, toes out (x10 meters)
- Walk on inside of feet (x10 meters)
- Walk on outside of feet (x10 meters)

Polakowski: For the foot, I do a lot during warm-down. All types of walking with bare feet. Writing things (name) in sand with bare feet. Some of the same warm-up activities in bare feet (keep intensity very low).

17. One of the limiting factors in improved performance is eccentric strength. Certainly one of the benefits of plyometrics is the development of eccentric strength. Are there any special exercises or drills you use (med balls, boxes, weights, etc.) that focuses on this critical factor?

Gambetta: Stabilization responses where the athlete has to hop, jump or bound and stick and hold the landing for five counts. The key to development of eccentric strength is bodyweight lower extremity work done at a rate of 1 rep / sec. This rate of work should continue up to 25-30% of bodyweight.

Judge: Strength training has come a long way from the time when coaches used a small group of

standard exercises and lifts to help develop stronger athletes. A multifaceted approach combining medicine ball work, bodyweight circuits, controlled movements, abdominal exercises, dumbbell circuits, and Olympic lifts can provide physiological and biomechanical advantages that enhance the development of eccentric strength. These types of exercises will enhance performance in most every track and field event and other sports.

Kerin: Depth landings are eccentric specific work. Squatting with slow downward tempos is a great non-plyo exercise. It can get you great results in the weight room because the athlete's lifting prior to coming to you has most often been fast down/fast up with no regard for the primacy of the eccentric action. Slow, down-tempos or paused squats will be lesser than the athlete's squat PR but in time they lead to breaking plateaus and their events benefit as well. Speaking to plyo's, the goal of a stretch-shortening cycle is to create and leverage muscle tension (lengthening and shortening) so there is much to be gained by detraining the level of neural! Golgi inhibition.

Radcliffe: As on the continuum, by progressing from jumps to bounds, bounding to hopping, tossing to throwing, then to catching and throwing we drill on the concept of eccentric loading. In addition, teaching Single Response movements first, then Multiple Response with a pause ("sticking"), then finally to true Multiple Response (like a "superball") we focus on the handling of eccentric loading and the utilization of the reflexes, responses, muscle mechanics, and proprioception that go into this training.

Cissik: Clearly most jumps can emphasize eccentric strength. I also try to spend time (especially beginning in pre-season) to focus on this in the weight room. I like exercises with a pause or exaggerated eccentric emphasis (for example, perform squats but take 10 seconds to descend). This can be done with almost any exercise, but a little imagination is necessary.

18. Final comments on plyometrics---(Is there anything you would like to add? Address an issue not mentioned above? Refer to a useful book or article? Reiterate an important point or make a summary statement?)

Gambetta: Remember the stimulus for optimum adaptation is intensity. Plyometrics should be taught and trained in a non-fatigued state. Just like any other training mode these exercises must be placed in the context of the total program. Here are several references that will give good information on plyometric training:

Albert, Mark. Eccentric Muscle Training In Sports And Orthopedics. (Second Edition) New York: Churchill Livingstone, 1995.

Bosco, Carmelo. "Stretch-shortening Cycle in Skeletal Muscle Function and Physiological Considerations On Explosive Power in Man," *Atleticastudi*, #1, pp. 7-113, 1985.

Bosco, Carmelo. Strength Assessment with the Bosco's Test. Italian Society of Sport Science, Rome, 1999.

Cometti, Gilles. La Pliometrie. Universite De Bourgogne, 1988

Radcliffe, James C. and Farentinos, Robert C. (1999) High-Powered Plyometrics. Champaign, IL: Human Kinetics Publishing Company.

"Strength And Power Training In Sport" by Ritzdorf, W. (1998) in *Training In Sport-Appling Sport Science*. Edited by Elliot, Bruce, West Sussex. England: J. John Wiley & Sons Ltd,

Starzynski, Tadeusz, and Sozanski, Henryk. (1999) Explosive Power and Jumping Ability for all Sports. Island Pond, VT: Stadion Publishing Company.

Judge: I have made some videos addressing the topic of plyometric training, core training, strength training, conditioning and other preparation work. My training philosophy and approach to strength and conditioning is clearly illustrated in the videos. My latest video entitled "Extreme Core Training for Sports Performance" shows many drills for postural stability. These are available though Championship Productions or on my website: www.coachlarryjudge.com or www.championshipproductions.com .

Kerin: While plyometric work can be of great value, it can just as quickly end a season. Especially when intensity is ramped up, there needs to be a watchful eye on what is taking place in the moment. Where possible, train holistically with a view of the four-year HS or college career.

Cissik: Plyometrics are one item in a coach's tool box; they are only one tool of many. They should be used when needed, after proper instruction, after a fitness base has been developed, and they should be kept in perspective.

Polakowski: Plyometrics can benefit most track athletes. Study the topic before you incorporate it in your program. It's most beneficial to your long-term athletes, because it takes time to bring them to levels in training that give you a return in performance.