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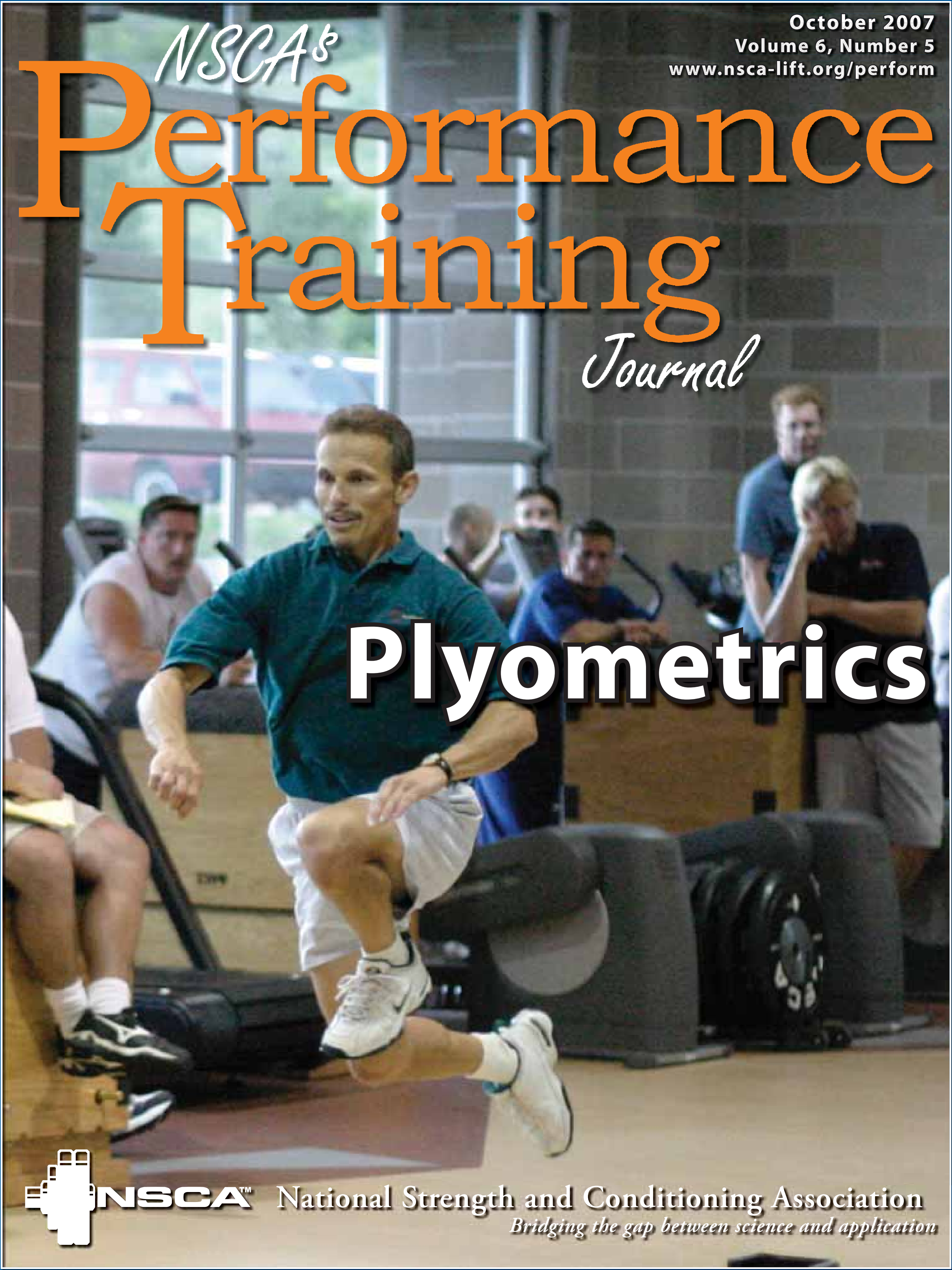
Plyometrics



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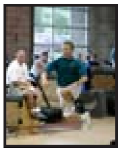

Plyometrics

Departments

On the Cover

Jimmy Radcliffe demonstrates to attendees at the 2004 NSCA Plyometrics and Speed Development Symposium at the NSCA World Headquarters in Colorado Springs, Colorado.

NSCA's Performance Training Journal

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Does Performing Plyometric Exercises in Chest and Waist Deep Water Result in Improvements in Performance?

Scientific inquiry into the efficacy of aquatic based plyometric training has recently received a lot of attention. In a recent investigation the effects of a six week aquatic plyometric training program on vertical jump performance was tested. Twenty-nine subjects were divided into three groups 1) chest deep aquatic plyometric group, 2) waist deep aquatic plyometric group, and 3) a control group which did no specific jump training. Each plyometric group trained two days per week with a periodized program where the volume of training ranged from 90 – 140 foot contacts and intensity was manipulated. Both plyometric groups performed an identical training program with the only difference being the depth of the water utilized. Prior to and after the 6 weeks of training the subjects vertical jump performance and force-time curve characteristics were assessed via the use of a forceplate analysis system. When the three groups were analyzed, no significant differences were noted between the three treatment groups when examining vertical jump displacement. Additionally, no significant differences were noted between the three treatment groups for peak force and power values. Based upon these findings it was determined that performing plyometric training in an aquatic environment offers no marked benefit to athletes. It is likely that this lack of performance gain occurs because the aquatic environment changes force characteristics associated with traditional plyometric exercises.

Miller MG, Cheatam CC, Porter AR, Richard MD, Hennigar D, Berry DC. (2007). Chest- and waist-deep aquatic plyometric training and average force, power, and vertical-jump performance. *International Journal of Aquatic Research and Education*, 1:145 – 155.

Static Stretching and Inactivity Do Not Maximize Vertical Jump Performance

Several studies have suggested that the use of static stretching does not optimize vertical jumping performance. However, very few studies have examined the effects of the time interval of the stretching intervention and the actual vertical jump performance. To address this question researchers from Emporia State University examined the effects of static stretching and inactivity on vertical jump performance immediately, three, six, 12, and 24 minutes after the stretching or control intervention. Each session began with a five minute cycle ergometer warm-up and a pre treatment vertical jump was performed. After completing the pre-treatment vertical jump test the subjects performed either the stretching protocol or the control intervention. The stretching protocol consisted of nine minutes of lower body static stretching, while the control treatment consisted of nine minutes of standing. After the nine minute intervention period, vertical jump performance was assessed at the previously mentioned intervals. The results of this study suggested that static stretching resulted in no effect on vertical jump performance when compared to the standing control. Interestingly, across the 24 minute post intervention period vertical jump performance decreased in response to both treatment groups. Based upon the data presented in this investigation it can be concluded that static stretching offers no benefit when compared to a standing control when examining vertical jump performance. The authors suggested that neither protocol optimized jumping performance and suggested that athletes utilize warm-up protocols which activate the stretch-shortening cycle and were dynamic in nature as these types of warm-ups appear to optimize jumping performance.

Brandenburge J, Pitney WA, Luebbers PE, Veera A, Czajka A. (2007). Time course of changes in vertical-jumping ability after static stretching. The *International Journal of Sports Physiology and Performance*, 2:170 – 181.

Does Performing Plyometrics in the Sand Improve Performance?

Some strength and conditioning professionals suggest that performing plyometrics in the sand can result in greater improvements in performance without the impact on the skeletal muscular system seen in traditional plyometric environments. Recently, researchers from the Human Performance Laboratory at the Mapei Sport Research Center in Italy examined the effects of four weeks of plyometric training on grass or sand on selected jumping and sprinting tasks. Before and after the four week intervention period 37 soccer players performed 10 and 20-m sprints, squat jumps, and countermovement jumps. Results of the testing revealed no significant differences between the treatment groups for changes in sprint times at either 10 or 20 meters or squat jump with both groups experiencing similar benefits. Conversely, the grass group experienced significantly greater increases in countermovement vertical jump performance when compared to the sand group. Based upon these results it appears that performing plyometric training on sand impedes the ability to maximize countermovement jump performance, but may be equal to grass when trying to improve running speed. Taken collectively it can be concluded that there is no reason to perform plyometric training on sand, unless the athlete is training for a sport which is performed on sand.

Impellizzeri FE, Castagna C, Rampinini E, Martino F, Fiorini S, Wisloff U. (2007). Effect of plyometric training on sand versus grass on muscle soreness, jumping and sprinting ability in soccer players. *British Journal of Sports Medicine*, in press. Epub ahead of print (doi:10.1136/bjsm.2007.038497)

Acute Bouts of Sub-Maximal and Maximal Stretching Impair Jumping Performance

Recently, researchers from the University of Kassel in Germany investigated the effects of various intensities of stretching on drop jump, countermovement jump, and squat jump performance. To establish stretching intensities the researchers determined the point of discomfort (POD) for three different static stretches (quadriceps, hamstrings, and plantar flexors). The subjects then participated in four treatment conditions, which required them to be stretched four times for 30s with a 30 s recovery: 1) 100% or POD stretch, 2) 75% of the POD stretch, 3) 50% of POD stretch, and 4) no stretching. Each testing session consisted of a pre-test jump test, a stretching intervention, and five minutes after stretching the jumping protocol was repeated. When examining the data it was determined that all stretching protocols resulted in a significant decrease in jumping performance. There were no significant differences in the amount of stretch induced performance impairments between the three intensities of stretches. Therefore, all the stretching protocols were collapsed into one analysis and it was determined that static stretching resulted in a significant decrease in drop jump performance (-4.6%), squat jump performance (-5.7%), and countermovement jump performance (-3.6%). Based upon this data it can be concluded that performing static stretching prior to performing jumping activities has the potential to impair jumping performance.

Behm DG, Kibele A. (2007). Effects of differing intensities of static stretching on jump performance. European *Journal of Applied Physiology*, (in press), epub ahead of print (doi: 10.1007/s00421-007-0533-5)

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Upper Body Plyometrics

Joseph M. Warpeha, MA, CSCS,*D, NSCA-CPT,*D

When one hears the word plyometrics, the first thought that comes to mind is likely some type of jumping movement; for example, on and off boxes of various heights. Plyometric exercises take advantage of a phenomenon known as the stretch-shortening cycle (SSC). Briefly, when a muscle is stretched very rapidly in an eccentric fashion immediately prior to a concentric shortening (rebound), stored elastic energy and neural mechanisms cause the resultant concentric contraction to be more forceful than if the rapid stretching of the muscle did not occur. The SSC phenomenon can be seen in a vertical jump test. A person performing a vertical jump test will always achieve a higher jump with a preceding countermovement. Try descending for the jump and then hold that bottom position for a few seconds before jumping and you will see the difference. The same holds true for a familiar exercise like the bench press. Do a touch-and-go 1-repetition maximum (1RM) test and then do one in which you pause the bar on your chest for a couple of seconds and see which one allows you to lift more weight.

Plyometrics are often performed as a shock method to increase power and explosiveness. For example, jumpers in track and field often employ lower body plyometric exercises in order to increase their power capabilities which are crucial to success in jumping. However, plyometric exercises for the upper body receive less attention. Certainly, the performance of many athletes would benefit from implementing upper body plyometric training into their routine. This article is meant to introduce three upper body plyometric exercises that can be incorporated into the program of any person for whom upper body power and explosiveness is required. Some of the exercises may be familiar and others might be new, but all are effective in terms of explosive power.

Medicine Ball Throws

(Figure 1)

Medicine ball throws have long been used for training and if any of the three exercises described in this article are familiar, it is most likely the medicine ball throw. This exercise is often accomplished with two people standing about five to ten feet from one another and throwing a medicine ball horizontally back and forth. While this is effective, the fact that gravity is pulling the ball downward means that the ball must be propelled with great velocity to achieve the desired loading on the upper body. An alternative to this is to lie flat on a bench and simply throw the medicine ball straight up, catch it while lowering it to the chest, and repeat as quickly as possible in a fluid motion.

Figure 1. Medicine Ball Throw

One thing to think about is the weight of the medicine ball. This exercise is frequently performed with a medicine ball that is too light. The movement should be performed with as much power and speed as possible. However, what you will realize with a light medicine ball is that if you push as hard and fast as you can, the ball will travel very high and either hit the ceiling or be difficult to catch. This problem can be solved simply by using a heavier medicine ball. Most facilities have medicine balls under 20 pounds in weight which is not optimal for stronger individuals. For example, medicine balls in the range of 40 – 60 pounds would be appropriate for many college football players or track and field throwers. Powerlifters have been known to perform medicine ball throws with balls in excess of 100 pounds. While the local sports store may not carry these behemoths, the performance-oriented equipment companies usually do. As a precaution, a spotter should always be present so that they can ensure the ball is safely guided back into your hands after each throw.

Bench Press Throws

This exercise is very similar to the medicine ball throw with one major difference, it is performed on a smith machine where the barbell is propelled into the air as opposed to a medicine ball. The idea is the same as the aforementioned medicine ball throw: propel the bar into the air with as much power and velocity as possible, catch it in an eccentric fashion while lowering the bar to the chest, and reverse the movement with as much velocity as possible throughout the entire concentric range of motion with a release at the end. This variation is nice because most facilities already have the necessary equipment (bench, a smith machine, and plates). A spotter is also crucial for this exercise to make sure the bar is always safety guided back into the hands. Maximal power production in this exercise appears to take place at a load between 30 – 45% of the 1-RM (2).

Band Push-Ups *(Figure 2)*

If there are any exercises new to you in this article, it is probably the band push-up. This exercise is a modification of the old-fashioned clap pushup where the goal is to push the body up as hard and fast as possible so as to allow for a clapping of the hands. The beauty of the clap pushup is that it can not be accomplished without being powerful and explosive. The disadvantage is that many people lack the necessary strength to perform clap pushups. By securing elastic bands overhead (as in a power rack) and then attaching the other ends to the body (preferably under the arms/armpits), a person's bodyweight is effectively reduced. Keep in mind that maximal power is generally achieved at loads between 30 – 70% of maximum (2) which means that an unloading of bodyweight via band tension will allow for maximal or near-maximal power production in most people assuming a maximal effort is given.

Figure 2. Band Push-Up

The three exercises discussed in this article can easily be implemented into the program of any person interested in training upper body power and explosiveness. As with other power-type exercises such as weightlifting, fewer repetitions are ideal as the ability to generate maximal levels of power drops off after the first few repetitions (1). If you are truly giving a maximal effort on each repetition, three to five sets of three to five repetitions will suffice. Higher volume with these types of power movements that significantly tax the neuromuscular system generally lead to poorer quality repetitions and less-than-optimal long term effects.

A major advantage of the three exercises mentioned here is that each allows for a maximal effort throughout the entire range of motion. Most traditional exercises (like the barbell bench press, for example) do not allow for this because the lifter will either consciously or subconsciously began to decelerate the bar toward the end of the range of motion to avoid injury and undue stress/trauma on the joints. The key to performing plyometric or SSC exercises is speed in both the eccentric and concentric phases. This should be the major goal of the individual performing the three exercises discussed above.

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About the Author

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Introductory Plyometirc Training Program for Golfers

Jason Brumitt, MSPT, SCS, ATC, CSCS,*D

Many amateur golfers play the game of golf for the shear enjoyment of the sport and for the benefits of physical activity. Despite the fact that golf is a non-impact sport, both amateur and professional golfers are at risk of sustaining sports-related injuries. Injuries to the low back, the shoulder, the wrist, and the hand are frequently experienced by amateur and professional golfers (7, 8). An epidemiological study has found as many as 57% of amateur golfers risk injury in any one year period (1).

The biomechanics of the modern golf swing has been cited as the reason for the high number of injuries experienced by professionals and amateurs. High torques, shear and lateral bending forces, and compression loads to the spine increase the risk of lumbar muscle strains and disc herniations (6). Compression loads alone are eight times one's body weight during the golf swing (6).

Including Plyometrics in a Strength Training Program

Participating in a comprehensive strength and conditioning training program may help to improve the golfer's game and reduce his or her risk of injury.

Table 1. Basic Plyometric Training Program for Golfers

Standing Horizontal Throws (each side)	1 – 3 sets x 10 repetitions
Seated Horizontal Throws (each side)	1 – 3 sets x 10 repetitions
Overhead Ball Throw	1 – 3 sets x 10 repetitions
Lateral Jumps over Barrier (or cone)	1 – 2 sets x 15 repetitions
Front-to-Back Jumps over Barrier (or cone)	1 – 2 sets x 15 repetitions
Jump from Box (small height)	1 – 2 sets x 8 repetitions

Each training program should include plyometric exercises. Plyometric forms of exercise consist of a rapid deceleration of movement followed by a rapid acceleration in order to develop explosive power (2). Research has demonstrated that the integration of plyometrics into a golf training program increases club head speed and driving distance (4,5). Plyometric training may also help to protect the body from potentially injurious forces and loads, ultimately reducing the risk of sustaining a golf related injury.

This article presents a basic plyometric training program that is appropriate for most golfers. In a forthcoming issue I will present an advanced golf plyometric training program.

Basic Plyometric Training Program

The program presented in table 1 should be performed one to two days a week with 48 to 72 hours rest in between sessions. Between each set rest for approximately one minute and rest up to five minutes between each exercise.

Standing and Seated Horizontal Throws *(Figures 1 & 2)*

Position yourself perpendicular to a rebounder approximately eight to ten feet away. While standing (figure 1) or in a seated position, throw a light plyoball or medicine ball across your body toward the rebounder. As the ball rebounds back to you, catch it, and quickly throw it back toward the rebounder. Repeat this sequence for the desired number of repetitions. When sitting on a physioball (figure 2), maintain an upright, neutral spine posture.

Overhead Ball Throw

Face the rebounder holding a light plyoball or medicine ball overhead. Throw the ball towards the rebounder, catch it off the bounce, and quickly throw it back to the rebounder again. Repeat for the desired number repetitions.

Lateral Jumps and Front-to-Back Jumps Over a Barrier *(Figures 3 & 4)*

Place a cone or small barrier on the ground (approximately four to six inches high). As fast and as safely as you are able, jump side-to-side (figure 3) or front-to-back (figure 4) over the barrier/cones for the desired number of repetitions.

Jump from Box (Figure 5)

Stand on the top of a six inch step or box (figure 5). Take a step off of the box, land on the ground with both feet, followed by immediately jumping straight up as high as you can. Repeat for the desired number of repetitions.

It is recommended that before an athlete performs lower extremity plyometrics he or she should be able to perform five squat repetitions, squatting 60% of one's body weight, in five seconds. At the bottom of each squat, the thighs should be parallel to the ground (3).

Conclusion

All golfers should consider participating in strength and conditioning training program. Inclusion of plyometric exercises can not only improve facets of a golfer's game, it can help to reduce the risk of becoming injured.

Figure 1. Standing Horizontal Throw

Figure 2. Seated Horizontal Throw

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Figure 3. Lateral Jumps Over a Barrier

Figure 4. Front to Back Jumps Over a Barrier

Figure 5. Jump From Box

Practical Guidelines for Plyometric Intensity

William P. Ebben, PhD, CSCS,*D

Strength and conditioning professionals have long relied on plyometrics as one of the primary tools for developing athletic power and speed. It is not surprising that training exercises such as plyometrics, which are performed with high movement speeds would improve the performance of activities requiring speed, such as jumping, running, and agility. The technical term for this idea is "specificity." In other words, training that is "specific" or similar to the activity to be performed is believed to be optimal. As a result, recreational athletes, as well as those who desire to increase their overall fitness and add variety to their training, often incorporate plyometric training into their programs.

Plyometrics can be thought of as exercises that train the fast muscle fibers and the nerves that activate them, as well as reflexes, and include a variety of hopping, jumping, and bounding movements, which ideally are organized into a cohesive program. The main difficulty with creating a plyometric program may be the choosing the correct exercises and progression of intensity (1). The focus of this article is to help the reader understand the basic types of plyometric exercises and to provide some guidelines regarding the progression of plyometric exercises through increasing intensity over the course of a program.

Categorizing Plyometric Intensity

Classic text books describe typical categories of plyometric exercises and intensities (2). These categories are a useful starting point for understanding plyometric exercise options, their intensity, and program design. Common categories and examples of plyometric exercises are briefly described in table 1, which represent increasing exercise intensity from jumps in place to depth jumps. Intensity has been defined as the amount of stress the plyometric drill places on the muscle, connective tissue, and joints (2). As such, for plyometrics, intensity depends on the specific exercises performed. However, recent research has advanced the understanding of the intensity of plyometric exercises based on the muscle activation, connective tissue, and joint stress associated with various plyometrics (1,3). The following guidelines have been gleaned from these studies. Assuming all plyometric exercises are performed maximally:

- Any single leg plyometric exercise is more intense than the same exercise performed on both legs.

- Despite being considered a low intensity category, "jumps in place" such as the pike and tuck jump have the highest knee joint reaction forces.

- The height that the athletes jumps up to or down from (as in depth jumps) is one of the most potent predictors of plyometric intensity. For example, a person who performs a "jump in place" with a 30 inch vertical jump will experience greater ground reaction force and thus stress, than if they performed a "depth jump" from an 18 inch box. Thus, "jumps in place" may be of higher intensity than "depth jumps."

- Jumps performed with added weight, such as a weighted vest or dumbbells held at the side are typically only moderate in intensity as a result of the ground reaction forces. For this type of plyometric intensity is determined more by the jump height than the added weight. Since the added weight limits jump height, these plyometrics are only moderately intense.

- Jumps performed while reaching the arms overhead, particularly when trying to reach to a challenging goal (e.g. basketball rim) result in higher jump height and as a result are of higher intensity.

Plyometric Program Design Guidelines

Table 2 presents a ranking of plyometric exercise intensity based on the research (1,3). With the knowledge of exercise intensity one can begin to create a program. A number of design variables for creating plyometric programs have been described (2). Plyometrics, like other forms of training are usually only performed two or three times a week. Training should occur in a non-fatigued state. Therefore, these exercises should not be performed after resistance training or aerobic conditioning. Ample rest between sets should be used in order to avoid turning these speed and power enhancing exercises into endurance training. As a general rule, rest five to ten times more than it takes you to perform the set of plyometrics. Thus, if you do a set of multiple hops that takes four seconds, you should rest 20 to 40 seconds prior to the next set or exercise. Another good rule to follow is to limit your sets to no more than 10 repetitions. In fact, it is probably good to use a range of repetitions such as sets of one, three, five, and ten repetitions in order to train explosiveness as well as power endurance across a continuum.

Table 1. Exercise categories for a number of plyometric drills

- Jumps in place. These are drills where involving repeated jumps and landing in the same place. Some examples include multiple vertical jumps while reaching an overhead object, squat jump (figure 1), pike jump (figure 2), or tuck jump.
- Standing jumps. These plyometrics can be performed with either a horizontal or vertical emphasis, but typically are performed for one maximal effort. Examples include the single leg jump (figure 3), maximal vertical jump (figure 4), standing long jump (figure 5), or lateral long jump.
- Multiple hops and jumps. These drills involve the performance of multiple hops or jumps. Examples would include multiple long jumps (figure 6) or cone hops performed in succession, such as 5 hops in a row (figure 7).
- Box drills. This type of plyometric is performed using special boxes or other stable elevated surfaces that the exerciser attempts to jump up to. Examples of these drills include box jumps (figure 8), repeated box jumps, and single leg box jumps.
- Depth jumps. These drills are also referred to drop jumps and are performed by jumping down from a plyometric box or other elevated surface such as the first row of bleachers. Examples include stepping off the box and landing, stepping off the box and jumping vertically immediately after landing (figure 9), or stepping off the box, landing, and sprinting.

The amount of plyometric training, or volume, which is performed in any given training session is measured by the number of foot contacts. Beginners often perform approximately 80 to 100 foot contacts per session (2). However, half of that amount may be appropriate, particularly for children, older adults, or those who are untrained. Obviously, exercise intensity is an important consideration as well. Eighty foot contacts of a variety of line hopes, cones, and ankle hopes is dramatically less intense than 80 foot contacts of high box depth jumps, single leg jumps, pike jumps, and maximal overhead jumps and reaches.

Plyometric programs should start with low intensity exercises such as those described in table 2. Over time, moderate and eventually higher intensity exercises can be incorporated for those who are healthy and fit. A sample program for a fit and moderately trained exerciser is described in table 3. You will notice that this program increases the volume (foot contacts) to a point and then volume eventually decreases as exercise intensity increases, in order to reduce exerciser fatigue and increase adaptation to the program.

Summary
Plyometrics can be thought of as one of the important tools in the tool box for those who wish to add another dimension to their training programs. If improving variables such as speed, jumping ability, and agility is a goal, plyometrics may be the most important of these tools. Maximizing plyometric program effectiveness and preventing injuries depends on the logical progression of exercise intensity. Therefore the goal of this article was to provide information about the intensity of plyometric exercises, as well as to offer some general guidelines for plyometric program design.

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About the Author
William Ebben is an assistant professor and researcher at Marquette University. He has previously served as a strength and conditioning coach for the University of Wisconsin, U.S. Olympic Education Center, Green Bay Packers, Marquette University, as well as in small college and high school position. He also conducts plyometric, vertical jump, and speed development camps and works with personal training clients.

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Table 2. The Approximate Highest to Lowest Intensity Plyometric Exercises

- Single leg jumps
- Depth jumps from heights that are similar to the exercisers actual vertica jump height
- Tuck and pike jumps
- Maximum jump and reach to overhead goals
- Maximum jump and reach without overhead goals
- Low box and depth jumps
- Weighted jumps
- Squat jumps
- Sub-maximal jumps in place (tall cone hops)
- Sub-maximal jumps in place (short cone hops, ankle hops, split squat jumps)

Figure 1. Squat Jump

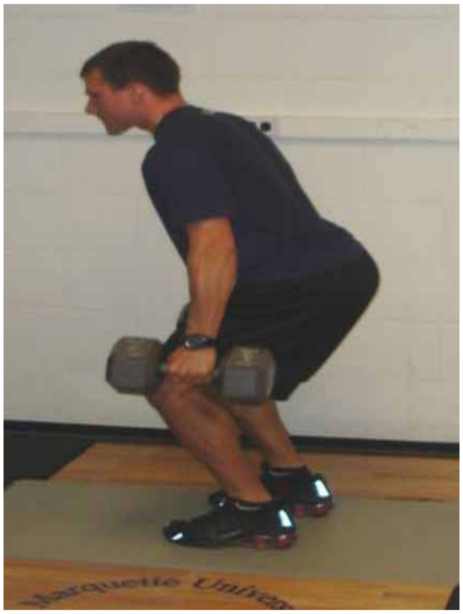

Figure 2. Pike Jump

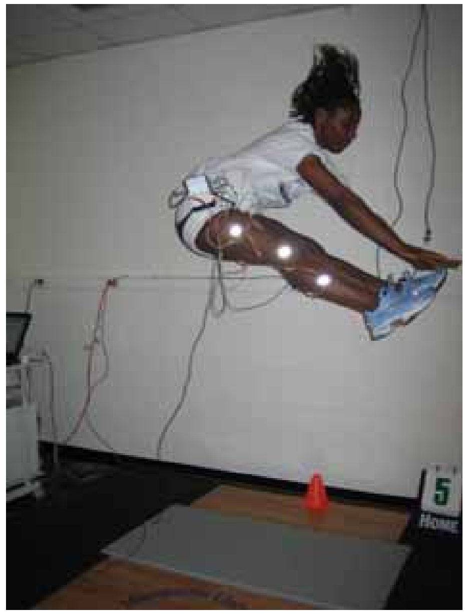

Figure 3. Single Leg Jump

Figure 4. Maximal Vertical Jump

Figure 5. Standing Long Jump

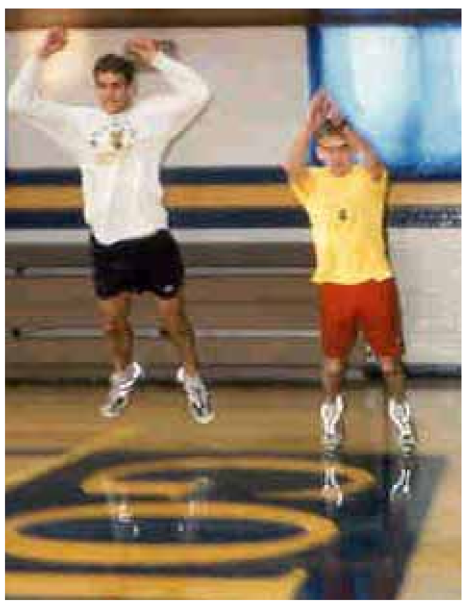

Figure 6. Multiple Long Jumps

Figure 7. Multiple Cone Hops

Figure 8. Box Jump

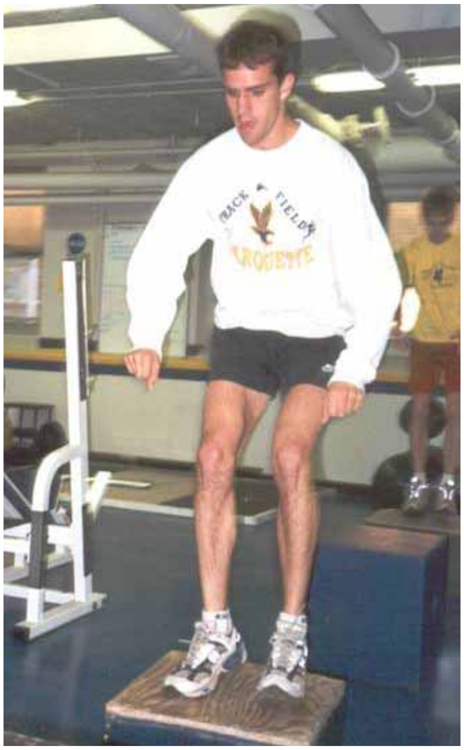

Figure 9. Depth Jump

Table 3. Sample 5 week program to be performed twice a week.

	Week 1	Week 2	Week 3	Week 4	Week 5
Volume	60 FC	80 FC	70 FC	60 FC	50 FC
Exercises	line hops 3x10	line hops 3x10	squat jumps 1 x 10	squat jumps 1 x 10	squat jumps 1 x 10
	ankle hops 1x10	ankle hops 2x5	split squat jump 3 x 5	split squat jump 2 x 5	multiple long jump 5 x 3
	cone hops 2x5	cone hops 3x5	multiple cone hops 5 x 3	tuck jump 5 x 1	lateral long jump 5 x 1
	squat jumps 2x5	squat jumps 2x5	lateral long jump 5 x 1	lateral long jump 5 x 1	pike jump 5 x 1
		split squat jump 2x5	weighted squat jump 10 x 1	weighted squat jump 10 x 1	two leg jump/reach 5 x 1
		long jump 5 x 1	box jump 2 x 5	box jump 2 x 5	single leg jump/reach 5 x 1
				12 inch depth jumps 10x1	18 inch depth jumps 5 x 1

FC = Total foot contacts per training session as determined by the total sets and repetitions for that session

Nutrition for Ultra Endurance Events: *Fluid and Electrolyte Guidelines*

Debra Wein, MS, RD, LDN, NSCA-CPT,*D

In the last issue of the *NSCA's Performance Training Journal*, we discussed the energy and macronutrient needs of ultra endurance athletes. In this issue, we will review fluid and electrolyte guidelines. Ultra endurance exercise is classified as prolonged exercise lasting longer than four hours in duration and most commonly, involves running, skiing, cycling or swimming (1).

Fluids

Meeting nutritional and fluid intake demands is a first priority to ultra-endurance athletes (6). Any loss of body weight in excess of three percent of body weight seriously disrupts temperature regulation and physical performance. Even a 2% loss of body weight can degrade aerobic exercise and cognitive / mental performance while more severe dehydration (3 – 5% body weight) may not degrade muscular strength or anaerobic performance but can result in other serious consequences (8). Consequences of dehydration include increased body core temperature, increased cardiovascular strain, increased glycogen utilization, altered metabolic function and possibly altered CNS function (8).

The American College of Sports Medicine's current position statement on fluid intake during exercise recommends intake of 600 – 1200ml/h of 'palatable' cooled fluid containing 4-5% carbohydrate and 0.5 – 0.7g/l sodium in events greater that one hour in duration. Recent research findings are, however, questioning the appropriateness of these recommendations (5). This volume may be considered too high for ultra-distance athletes competing at relatively low-intensities or for smaller athletes with relatively low metabolic and sweat rates during exercise. It has also been postulated that female ultra endurance athletes may have lower fluid requirements and are at significantly greater risk of developing hyponatremia due to fluid overload. This is thought to be due to lower sweat rates as women are usually smaller and have smaller fluid compartments, and also due to the longer time taken by women to complete events (6).

Ultra-endurance athletes are therefore advised to adhere to more conservative fluid intake volumes than those who exercise more intensely for shorter periods. For instance, in ironman triathlon events the recommendation is to limit fluid intake to 500 – 800ml/h during the cycling portion and 300 – 500ml/h during the running portion, with lightweight men and women being advised to drink even lower volumes (6). Marathoners should likely ingest 400 – 800ml/h (4). It is now accepted that 5 – 10% concentrations of glucose, glucose polymers, and other simple sugars do not impair gastric emptying, making it possible to simultaneously achieve fluid and carbohydrate requirements of endurance exercise (6).

Electrolytes

Sodium needs vary according to the concentration of the sodium lost in the sweat, the amount of sweat lost, environmental conditions, as well as the duration and intensity of the exercise. Taking in 0.3 – 0.7 grams per liter of fluid (2) can help to offset salt losses and minimize muscle cramping and the risk of hyponatremia. Measuring sweat rate is important in order to customize the sodium requirement. Devising a diet with individualized recommendations for foods, beverages, and supplements, when necessary, is imperative. This is because some reports show sodium supplementation unnecessary to maintain serum sodium concentrations in athletes completing an ironman triathlon (5), whereas other reports show hyponatremia as a real risk (9,10). Hyponatremic runners seeking medical assistance present with a variety of symptoms that range from nausea, weakness, confusion, and incoordination to grand mal seizures and comas. Athletes engaged in very prolonged exercise should ingest 1g/hour of sodium (3).

Fluid and electrolyte balance are critical to optimal exercise performance and, moreover, health maintenance. Ultra endurance sportsmen and women typically do not meet their fluid needs during exercise. (7). Therefore, a consultation with a qualified sport nutritionist may enhance performance and prevent serious consequences.

About the Author

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To read part 1 of this article, download issue 6.4 of the NSCA's Performance Training Journal on www.nsca-lift.org.

Introduction to Plyometrics: Converting Strength to Power

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Power, the combination of speed and strength, is crucial for success in many sporting events. The purpose of plyometric work is the same as that of strength training, to develop greater physical power. Many athletes spend all their time in the weight room trying to increase power with barbell and dumbbell exercises. While these exercises have their place, they are not the most efficient means of developing power. Traditional weight room exercises do not allow the athlete to move at the speed, or use the movements needed, to develop sport specific power.

While strength training can create the muscular and nervous system adaptations necessary for power development, plyometrics focuses on the speed component of power and transforms the physiological changes into athletic ability. It does this through the use of the elastic properties of muscle and the stretch shortening cycle.

The Stretch Shortening Cycle (SSC)

Muscles are capable of three types of contraction.

1. Isometric contraction in which the length of the muscle does not change
2. Concentric contraction in which the muscle is shortened
3. Eccentric contraction in which the muscle is lengthened

In normal activity, these contractions seldom occur alone. Due to the influence of gravity, compression and impact forces, from running and jumping activities, there is usually an eccentric contraction followed by a concentric contraction. This combination of eccentric-concentric contractions is known as the stretch shortening cycle. The addition of an eccentric contraction prior to a concentric contraction has been found to increase the force, speed, and power output of the concentric contraction.

Mechanisms Behind the SSC

The stretch shortening cycle results in more powerful concentric contractions. How does this happen? There are two mechanisms that help to contribute to the explosive concentric contraction these are the elastic potential of the muscle and the muscle spindles. The muscles contain elastic fibers made up of a protein called elastin. These fibers are easily stretched and return to their original length. They function similar to a rubber band and when stretched can add to the power of a movement. Since much of the original research into the SSC was done on isolated muscles fibers that had been removed from a frog, the elastic response was thought to be the main cause of the greater power output. However, the muscle spindle also plays a role when living muscles are activated.

Muscle spindles are located within a muscle near the point that it joins the tendon. A spindle consists of a modified skeletal muscle fiber with a sensory nerve wrapped around one end of it. The muscle spindle senses changes in the amount of stretch in a muscle. A signal is sent through the sensory nerve to the spinal cord where motor nerves are stimulated and the muscle that was stretched contracts. This is called the myotatic or stretch reflex. The most common example of this is the knee tap examination that doctors perform during an annual check-up. When tapping the knee, the patellar tendon and quadriceps muscle group is rapidly stretched. The quadriceps muscle group will react to this by contracting. An impulse is also sent to the antagonist muscle group inhibiting its contraction. During jumping activities the rapid stretching of the muscles on landing causes the spindles to be activated and thereby add to the power output. The spindles are sensitive to the rate of stretch, the more rapid the stretch the greater the activation level of the spindle. Since most natural movements will involve the activation of both the muscle spindle and the elastic components of the muscle, they both play a role in the increase in power output following SSC movements.

Plyometric Sequence

Plyometric exercises always follow the same specific sequence:

- A landing phase
- An amortization phase
- Take off

The landing phase starts as soon as the muscles start to experience an eccentric contraction. The rapid eccentric contraction serves to stretch the elastic component of the muscle and activate the stretch reflex. A high level of eccentric strength is needed during the landing phase. Inadequate strength will result in a slow rate of stretch and less activation of the stretch reflex.

The amortization phase, the time on the ground, is the most important part of a plyometric exercise. It represents the turn around time from landing to take off and is crucial for power development. If the amortization phase is too long, the stretch reflex is lost and there is no plyometric effect.

The take off is the concentric contraction that follows the landing. During this phase the stored elastic energy is used to increase jump height and explosive power.

Getting Ready for Plyometrics

Plyometrics are a very high intensity form of training, placing substantial stress on the bones, joints, and connective tissue. While plyometrics can enhance an athlete's speed, power, and performance, it also places them at a greater risk of injury than less intense training methods. Prior to starting a program there are several variables to consider so the training sessions are performed in a safe and effective manner.

Landing

As a general rule an athlete should not be jumping if they do not know how to land. A good landing involves the knees remaining aligned over the toes, the trunk inclined forward slightly, the head up, and the back flat (figure 1). When an athlete is learning to do plyometrics for the first time they should spend the first two to three weeks focused on landing and being able to move out of a landing before moving on to more intense drills.

Figure 1. Landing

Landing Surface

Plyometrics can be performed indoors or outdoors. The landing surface should be able to absorb some of the shock of landing. Gymnastic or wrestling mats are good indoor surfaces as are the sprung wood floors found in many aerobics studios. Outdoors, plyometrics are done on the grass or sand. Jumping on concrete or asphalt can lead to knee, ankle, and hip problems, as such these surfaces should be avoided.

Strength

Having a good strength base is essential for performing plyometrics safely and effectively. Without good lower body and core strength, the amortization phase becomes too long and much of the benefit of the plyometric is lost. Over the years, the need to squat one to two times body weight has been suggested as a requirement for plyometrics. While this is a good guideline for some of the higher intensity drills, simple jumps in place and hops over very low barriers can be used with most athletes as long as they have demonstrated the ability to land properly.

Injury History

Those athletes with a history of lower body injury must be full rehabilitated and have medical clearance prior to starting a plyometric program. The program should start with basic running and change of direction drills including cuts, corners, and rotations before moving on to higher intensity hops, throws, and jumps.

Designing a Plyometrics Program Intensity

Intensity is a measure of how hard you work, often compared to the maximum amount that you can do. Intensity is a factor in determining the overall stress a training sessions creates. As a power training technique, the speed of movement and power produced in each repetition of plyometric training determines whether or not you will get a training adaptation. All repetitions in a plyometric exercise are performed at maximum speed and power, anything less deceases the stretch shortening response and plyometric effect of the movement.

Contacts Per Session

Plyometrics are recorded by the number of single foot contacts with the ground. For example 80 contacts would be four sets of 10 repetitions with a two-legged type movement or a total of 80 steps with walking lunges. The volumes listed in table 1 represent the total number of contacts per training session, not the number of contacts per exercise. This table assumes that each movement is at 100% effort. Plyometrics performed at anything less than 100% do not get the benefit associated with rapid elastic force production. However, new plyometrics drill should be performed at 70% – 80% until you are comfortable and confident with the technique of the exercise.

Plyometrics should not be performed more than two to three times per week unless you are alternating days of upper and lower body plyometric drills. If you are just starting to incorporate them into your current conditioning program, two sessions per week is adequate.

Rest Between Sets

Rest and recovery are crucial variables in a plyometric program. Rest refers to the time that is taken between each exercise or set. Recovery refers to the amount of time that is needed before the workout can be repeated.

The amount of rest that is taken depends upon the duration of work and the type of drill or exercise used varying from zero to seven minutes between sets or exercises. Table 2 summarizes the duration of work and rest periods for a variety of work periods. In this table the work period refers to the period of continuous work and may not represent the total time for each set. In the case of single response drills, it is common to take five to ten seconds between repetitions to reset your body position, this can make the total time for the set quite long even though the continuous work time is very short, usually less than one second.

Sample Beginner Program

Table 3 contains a sample lower body program that is suitable for someone starting plyometrics. It is assumed that landing technique and body control are both good and that a dynamic warm up is done prior to the workout.

About the Author

Ed McNeely is a founding partner in StrengthPro Inc. A Las Vegas based sport science and nutrition business. He has been a consultant to 17 Canadian National and professional sports teams. Ed is the author of five books; The Resistance Band Workout Book, Power Plyometrics, One Hundred Strength Exercises, Training for Rowing, and Skillful Rowing, and has published over 100 articles on training and athlete conditioning covering topics such as strength training, plyometrics, making weight, assessing fitness, speed and power development, planning and periodization, and aerobic fitness.

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Table 1. Foot or Hand Contacts per Session

Level	Low Intensity	Med. Intensity	High Intensity
Beginner	80	60	40
Intermediate	100	80	60
Advanced	140	120	100

Table 2. Work and Rest Periods

Work Time	Rest between reps	Rest between sets	Rest between exercises
< 1s	5 – 10 s	1 – 2 minutes	None
1 – 3 seconds	None	2 – 3 minutes	None
4 – 15 seconds	None	2 – 4 minutes	None
15 – 30 seconds	None	3 – 5 minutes	5 – 10 minutes

Table 3. Sample Beginner Lower Body Plyometrics Program

Exercise	Sets	Reps	Total Contacts	Rest Between Jumps	Rest Between Sets
Single response vertical jumps	3	5	30	5s	3 minutes
Hurdle Hops	3	4	24	No rest	3 minutes
Box jumps onto box	3	4	24	5s	3 minutes
Totals	9		78		

Childlike Simplicity

Suzie Tuffey Riewald, PhD, NSCA-CPT,*D

Do the following phrases sound familiar to you? "Race you to the light pole," "Whoever gets ten points first wins," "Coach said I get to start in the game today. I can't wait." They are all things that you likely would hear come from the mouths of young athletes.

Contrast that with the following quote, "I've never played so poorly in my entire life. I can't believe how nervous I was and how I collapsed under the pressure." This actual quote came from an athlete who had been playing and competing in her sport for years and years. It came after a poor performance in a major, international competition where she felt she had prepared herself to do well yet failed to do so.

In these competitive scenarios, there seems to be contrasting emotional experiences. In one, there is an overriding pressure or expectation to perform and in the other the athlete exhibits a joy and excitement about performing. Which emotional reaction or perspective of competition do you think facilitates optimal performance?

There is something positive to be learned from kids and competition; have fun and treat your sport like the game it is and this attitude will translate over to great performances. In this article, we will take a look at how to bring this childlike simplicity back into your training and your approach to competition and see how it can enhance your enjoyment of your sport while also improving your performance.

Think for a minute abut your own childhood athletic experiences. What words come to mind when recalling competition? Ask a group of adults to reflect back and you will hear them use words like "fun," "easy," "enjoying the process of performing," "naive," "not too stressed." And now ask yourself about how you perceive competition as an adult? You are likely to come up with words like "overly complex," "stressful," "not so much fun" and "anxiety provoking," and that is what competition can become, if we let it.

Many elite athletes tell me, when recounting competitions as a child, that "it was so easy back then." By easy, it seems athletes are referring to having the ability to just compete, to get up and do what they have been training for while not worrying too much about the outcome or the environment. Somewhere along the way a shift occurs where athletes worry about the outcome, worry about the environment ("This is the US Open" or "This is my first nationals") and they then force their performances. And such thinking sure takes the fun out of competition.

While there is no one answer as to how to keep competition light and fun, I present some thoughts and ideas about how to help you bring the simplicity and ease back to competition:

Alter Your Perspective

I had an athlete once tell me that to get in an effective competition mindset he recalls when he used to race with his childhood friends. Specifically, he would remember walking home from school when someone would yell "race you to the end of the block" and all the kids would take off. Everyone would just race, there was no worrying about who was going to win. Now, in his competitions as an elite athlete, he tries to bring back this unencumbered, simplified approach. He reminds himself to "just race to the end of the block." It can be that simple.

What, Really is the Task?

Kids do not get too caught up in the environment. It is about getting from point A to point B or hitting the ball over the net. This is true whether it is competing with friends after school or competing on a local or regional team. As adults, we sometimes let the environment complicate what needs to be done. Athletes often make the task more difficult by telling themselves it is the Olympics, or that a college recruiter is in the stands and that they have to be even better, faster, and more perfect. This is not true, the task is the same regardless of the environment. Remind yourself of this. Get back to the task stripped bare of the surrounding, getting from point A to B as fast as possible or hitting the ball over the net.

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Let the OutcomeTake Care of Itself

Of course, kids want to win. They want to be the first to the end of the block, they want to catch the ball and they want to score a goal. But, they seem caught up in the joy of competing and trying one's hardest. As adults, instead of directing our energies to the process, we are consumed with the outcome. We forget that the process of performance is what influences the outcome. Acknowledge that winning, placing, running a specific time are important. Then, let it go and focus instead on what you need to do to perform well. The joy and ease of competing is sure to manifest itself with such an approach.

It is not often you are instructed to act like a child, in fact in most cases we are told to grow up or act our age. However, in this one regard, you should be like a child. Leave all your baggage at the door. Simplify things in your mind so all you are doing is really jumping as far as you can or racing your buddy across the pool. Bring this attitude to your competition and watch your performances improve.

About the Author

Suzie Tuffey Riewald received her degrees in Sport Psychology/Exercise Science from the University of North Carolina – Greensboro. She has worked for USA Swimming as the Sport Psychology and Sport Science Director, and most recently as the Associate Director of Coaching with the USOC where she worked with various sport national governing bodies (NGBs) to develop and enhance coaching education and training. Suzie currently works as a sport psychology consultant at the University of Miami.

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