A Comparison of the Various Methods Used To Enhance Sprint Speed

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SUMMARY

IN TODAY'S ATHLETICS, SPEED IS BECOMING A MORE IMPORTANT FACTOR. SPEED, STRIDE FREQUENCY MULTIPLIED BY STRIDE LENGTH, IS THE ABILITY TO ACHIEVE MAXIMUM VELOCITY. THE PURPOSE OF THIS ARTICLE IS TO EXPLORE AND COMPARE THE VARIOUS METHODS FOR ENHANCING SPRINT SPEED. THE GOAL IS TO PROVIDE INFORMATION TO PRACTITIONERS ABOUT THE MOST EFFECTIVE METHODS FOR ENHANCING SPRINT SPEED.

In today's athletics, the face of the game is changing. Not only do teams require their athletes to become bigger and stronger, but speed is also becoming an ever-more important aspect of the game because it may give an athlete the edge over the rest of the competition. Sprinting speed, stride frequency multiplied by stride length, is the ability to achieve high velocity (21). To improve an athlete's speed, one or both parts of this equation must be improved (7,9). In addition, an athlete must have the ability to efficiently accelerate and reach his or her maximal velocity quickly (8,30). By implementing training focused on improving both components of sprinting, stride length *and* stride frequency, an athlete's speed will be enhanced to the fullest potential.

The goal of speed training is to increase the physical, metabolic, and neurological components that are essential for increasing sprinting speed (10). The various training methods used to improve speed can be divided into 2 groups: those designed to improve stride frequency and those used to improve stride length. High-speed treadmill sprinting, elastic-cord towing, and downhill sprinting are examples of overspeed training that are intended to improve stride frequency. The training method used to improve stride length is resisted training that includes the following: resisted sled training, weighted vest, uphill sprinting, strength training, and plyometrics. Next to strength and endurance, speed is the most difficult component of physical training to improve (26). Although improving speed is difficult, it is an important component of sport and well worth the time and effort.

Although it is true that many other factors besides speed determine the outcome in most sports (talent, agility, strength, power, and mental toughness), the purpose of this paper is to focus on the different training methods used to enhance speed. A description is provided for each method along with evidence of its ability to enhance speed. There are 2 sections, assisted and resisted sprinting, and within each section, the methods are ranked based on their effectiveness at improving speed. In conclusion, recommendations are made for the methods that are the most beneficial.

ASSISTED SPRINTS

The main purposes of assisted sprinting are to achieve higher velocities beyond the current capability of the athlete (3) and to train the neuromuscular system to maintain these high rates without assistance (7). Examples of assisted sprinting are towing, downhill sprinting, and high-speed treadmill sprinting. Although the main goal is to improve stride frequency, this type of training forces the athlete to take both faster and longer strides (22,7). Although there are other methods, this paper will focus on the most prevalent forms of assisted sprinting: elastic-cord towing, downhill sprinting, and high-speed treadmill sprinting.

Research has shown that stride length will eventually reach a plateau and stride frequency may continue to increase when approaching maximal sprinting speed; therefore, attention should be focused on improving stride frequency (10). Supramaximal sprinting, or overspeed training, has the potential to enhance neuromuscular adaptations through prolonged training, with the result being an increase in stride frequency (18). By creating an overspeed environment, the stretch-shortening cycle (SSC) of the neuromuscular system can improve the efficiency of the ground contact phase. This leads to the muscles being able to tolerate greater stretch loads and possibly storing more elastic power by increasing the stiffness of the muscle in the eccentric phase of the SSC (10).

KEY WORDS:
sprint; speed; assisted; resisted; speed enhancement

Assisted Towing

Assisted towing is a method of assisted sprinting where the athlete focuses not on increasing stride length but on increasing his or her stride frequency. Towing with an elastic tube or band can involve 2 people from a fixed position. Partner towing involves one person who is towing the other. The person being towed is the athlete who will be focusing on overspeed training. This method of assisted sprint training allows the athlete to achieve speeds beyond his or her unassisted capability.

The purpose of towing is to force the athlete to take faster steps without a change in running form. During assisted towing, the athlete must not allow himself or herself to be pulled. This implies that the athlete needs to increase his or her stride frequency rather than not putting forth an effort and allowing the elastic tubing to perform the work. Distances should not cover more than 30–40 m (3). Running mechanics are difficult to control with assisted towing (10); therefore, athletes should not achieve speeds greater than 106–110% of their maximum running speed (3,10,22). It is important for the coach to observe and ensure that the athlete is maintaining proper form when using towing.

High-Speed Treadmill Sprinting

This form of assisted sprinting involves treadmills that can adjust running speed beyond the current capability of the athlete. The sprint kinematics of high-speed treadmill sprinting are very similar to overground sprinting, and as velocity increases, the stride frequency increases and flight time and stance phase decrease (14). During high-speed incline, treadmill sprinting adaptations in stride frequency are created by increases in muscle activation of the lower extremity–which also produces a larger mechanical load on the hamstrings–and through increases in joint angular velocities (10,20). After treadmill sprinting, significant increases in peak hip extensor and knee flexor torques were recorded (10). An increased hip extensor torque can result in a greater stride length.

However, high-speed treadmill sprinting is not perfect. It is difficult to create the smooth and consistent acceleration patterns generated during a sprint race (14). Also, there are possible changes in kinetics because of the belt moving and the athletes not having to propel their mass forward, which does not increase kinetic energy (10). The increase in hip extensor and knee flexor torques is because of a higher muscle activation to enhance stride frequency. Although there is an enhanced stride frequency, the moving ground of the treadmill may change the amount of kinetic energy the athlete would have to create if sprinting on a normal surface. The kinetic energy generated during high-speed treadmill training might possibly be less than that generated during normal sprinting.

Downhill Sprinting

Downhill sprinting is the most popular (22), efficient, and cost-effective method of assisted sprint training (8). The purpose of downhill sprinting is to also improve stride frequency, and the athlete uses his or her body mass, the acceleration because of gravity, and the downhill slope to increase sprint speed beyond normal level ground sprinting (15).

There are discrepancies in the recommended degree of slope that is optimal for downhill sprinting. One recommendation is that the slope should not exceed an angle of 2–3° to prevent changes in mechanics (3), although another study found that a slope of 5.8° was faster than those of 2.1, 3.3, and 4.7°, which were faster than level ground and a slope of 6.9° (8). Dintiman and Ward (7) recommended a slope of 1–2.5% to prevent braking effect. Klinzing (15) suggested a slope of 5°, and Plisk (22) suggested slopes varying from 3 to 7° for the optimum downhill angle.

Although downhill sprinting is the most popular method to improve stride frequency, there are problems that arise when using this method. Declines greater than 3% may lead to excessive stride lengths, with no increase in stride frequency, and will result in an increased braking effect (3). These conflicting data demonstrate a problem with downhill sprinting: there are many recommendations on the degree of slope; however, there is also evidence that contradicts these recommended slopes.

Assisted Sprints Recommendation

Of the 3 forms of assisted sprinting presented–assisted towing, high-speed treadmill sprinting, and downhill sprinting–the best training method would be assisted towing. Downhill sprinting, although inexpensive, presents several problems: finding the proper slope, braking effect, and discrepancies as to which slope is most effective. High-speed treadmill sprinting would be a viable option, but this training method may be too costly for most athletes. Assisted towing is the best method because of the sport-specific characteristics. With assisted towing, the athlete still experiences an acceleration phase, with a transition to the maximal velocity phase. With high-speed treadmill sprinting, it is difficult to achieve the acceleration phase, and with downhill sprinting, it would be difficult to control this phase because of the forward lean on a downhill slope.

RESISTED SPRINTS

Resisted sprinting is a form of sprint training designed to increase the strength of the hip extensors, thus sprinting velocity, without substantial changes in running form (1,2,11). It is a common practice to include resisted sprint training to improve the athlete's ability to accelerate and enhance maximum sprint speed. It is believed that through resisted sprint training, more muscle fibers will be recruited via a greater neural activation and result in an improved stride length (1–3,11,19,22,30). Examples of resisted sprint training include towing, weighted vests, uphill sprinting, and sprinting in sand or water. The focus here will be on the most popular forms of resisted sprinting: towing and uphill sprinting.

Resisted Towing

Resisted towing is one of the most popular resisted sprint training exercises and can involve pulling a tire, sled, or any other device that offers resistance (19). Training with a weight sled may be the most effective method for improving maximum sprint speed because the weight can easily be changed. Resisted towing increases muscular force output at the hip, knee, and ankle, leading to a potential increase in stride length that can result in an improvement in acceleration mechanics (2,27). This type of training can be considered sport specific because it develops strength in the muscles used in sprinting, and with the proper weight used, the kinematics are the same as unresisted sprinting.

Finding the proper load for each athlete is necessary to produce the proper training stimulus without altering sprint form. There are several recommendations for the amount of weight to be towed because a weight that is too light may not produce a training stimulus and a weight that is too heavy can alter mechanics. For example, towing a weight of 5 kg resulted in no improvement in maximum speed from 20 to 50 m for pre- and posttest (3.54 and 3.55 seconds, respectively) (26). However, towing too much weight alters sprint kinematics by increasing ground contact time, decreasing stride length (1,19), and not allowing the hips to extend (3,7,16,19,22). Spinks et al. (27), Young (29), and Harrison and Bourke (13) recommended 10, 12.5, and 13% of the athlete's body mass, respectively, for towing. Alcaraz et al. (1) developed an equation for a synthetic track surface (different friction coefficient from other surfaces) to determine the specific load for each athlete: %body mass = (−0.8674 × %maximum velocity) + 87.99. Whatever the optimum amount of resistance is, it should not slow the athlete down more than 10% (3) or the horizontal velocity should not fall below 90% of the athlete's maximum velocity (1).

Towing with a sled may have a greater impact on the acceleration phase than maximum sprint speed: in a study conducted using rugby athletes, there was improvement during the acceleration phase but not maximum velocity (13). Even though there was only an improvement in acceleration, for a number of sports such as football, the athletes may accelerate but never reach maximum velocity.

Coaches using towing as a method to enhance speed must be aware of certain tendencies of this method to change the athlete's running form. It is suggested that towing eliminates the pulling action of the hamstrings (26). Proper sprinting mechanics must again be reinforced (3,7). If the athlete is not able to maintain proper mechanics, the weight being towed may be too heavy for that athlete. The location of the harness is also crucial. The harness should be worn on the hips. The higher the harness is above the hips, the greater the lean, and too much lean negatively affects sprinting kinematics by increasing the knee joint angle of the support leg (2). A correction for this is that the athlete should focus on driving his or her legs when there is a loss of stride length instead of focusing on increasing his or her stride frequency (16).

Uphill Sprinting

The next form of resisted sprint training is uphill sprinting. It is the most popular and most cost-effective method of resisted sprint training (22). It is used to increase the strength of the hip extensors by forcing the body to overcome the positive slope and use the hip extensor muscles to propel the moving mass uphill. Research has shown that the uphill grade results in a shortened eccentric phase and an extended concentric phase for propulsion (22). One study showed trends to increase maximum sprinting speed (1.0%), step length (1.6%), and contact time (2.4%), but these differences were not statistically significant (21).

There are several recommendations as to what angle of slope is best for uphill training so that running form is not altered (16). Dintiman and Ward (7) suggested a steep angle of 8° for starting ability and acceleration and angles of 1, 2.5, and 3° for speed enhancement and speed endurance. An incline greater than 3% is beneficial for developing hip extensor strength (11).

Uphill sprinting also has drawbacks. Studies indicate that uphill sprinting is ineffective possibly because of the angle of slope being too small or uphill sprinting not resembling training on a flat surface. One obvious problem with uphill sprinting is finding a suitable hill with the correct slope angle. The other drawback in uphill sprinting is that it is not sport specific to most sports. Most sports are played on a level playing surface, and the wrong slope may lead to a change in sprint kinematics (decreasing the eccentric phase before foot strike and increasing the concentric phase of push off), which can alter the transfer to a level surface.

STRENGTH TRAINING

The goal of strength training is to increase the size of the muscle fibers and strength of the athlete, which improves the ability to generate power. Strength training has been used for years by a wide variety of athletes to improve their athletic performance. Through new research, we have the ability to train our athletes more efficiently and prescribe them training programs that focus on the muscles necessary for enhancing sport-specific speed. The principle of specificity states that for an exercise to be effective, it must contain similar characteristics to the sport (1).

Sport-specific weight training has the greatest potential for transfer from the weight room to the playing field. Biomechanically, a coach must know which muscles are the most important for the particular sport being trained. Sprinting is a unilateral and mainly a horizontal movement. For example, during ground contact, only one leg is loading the muscles to propel the body's mass forward, while the other leg is in the swing phase preparing for ground contact. To meet specificity of training, more unilateral and horizontal exercises are needed for sprinters (29). For example, exercises such as squats and single leg squats will help improve short sprints and starting ability, and reverse hyperextensions, and Romanian deadlift (RDL) or single leg RDLs that strongly activate the gluteal and hamstring muscle groups are more specific to maximum-speed sprinting (28).

Biomechanical research suggests that the musculature around the hip is more important in sprinting than that around the knee (12). The power generated from the muscles around the hip acts as a kinetic chain. The hip flexors assist in pulling the leg forward–a faster flexion of the hip and leg recovery allows for a faster stride frequency (28). The hip extensors (gluteals and hamstrings) drive the body forward and perform concentric and eccentric actions during the ground contact phase (12). It was found that elite sprinters had superior hip extension velocities compared with subelite sprinters (10). As hip strength improved, speed improved (13). The hip extensors produce the greatest muscle moments during sprinting (11) and are active during the start of the sprint and increase activity as running speed increases (28). Although the hamstrings play a more important role than the gluteals (28), they are many sprinters' weakest link (7).

Because the hamstrings have significant potential to limit sprint performance, they should receive considerable amount of attention when training. The hamstrings undergo the greatest amount of force during the eccentric contraction of the swing phase and are most prone to injury. Therefore, exercises such as hamstring curls focusing on a rapid eccentric component and hamstring dips with a partner should be included to develop the eccentric strength necessary to prevent injury. To perform the eccentric hamstring curls, the athlete can slowly let the weight down and prolong the eccentric phase or can move through the concentric and eccentric phases rapidly to mimic the velocities of sprinting. The hamstring dips (Norwegian hamstrings) (Figure) can be a partner exercise, or if there is a device that locks the ankles in, the most important aspect is to keep the knees on the ground and do not allow any flexion or extension of the hips. The exercise is performed by extension of the knee, which is the eccentric phase of the hamstrings, followed by a flexion of the knee, which is the concentric phase. During this exercise, the athlete can slowly let his or her body mass drop slowly, allowing more eccentric stress to be placed on the hamstrings.

Understanding the components, forces and velocities, of sprinting is important when designing the resistance training program. During the acceleration phase, the athlete is using power to overcome inertia. After the acceleration phase, which can last up to 6 seconds (10), the athlete achieves maximum velocity, and the movements become high-velocity movements.

Even with this understanding of the forces and velocities of sprinting, there is still no clear consensus as to which load intensity is most beneficial during resistance training (4). The relationship between speed and maximal leg strength tends to be nonsignificant because of the squat exercise having a different velocity/acceleration profile than sprinting (5,29). Power is the amount of work divided by the time to complete the work, and many sprinters train low-resistance high-velocity movements to train at the optimum power output of approximately 30% of maximal voluntary contraction (7,17). A combination of high-resistance low-velocity and low-resistance high-velocity training showed improved speed performance as well (4,29). For example, it was found that low-velocity exercises such as squat, hip extension, and flexion improved 20-m acceleration time by 2.9% and the high-velocity exercises improved 20-m acceleration time by 4.3% (4). However, squats have hormonal and muscular benefits and can serve as a solid base of strength, but the velocity of the squat movement is much too slow to replicate a sprinting action. For a squat exercise, the time for the force to be applied may be 1–2 seconds directly across the whole foot, whereas during sprinting, the force is 3–4 times the body mass in a fraction of a second on the balls of the feet (19). High-intensity low-velocity movements can enhance speed but not to the same effect high-velocity movements can. So coaches need to find the proper exercises that fit the profile of sprinting.

Strength training movements such as the clean and jerk and snatch are explosive in nature, and the power generated from the exercise is more similar to that from sprinting speed. These explosive exercises allow heavy loads to be lifted, with high velocities producing some of the highest power outputs in human performance (7,17). Strength training has been shown to improve sprint speed from 5.19 to 5.38 m/s over a distance of 10 m (27). There is also a correlation (Pearson correlation coefficients, $r = -0.56$ to -0.66) between jump squats and speed for distances of 5, 10, and 30 m (5). Thus, implementing the correct exercises that are sport specific and focus on the proper velocities and intensities enhances sprint speed.

Additional exercises specific to sprinting can also enhance speed. For example, a front lunge contains movements that closely resemble sprinting form, and this exercise strengthens the quadriceps, gluteals, and hamstrings. In addition, because much emphasis is placed on the musculature around the hips, exercises such as multi-hip, glute ham raises, hyperextensions, and reverse hyperextensions should also be included in a speed development program.

Although the main focus is on the lower body, an athlete's body should be trained so that there are no weaknesses. Upper-body and core exercises should be included as well because the whole body is involved in sprinting. The Table shows a sample workout, which is designed to target muscles necessary for speed enhancement.

PLYOMETRICS

Plyometrics began appearing in training routines in the 1960s. Yuri Verkhoshansky suggested that individuals could significantly improve jumping and sprinting ability by progressive jumping techniques (24), and Olympic sprint champion Valeri Borzov substantiated those statements by winning the 100 m at the 1972 Olympics. Plyometric exercises are used to develop maximum force in a short amount of time (7) by training the SSC (15). During the eccentric contraction, elastic energy is generated and stored for the concentric contraction. The elastic energy stored during the eccentric phase is then released during the concentric phase (23). The faster the eccentric loading, the more powerful the concentric contraction (7). The objective of plyometric training then is to achieve a maximum eccentric contraction, which loads the muscle, and then rapidly switch to a concentric contraction (7). These exercises are beneficial for sports that require explosive movements and jumping enhancement and develop strength and power to improve stride length (6).

Research supports combining plyometric training with weight training, as evidenced by enhanced physical performance beyond weight training alone (22), and has a greater impact in the first 10 m (25). Enhancement in 20-m sprint time was seen more with a low- to moderate-frequency training plan than with a high-frequency training plan (6). Training at a low to moderate frequency reduces the number of repetitions (reps) being performed compared with a high frequency, which would be the greatest amount of reps. Again, the evidence of improvement in the short distances show that plyometrics at a low-resistance high-velocity movement result in generating more power, which transfers to starting ability and maximum velocity.

Specificity of training applies to plyometrics also. Sprinting is a horizontal movement and requires movement in the horizontal plane (25). The plyometric exercises that involve muscle velocities that closely resemble those of sprinting and emphasize forward motion with minimum vertical motion will have the greatest transfer to sprinting ability (25). Exercises such as alternate leg bounding, double- and single-leg hops, hurdle hops, and sandpit jumps have the greatest ability to transfer to performance (11).

Plyometrics place a large amount of strain on the body, and a high-frequency training plan may push the body beyond its limit; thus, a solid base of weight training is recommended before starting a plyometric training program (15). It is suggested that an athlete be able to leg press 2.0–2.5 times or back squat 1.5 times his or her body weight before starting lower-body plyometrics and be capable of doing 5 consecutive clapping push-ups or bench press 1.0 times his or her body weight before starting upper-body plyometrics (23,14).

TRAINING RECOMMENDATIONS

Speed involves 2 components–stride length and stride frequency. Resisted sprinting is used to improve stride length, and assisted sprinting is used to improve stride frequency. Weight training and plyometric training can improve power, which is necessary for acceleration and enhancing stride length. Sport-specific exercises result in the best transfer, and sprint-specific movements lead to the greatest improvement. For example, a combination of sprint and plyometric exercises results in a specific replication of the dynamic movements involved in sprinting, which leads to an improved sprinting velocity (25).

The information presented for assisted and resisted sprinting, strength training, and plyometrics gives the coach or practitioner some insight and knowledge about appropriate methods to enhance speed in his or her athletes. There is no one best method as sprint training programs that use a combination of modalities have been shown to increase running velocity by 7–8%

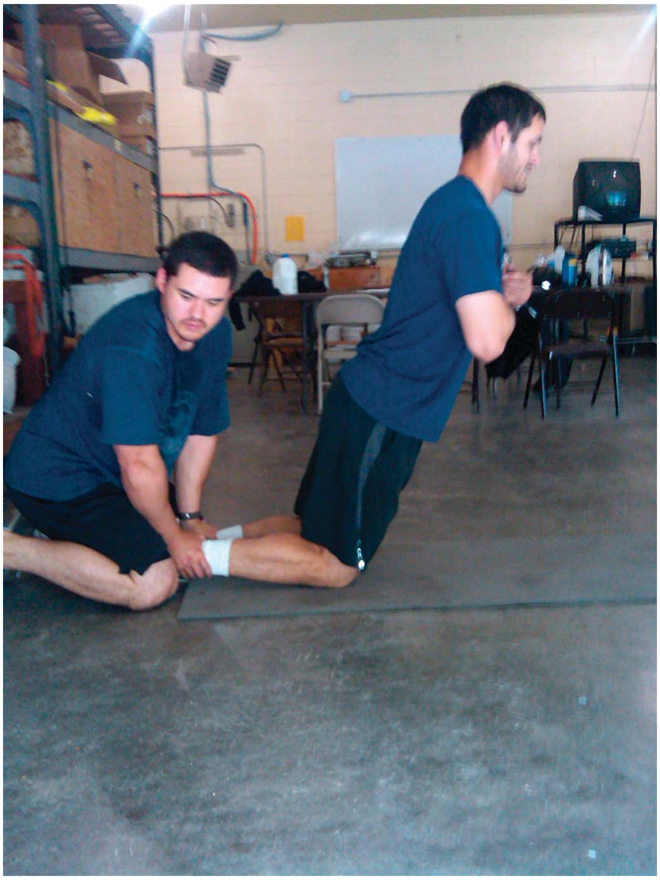

Figure. Hamstring dip (Norwegian hamstrings).

Table Sample resistance training program				
	Week 1	**Week 2**	**Week 3**	**Week 4**
Monday				
Power clean	5 × 4 at 80% 1RM	5 × 3 at 85% 1RM	5 × 3 at 90% 1RM	5 × 2 at 95% 1RM
Front lunge	3 × 10	3 × 10	3 × 8	3 × 8
Reverse hyperextensions	3 × 10	3 × 10	3 × 8	3 × 8
Incline flyes	3 × 10	3 × 10	3 × 8	3 × 8
Chin-ups	3 × maximum	3 × maximum	3 × maximum	3 × maximum
Front delt raise	3 × 10	3 × 10	3 × 8	3 × 8
Front and side planks	2 × 45 s	2 × 45 s	2 × 60 s	2 × 60 s
Wednesday				
Jump squat	4 × 5	4 × 5	4 × 5	4 × 5
Hang clean and jerk	4 × 6	4 × 6	4 × 4	4 × 4
Romanian deadlift	4 × 8	4 × 8	4 × 6	4 × 6
Dumbbell bench press	3 × 12	3 × 12	3 × 8	3 × 8
Barbell row	3 × 12	3 × 12	3 × 8	3 × 8
V-ups	2 × 15	2 × 15	2 × 20	2 × 20
Friday				
Back squat	5 × 4 at 80% 1RM	5 × 3 at 85% 1RM	5 × 3 at 90% 1RM	5 × 2 at 95% 1RM
Norwegian hamstrings	3 × 10	3 × 10	3 × 10	3 × 10
4-way hip	3 × 10	3 × 10	3 × 10	3 × 10
Incline press	3 × 12	3 × 12	3 × 8	3 × 8
Seated row	3 × 12	3 × 12	3 × 8	3 × 8
Posterior deltoid raise	3 × 10	3 × 10	3 × 8	3 × 8
Weighted sit-ups	2 × 15	2 × 15	2 × 10	2 × 10

RM = repetition maximum.

compared with 4–5.5% for sprint training alone (25).

Because most sports are played on a level playing field, resisted sled training and assisted towing would be the most sport-specific training methods to improve sprint speed. Both methods are performed on a flat surface where sprint form should remain the same if all guidelines for each method are followed. The problems with uphill and downhill sprinting are the discrepancies in selecting and the availability of the optimum slope that should be used. Also, it is difficult to find the proper slope with a suitable training surface. The kinematics of uphill and downhill sprinting are also different compared with sprinting on level ground. High-speed treadmill training has been demonstrated as an effective method; however, research has shown that there may also be changes in kinematics. In addition, there may be a difference in kinetics because the ground is moving and the athlete does not have to propel himself or herself.

For strength training, the musculature around the hips and the hamstrings is the most important for developing speed. Increased strength levels do allow for greater force production; however, evidence has shown that a combination of high-resistance low-velocity and low-resistance high-velocity movements results in the greatest increases in sprint speed (27). Also, explosive weightlifting exercises which are high-resistance high-velocity movements result in increases in sprint speed. The use of all 3 training techniques can ultimately produce the best enhancement of sprint speed. The use of standard resistance exercises can build a base of strength, and weightlifting will develop the power needed for sprinting and starting ability, and low-resistance high-velocity movements can produce power and speed, which transfer to performance. For example, a sprinter can include back squat for strength, hang clean for power, and weighted squat jumps to improve power and velocity. But the hamstrings should also be emphasized; therefore, exercises such as Romanian deadlift, Norwegian hamstring, and reverse hyperextensions should be included.

The use of plyometric exercises has been shown to improve speed, especially the ability to accelerate. The plyometric exercises prescribed must be specific in nature and should involve movements that produce horizontal power. The use of alternate leg bounding, single leg bounding, single- and double-leg hops, and hurdle jumps all have horizontal components that are sport specific to maximal sprint speed. These exercises are of low resistance high velocity and reflect the type of training needed for improving sprint speed. Plyometrics coupled with strength and power training can produce the best training result.

CONCLUSION

To maximally enhance speed, coaches should use variations of all the techniques discussed here: resisted and assisted towing, strength and high-velocity power training, and plyometrics that focus on horizontal movements. It is important to use and incorporate these methods and exercises in a sport-specific program.

Most methods of speed development have been shown to improve speed. As more research is done and technology is improved, newer and improved methods may be developed, and as athletes continue to become faster, we may see speeds not yet measured.

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