Improving Speed, Power and Explosiveness

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Which abilities do coaches and athletes want to improve more than any others? Virtually all individuals involved in sports would agree that the answer is speed and power and with good reason, because speed and power are essential ingredients for numerous sports. The expression of sport-specific speed and force (popularly referred to as explosiveness) strongly influences the rate of success in many of today's popular sports. For example, in a sport like football, the players who demonstrate the greatest amount of explosive power (all other variables being equal) should dominate their opponents. Similarly, in track and field the shot putter or hammer thrower who overcomes his/her implement's resistance with the greatest possible speed of movement should, in theory, produce the longest throw.

Hay and Reid (1988) define speed as distance covered divided by the time taken to cover it. They propose focusing on the form, pattern, or sequencing of movements with respect to time when trying to enhance movement speed. In many competitive racing events, this recommendation means trying to improve an athlete's stride length and/or stride frequency. Hall (1991) supports these suggestions. She states that a major difference between highly skilled sprinters and ice skaters when compared to their novice counterparts is much higher stride frequencies seen by the elite group. She also documents that elite cross-country skiers are usually distinguishable from their slower (less-skilled) counterparts by longer than average stride lengths.

In scientific terms, power is expressed by the equation: **P**ower = **F***orce* x **D***istance* / **T***ime* (Bryant, 1988). According to this description, training that involves all or various parts of the power equation can affect explosiveness in sport.

Power output can be enhanced in three general ways. The first method is to increase the force producing capabilities of the muscles (keeping the distance moved and time it took to move the distance constant). Since increases in explosiveness can be brought about by an increase in force, a hockey player who improves full-body strength (other power variables remaining constant) should be more explosive when skating up and down the ice.

The second way to enhance power is to decrease the time it takes to move over a given distance because of faster movement speed (keeping force generated and distance moved constant). Using the concept that improvements in power can be brought about through increased speed of movement, elite swimmers repetitively practice their stroke mechanics in an effort to improve skill coordination. Improved coordination of the muscles involved in a sport skill should increase overall speed and power output (other power variables remaining constant).

Increasing the distance that a force acts on a body or implement (keeping the force generated and time elapsed constant) is another technique used to enhance explosive power. A volleyball player or track jumper who drops down into a deeper (optimum) crouched position than normal may exhibit an improvement in explosion (provided the force applied and time it is applied remain constant) (Myers and Munroe, 1981).

Most sports require speed and power for success. There are many general areas that can be addressed to enhance the expression of explosiveness in sport. There are also specific strategies available to affect movement speed and power output. The question is what areas and strategies should be emphasized to enhance the expression of speed, power and explosiveness in sport? The purpose of this chapter is to suggest probable physical and mental strategies to improve speed, power and explosiveness in sport.

Specifically, the objectives are 1. To identify methods that directly enhance movement speed and power output; 2. To review areas of motor learning and sport psychology that may positively affect the expression of speed and power.

WEIGHT TRAINING

Weight training, resulting in increased strength, is important for improving explosiveness. Whenever the force producing capabilities of the muscles are increased, the potential to improve speed and power for skill execution is enhanced. Recent studies have shown that a progressive weight training program can increase sprint speed and throwing velocity (Napier, 1991; Wooden, Greenfield, Johanson, Litzelman, Mundrane, and Donatelli, 1992). Some of this increase is due to greater amounts of muscle proteins (actin and myosin); which means an increase in the ability to generate force. Understanding and adhering to the guidelines that follow may achieve speed and power enhancements through weight training.

Train full-body. Current research suggests that strengthening opposing muscle groups (agonists and antagonists) enhances movement speed (Jaric, Ropret, Kukolj and Ilie 1995). According to these data, strengthening a major muscle group such as the hamstrings may result in faster leg deceleration during high-speed activities (sprinting). Less time needed by the hamstrings to decelerate the leg (while running) leaves a longer period of time available for the quadriceps to increase leg acceleration, resulting in faster lower limb speeds.

Maximal strengthening of all the major muscle groups of the body may increase the time available for movement acceleration. The end result should be faster movement speeds and explosiveness in potentially all sport skills.

Systematically make the muscles work harder over time. To increase muscle strength, make the muscles work progressively harder. The four most common methods to make the muscles work harder are to increase the repetitions, sets, load, or to systematically decrease the rest time between sets/exercises.

Diminish momentum (lift slowly). Momentum is always present when lifting weights. However, the less momentum allowed into the performance of each repetition, the more work the muscles have to perform. The more work the muscles have to perform the greater gains in force generating capacity, speed, and explosiveness.

Continue lifting to a point of demonstrated fatigue. Coaches for years have asked, “should we have our players lift to a point of all out fatigue for maximum results?” Exercise scientists do not currently know what level of fatigue should be demonstrated before the termination of a set for optimal strength in each muscle and individual. However, training to a point where no complete concentric (positive portion of the repetition) contraction can be achieved assures that athletes have accomplished their intensity threshold (amount of fatigue) for optimal results, whatever level of intensity it may be (Carpinelli, 1997).

STRETCHING AND FLEXIBILITY

Flexibility has been defined as the range of motion about a joint (Fox, Bowers, and Foss, 1993). Flexibility is important in improving speed and power because the greater the range of motion about a joint, the greater distance available to apply force. When distance to apply force is increased while force and time are constant, explosiveness is improved. For example, the quarterback possessing the greatest amount of shoulder girdle flexibility should also have the greatest power output on each throw (all other variables being equal). Speed and power enhancements through flexibility training can be achieved by understanding and following the guidelines outlined below.

Develop a program that is sport specific. Stretch all the major muscles involved in the performance of the sport. Pay careful attention to stretching opposing muscle groups and limbs so flexibility imbalances are avoided. There is some research suggesting a greater incidence of

injury in populations with flexibility imbalances (Knapic, Bauman, Jones, Harris and Vaughan, 1991).

Stretch after a warm-up or after the training activity. Beaulieu (1981) suggests that a warm-up period decreases a muscle's chance of injury when stretched because of greater extensibility. He also suggests increased gains in flexibility occur when stretching is performed after the muscle is warmed.

Ease into each stretch (without bouncing) to a point where a tug is felt. Easing slowly into each stretch brings about relaxation in the muscle enabling a further stretch (Noakes and Granger, 1990). Along with stretching slowly it is important not to overstretch, which may lead to injury. Signs of going beyond a relative tolerance can include accelerated breathing and burning sensations in the targeted muscle.

Hold each stretch for 15-20 seconds. One of the latest reviews on stretching suggests no meaningful differences between holding a stretch 15 seconds, 45 seconds or 2 minutes (Smith, 1994).

Stretch each muscle three to five times. Current research suggests that for maximal flexibility adaptations, each muscle may need to be stretched 3-5 times per session (Smith, 1994).

TECHNIQUE

In sports, the nature of the activity and the equipment used usually control the distance over which force can be applied. However, by modifying performance technique some athletes may be able to increase explosiveness by increasing the distance over which they apply force. For example, the shot putter who switches to a short-long technique where the glide across the ring is shorter and length of the push (force application) is longer may see improved power provided all other variables (time and force) remain constant (Myers et al., 1981).

EQUIPMENT

More and more, sport scientists are pursuing ways to alter sports equipment to increase the distance a competitor has to apply force. As with modifications to technique, an increase in the distance to apply force may result in greater power output.
One of the latest examples of this theory in action is the new skate blade used by some Olympic long track speed skaters. The back portion of the blade is not completely attached to the heel. This skate modification increases the distance the skater applies force against the ice before the blade has to snap back up against the skate boot. In theory, this increased distance to apply force should result in more explosive skating strides (provided other power variables remain constant).

RATE OF FORCE DEVELOPMENT

Increasing the size of one's engine (muscles) should allow the mass of the body (during jumping or sprinting) or an external object (like a competitor in football or wrestling) to be accelerated more explosively. To be optimally successful in many speed and power sports it is also important to be able to develop (the engine's) force rapidly. Having a big engine but not being able to get it to top speed quickly is like racing a Cadillac in the quarter mile. All that power may still result in an unsuccessful performance if the driver cannot get to maximum speed until the half-mile mark. For optimal sport success, speed and power athletes should have large engines that reach top speed quickly.

Rate of force development is the ability of the neuromuscular system to develop as much force as possible in a short period of time (Newton and Kraemer, 1994). A rate of force development enhancement improves explosiveness by decreasing the time it takes to move over a given distance (provided other power variables are constant). Researchers suggest that the key stimulus for enhancing rate of force development is maximum voluntary effort (the intent) to develop force as fast as possible, not the external speed of movement while training (Young and Bilby, 1993).

Coaches and athletes have the option of trying to enhance rate of force development in the weight room, the sport setting or both. They also have the choice of training using high speed or slow movements with an intent to develop force quickly (for example, trying to accelerate a heavy weight explosively).
Recent research suggests some options may be more practical than others. For example, there is evidence to suggest an increased probability of injury from the performance of some types of explosive weight training movements (e.g., Olympic lifts, Leaper training and exercises using chain operated equipment) (Brady, Cahill, Bodnar, 1982; Hall, 1985; McCarroll, Miller, Ritter, 1986; Reid, Yeater, Ullrich, 1987). However, since most subjects in the reviewed studies were unsupervised, it is unknown whether it was the movements that caused injuries or the improper execution of the movements. Regardless, explosive movement training in the weight room still has a higher probability of causing musculotendinous injury compared to slowly performed dynamic movements since greater forces of momentum are generated at higher speeds (Behm, 1988). Furthermore, most injuries appear to occur in the weight room from breaks in technique. Explosive lifts requiring large amounts of technique (Olympic Lifts) certainly add to the probability of improper execution and musculotendinous injury.

A more practical and perhaps optimal method to increase rate of force development may be for coaches and athletes to implement explosive sport specific drills. Currently, some motor learning researchers suggest that because weight training movements are different than those executed on the field and court in dynamic situations, the explosive transfer may be less than optimal (Schmidt, 1982). Furthermore, Sage (1984) proposes that training tasks (movements that are dependent on practice and experience for their execution) must be virtually identical in order for transfer to performance to be practically meaningful.

To improve rate of force development in the sport setting, coaches should study game film and design explosive drills incorporating identical sport performance movement patterns. When implementing sport-specific power workouts, athletes should explode at the start and try to accelerate for the duration of each drill. As an example, basketball players should perform jumps, defensive position lateral slides, diagonal, forward and backward sprints explosively to enhance sport specific explosiveness. Execution of sport movements with maximum voluntary effort to develop force as fast as possible enhances athlete's rate of force development in an exact (specific) manner. There may be no better form of movement and velocity specific power training to ensure that explosive sport training carries over to explosive sport performance.
The need to prepare in the exact manner as one is expected to perform cannot be overstated. Students do not study algebra to take a geometry test, even though they are similar subjects. Although both subjects are under the umbrella of mathematics and because of their similarities studying one may positively affect test results in the other, it should be obvious that 'best' results would come from preparing in an exact manner.

WARM-UP

McArdle, Katch and Katch (1991) state that speed of contraction can be significantly increased by raising body temperature. A proper warm-up should include activities that incorporate the large muscle groups of the body in a rhythmic and repetitive manner. Warm-up activities should be specific to the training exercise(s) but performed with a lower level of effort for seven to fifteen minutes.

DRAG

In many sports, movement speed and power may be improved by reducing drag. Drag can be described as an external resistance that slows forward motion (Lamb, 1995). Examples of drag in sport include headwind on the forward speed of a track sprinter, water on the movement speed of a swimmer, and an offensive tackle on the pass rush of a defensive lineman in football.

Equipment

To reduce drag, sport scientists have developed various forms of aerodynamic and hydrodynamic sport apparatus. For example, newly designed rowing shells have reduced water drag, while

cycling helmets have reduced air drag, thus improving competitive velocities and performance power. Athletes who are involved in competitive sports that require movements against the resistance of air or water are advised to research sport specific apparatus to find the most drag reducing equipment available.

Body Composition

Modifications of body composition may also lead to the enhancement of movement speed and power through reductions in drag. In explosive jumping sports (high jumping, long jumping, triple jumping), a loss in body mass results in a reduction in the drag of gravity (a limiting factor to success in jumping sports). However, if the body mass lost is muscle tissue, reductions in ability to produce force and explosiveness may also be expected. Body composition alteration strategies should be carefully considered before they are implemented so that power performances are enhanced rather than affected negatively.

To improve explosiveness through enhanced body composition, athletes should
1. Consult with a registered dietician who can provide a body composition analysis, evaluation of current diet, determination of optimal and realistic body composition expectations and diet modification strategies; 2. Perform a weight training program following the suggestions previously discussed; 3. Acknowledge and accept that there does not currently appear to be a safe and effective nutritional supplement that provides consistent body composition enhancements in athletes.

Biomechanical Factors

Biomechanical factors further influence drag and sport explosiveness. Changing body posture may decrease air drag in some racing sports. For example, elite cyclists and downhill skiers gain speed and power output by dropping into crouched postures thereby diminishing body surface area exposed to air resistance.

Track coaches and runners have made an art out of reducing drag through efficient biomechanical positions and postures. Although track experts utilize a variety of technique cues, their general recommendations remain the same: (a) demonstrate straight-line movements, and, (b) reduce vertical lift and time spent in the air.

Successfully performing the following cues may enhance movement efficiency, reducing drag and improving explosiveness. Start by driving with both legs explosively in a straight-line direction. Gain as much ground as possible with the first step. Run with the head erect and still. Relax the jaw and face. Focus the eyes straight ahead. Keep the torso straight, trying not to turn or flex. Rotate the arms at the shoulder (with very little lift of the shoulders). Keep the arms tight to the torso. Do not allow the hands to cross the mid-line of the body. Consistently drive the front leg forcefully toward the ground. Point the toes and knees straight ahead and toward the target or finish line (Riley, 1996).

Strategic Play

Strategic play and game planning in many contact sports is another method that can be implemented to reduce external resistance to movement. For example, an opponent's resistance (body mass) can be overcome through practiced techniques under the instruction of intelligent coaches. A case in point, wisely executed misdirection movements by a wrestler can deceive a countering opponent into resisting in the wrong direction. The reduction in external resistance by the opponent increases countering movement velocity, and the opportunity for successful power movements and performances.

Skill Execution

Skill execution can also affect drag and explosiveness. A good illustration of the impact of skill on power is the contrast in blitz performances of rookie and veteran defensive ends in football. The rookie may produce the same power output as the veteran, but because the rookie is less skillful in the execution of each explosive movement, power output is misdirected. The veteran

defensive end because of less wasted movement encounters less resistance, gains greater forward velocity, and expresses more functional explosiveness.

To improve explosiveness through enhanced skill demonstrations, athletes need to learn efficient techniques from competent sport coaches and study film of themselves executing the sport skills. Athletes should then practice the exact sport movement patterns demonstrating their most skillful technique. The specific goal of these procedures is to reduce drag resistance while demonstrating the movement pattern as a purposeful conditioned reflex, rather than as a skill that must be thought about before execution.

ATTENTIONAL FOCUS AND REACTION TIME

The ability to focus one's attention (read) and react in explosive sports often appears to be at least as important as movement time for successful power performances. Watching a football linebacker get flattened by the off-side guard on a misdirection play illustrates this point. In many cases the linebacker gets crushed not because he was not explosive, but because he did not have a correct read (focus) and/or did not demonstrate good reaction time. Athletes can have awesome explosive capabilities from the neck down but never get to use them effectively because of limiting factors (mental focus problems and reaction time deficiencies) from the neck up. Athletes may have a big, powerful gun (body) but if they cannot pull the trigger (read and react appropriately) under competitive conditions, the size of the gun and speed of the bullet (explosive movement speed) become irrelevant (Ted Lambrinides, personal communication, April 3, 1998). Few, if any, other factors influence the expression of sport explosiveness more than attentional focus and reaction time.

Attentional Focus

Attentional focus has been described in the scientific literature as a process whereby athletes put a conscious effort into gathering appropriate information from a specific situation (Posner, 1971). Nideffer (1976) says that attentional focus can be broad or narrow, and internal or external. A broad-external focus is usually used to quickly assess situations. A quarterback in football should be able to keep this type of focus because relevant cues for success come from stimuli that are in the external environment (defensive scheme, weather).

The broad-internal focus is customarily employed to analyze a game plan. A coach or athlete who is developing game strategies uses this type of attentional focus.
A narrow-external concentration is practiced when minimal amounts of external cues need to be focused on for success. A golfer focusing attention on the ball he or she is about to drive is using this type of concentration.

The last type of attention is the narrow-internal. This focus is used to systematically rehearse a performance or to control arousal. An example of narrow-internal focus is a gymnast who mentally rehearses an explosive vault or who is focused on his or her arousal level and is taking slow deep breaths to relax. This type of focus is also used in competitive weight lifting, where the focus is on effort.

Each explosive sport and event requires distinct attentional demands at specific times for proper reads. For example, as offensive linemen in football walk to the line of scrimmage they have an external-broad focus on the environment (position of the defensive linemen, linebackers and defensive backs). Once they have gathered this external information, focus shifts to broad internal as each member of the line plans his duty within their shared assignment. After the line calls are made, attention focuses to a narrow-internal as the linemen monitor their tension, making sure to be calm yet optimally aroused and aggressive. During this focus the linemen may also mentally rehearse the moves they plan to use against their individual opponents. Lastly, the linemen shift attention to narrow-external as they focus on the quarterbacks' signals and their opponent.

Watching football linemen on film we can see when they do not look explosive, miss their assignments and mess up plays. What we cannot tell is why. Did a lineman miss picking up the

blitzing defensive back because his movement speed was too slow? Possibly, but lack of explosiveness could also be attributed to improper focus and a bad read. If, for example, linemen stay focused internally on their nervousness and do not switch over to the appropriate narrow-external focus (quarterback's cadence and their opponent's position) at the right time, they can get off the line too late and miss their opponent.

Implementing the following suggestions may improve attentional focus leading to an enhanced ability to read, react and dominate explosive play. Operationally define the terms "focus" and "concentration" so that common language is used between coaches and athletes. Recognize which type(s) of attentional focus are appropriate during specific sport situations. Practice the proper focuses mentally while physically practicing the sport skills. The combination of both physical and mental training may help individuals learn to lock into a correct focus that allows faster and more accurate reads. Improvements in attentional focus may lead to faster more accurate reaction times and successful performances in high-speed interactive sports.

Reaction Time

Reaction time refers to the time it takes to initiate a motor response to a presented stimulus (Grouios, 1992). Reaction time can be improved by implementing the following suggestions. Instruct athletes through film study to identify a small number of relevant variables. The fewer situational and opponent cues that need to be read and reacted to, the shorter the response times (Nemish, 1994). Watching a hockey goalie demonstrates this point. Most goalies have higher save success rates when they have to react to only one player on a break away as opposed to two or three.

Limit the amount of possible response choices an athlete has to consider before reacting. For example, a basketball player defending a three-on-one fast break who has been told to pressure the ball will read and respond faster than a player defending the break who has been told he/she has three defensive options to analyze before choosing a correct response.

Scout adversaries. Scouting brings knowledge of opponent tendencies that may allow athletes to invest in early reads and responses. For instance, in baseball a hitter may know that the pitcher has a tendency to throw the fastball for his 'out' pitch. Knowing this the hitter primes his concentration and physical readiness for the fast ball on a three and two count, thereby improving response time and the probability of hitting the fastball.

APPROPRIATE CONDITIONING

Most sports require competitors to express their explosive power and speed repeatedly in order to excel. Having wide receivers in football run 4.3 forty-yard dash times in the first quarter and 5.5 forty-yard dash times in the fourth quarter, describes a potentially explosive athlete who is unable to produce at a critical time in the game. All athletes must be conditioned in a sport specific manner to maximize their explosive endurance capacity.

There are two important methods to improving absolute speed and explosiveness through conditioning. First, systematically train the specific energy system used in the performance, using identical sport movement patterns. This way the athletes accomplish cardiovascular and muscular conditioning in an identical manner, as he/she will be asked to perform. Second, practice repeated sport movements (starts, sprints, jumps) at maximal speed and effort with total recovery between work intervals. The reason for repeated practices in this manner is because during the conditioning process a majority of athletes gauge their effort in order to make it through the workout. To see optimal gains in explosiveness, athletes need to train in a non-fatigued state. This teaches the players to consistently demonstrate maximal efforts and coordinate their movements efficiently at high speeds.

CONCLUSION

Many sports require the expression of great speed and power for success. There are many areas and strategies currently available to improve sport explosiveness. At the present time, there does

not appear to be one best method or recipe to improve speed and power for all athletes in all sport situations.

Each sport, position, and circumstance should be analyzed to decide how speed and power can be modified to maximize performance. Realistic training and performance goals should then be set based on the speed and power improvement possible. Coaches and athletes need to understand motor abilities like speed of limb movement, explosiveness and flexibility, to a large degree, are genetically determined. For example, Wilmore, (1982) suggests that sprint speed may only be enhanced about 10% through training. Olympic history supports this hypothesis. In 1900 Jarvis, from the USA, set the Olympic 100-meter dash at 11 seconds. In 1980, Wells from Germany, set a new 100-meter dash mark of 10.25, an improvement of only .75 over an eighty-year period (Komarek, 1998). This actuality tells all that speed and explosiveness can be improved, but not to a large degree. It suggests to coaches that recruitment of gifted (explosive) athletes should be the first priority (if speed and explosiveness are an important part of the game).

More importantly, it tells competitors that the purchase of magical training recipes and equipment are ill advised at best. Meaningful sport specific speed and power improvements do not come from running along the yellow brick road with a parachute or by paying the wizard for magic pills and powders. The demonstration of sport specific explosiveness comes from a combination of genetics; intelligent coaches who know how to communicate their training knowledge and athletes who are motivated to use that knowledge. Good Luck!

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