THE NEED FOR SPEED—IMPROVING SPRINTING PERFORMANCE IN FOOTBALL PLAYERS

KEN CLARK, PHD, CSCS

INTRODUCTION

It has been said many times that "football is a game of inches," and now more than ever, football is a game of speed. With recent rule changes that favor wide open offensive attacks, such as increased protection of quarterbacks and wide receivers, and the proliferation of spread offenses and nickel defenses from the high school level through the professional ranks, fast athletes are more valuable than ever. Therefore, coaches are increasingly searching for the best methods to improve the speed of their individual athletes and their entire team. This article will review several aspects of sprint mechanics and training to enhance linear (straight-ahead) speed for football players.

First, a needs analysis of football game speed will be covered, to serve as the foundation for speed training protocols. Second, an examination of both acceleration and maximal velocity sprinting will be reviewed, including a review of the underlying biomechanical factors, and effective methods to increase performance. Finally, strategies for implementing speed training will be discussed, so that the reader can apply the concepts being presented in this article (agility and fitness/conditioning will not be discussed, as those topics are outside the scope of this article).

NEEDS ANALYSIS OF FOOTBALL SPEED

To better understand the best methods for improving linear speed for football players, the physiological and movement demands of game play must be understood. Across all levels of football (high school to college to the National Football League [NFL]), the average play from scrimmage lasts approximately 5 – 6 s (21). With regards to special teams plays, the typical punt lasts approximately 9 – 10 s and the typical kickoff lasts 8 – 11 s, depending on the level of play (21). There are approximately 6 – 8 plays per series and between 11 – 14 series per game, with an average of about 31 – 35 s between plays (13,21). Therefore, given a work-to-rest ratio that is close to 1-to-6 for football players at all levels, the energetic demands of football are highly anaerobic in nature (13,21).

The speed and distance covered per play obviously differs depending on position, success of the play, and position on the field. For example, recent Global Positioning System (GPS) data from a National Collegiate Athletic Association (NCAA) Division I team has shown that there are differences between positions for the number of sprints per game and the distance covered while sprinting (28). Skill positions (wide receivers and offensive/defensive backs) complete more high-speed sprints and sprint for longer distances than "big skill" positions (e.g., quarterbacks, tight ends, and linebackers), who in turn complete more high-speed sprints and sprint for longer distances than offensive and defensive lineman (28). Although nearly all players have to execute some form of acceleration on almost every play, most players will rarely approach maximal velocity in a game situation. Given this context, one interesting consideration is the amount of time that should be spent training for acceleration versus maximal velocity. Certainly, acceleration is of paramount importance to on-field performance, and must be trained on a regular basis.

However, although players may infrequently reach maximal velocity, it is indeed a factor in many game-breaking plays. In fact, recent in-game statistics demonstrate that wide receivers and offensive/defensive backs may reach peak velocities of greater than 10.0 m•s-1 (greater than 23 mph) during longer plays (26). Additionally, recent research has shown that maximal velocity is highly correlated with short sprint performance, and may serve as an upper limit to acceleration performance (9). Therefore, improving maximal velocity may indirectly improve acceleration, and thus may be warranted for all positions, although the total volume and training time devoted to maximal velocity sprinting should be less for lineman than for skill and big skill positions.

ACCELERATION

BIOMECHANICS OF ACCELERATION

To accelerate effectively, Newton's laws dictate that an athlete must satisfy two requirements. First, enough vertical force must be applied down into the ground to support and rebound the body upwards into the next step (7). Second, force must be applied backwards, as the horizontal action-reaction forces will propel the body forwards (7). Recent research has shown that athletes who apply more horizontal force in relation to body mass demonstrate greater acceleration performance (14,17,20). From a technique standpoint, this can be accomplished with an aggressive forward body lean, piston-like leg action, and a stiff ground contact on the ball of the foot. The foot should aim to strike underneath the hips, and not in front of the center of mass. The thighs should execute powerful scissor-like flexion and extension through big ranges of motion, with equally forceful arm drive originating from the shoulder joint. Excessive air time should be avoided during the beginning of a sprint, as increases in speed can only occur when the athlete is pushing into the ground. As opposed to maximal velocity sprinting, acceleration typically occurs with relatively flexed hip and knee angles, and muscle actions that have a large concentric component (4). Table 1 lists a technical checklist for both acceleration and maximal velocity.

TRAINING TO IMPROVE ACCELERATION

A number of training strategies have been shown to improve acceleration, including general methods (e.g., strength, power, and plyometric training), specific methods (e.g., sprinting with and without resistance), and combinations of both (22). As previously mentioned, force application is a key determinant of sprinting performance. Therefore, the goal of general training methods should be to increase the amount of force that can be generated and transmitted to the ground. It is important to note that due to Newton's Second Law (force = mass • acceleration or force ÷ mass = acceleration), an athlete's strength relative to body weight (relative strength) is a key factor in speed improvement. Prior research has demonstrated the relationship between relative strength and speed (24). Furthermore, although increasing lower body relative strength does not necessarily guarantee that an athlete will get faster, recent evidence suggests that there is a large transference from increases in relative strength improvements in speed (23).

With respect to strength and power training exercise selection, it may be logical to focus on closed-kinetic chain, multi-joint exercises that span the force-velocity curve. The force-velocity curve indicates that lighter loads can be moved at faster speeds while heavier loads are moved at slower speeds. Therefore, exercises that span this curve could include heavier load, slower velocity exercises such as the full squat and deadlift, and relatively lighter load and higher velocity movements like the Olympic-style lifts and derivatives to improve power (3,25). These exercises are similar to acceleration in that they work through large ranges of motion at the hip/knee/ankle joints and contain a forceful concentric phase to the lift.

With regards to plyometrics, utilizing both vertically- and horizontally-based exercises may be optimal, as this matches the force demands of initial acceleration (15). Therefore, examples of plyometrics aimed at improving acceleration include broad jumps, power skips for distance, and alternate leg sprint bounding. These plyometrics exercises are excellent for improving the acceleration phase of sprinting because they emphasize triple extension through the hip, knee, and ankle while projecting the body up and out, similar to the first few steps in a sprint.

Specific training for improving acceleration can include technical drills and both unresisted and resisted runs. Technical drills can include the wall drill series, which provides the athlete with context for the proper body angles and leg mechanics during acceleration. During these drills, the athlete leans in to a wall at approximately a 45 – 60° angle and executes powerful flexion-extension at the hip while maintaining proper posture from the stance foot through the hips and torso (Figure 1). Partner-resisted marches and skips using a torso-harness can also be effective to help the athlete learn to hold the body in an aggressive forward lean while striking down and back underneath the hips.

Because of the multi-directional nature of football, a variety of starting stances and starts should be utilized with regards to unassisted sprints. These variations can include two-point, three-point, prone, lateral facing, and rolling starts (where the athlete transitions from a jog to a sprint). Partner competitions or chase drills are also excellent for developing acceleration, and can include an "offense versus defense" reactive element which matches the demands of the game (see drill diagrams in Figures 3 and 4).

With regards to resisted sprinting, several different modes may be utilized. Uphill sprints are commonly employed as this appears to share biomechanical similarities to acceleration, and research has demonstrated that training on an incline sprint treadmill can improve acceleration performance (11,18). Additionally, over the last decade, resisted sprints via sled pulling (Figure 2) has become an increasingly popular form of training to enhance acceleration performance (19). Interestingly, recent research indicates that the training effects of resisted sprinting may be optimized with very heavy sled-pulling, incorporating sled loads of 10 – 40% bodyweight, with some researchers suggesting that a load equivalent to about 80% bodyweight may be ideal (10,19). Although more research is required to conclusively determine the ideal resisted sprint load for specific populations, it appears that resisted sprinting is generally as effective as or more effective than unresisted sprinting for improving acceleration (19).

MAXIMAL VELOCITY

BIOMECHANICS OF MAXIMAL VELOCITY

As top speed is approached, the body becomes upright, and most of the force is applied straight down into the ground. Furthermore, as running speeds increase, the amount of time the foot is on the ground decreases. Therefore, research has shown that runners with faster maximal velocities can apply more vertical force (relative to body mass) in shorter ground contact times than slower runners (6,29,30). From a technique standpoint, this can be accomplished in the following manner. The entire body posture should be upright with a neutral pelvis (hips pointed forward, not down). Once the foot toes off the ground, the thigh should not swing too far back behind the body, but rather should immediately swing forward in front of the body into a high knee-lift position. From this position, the foot should attack the ground, aiming to strike underneath the body. Ground contact should occur on the ball of the foot, and the entire body should be stiff and not collapse during ground contact (i.e., minimal compression of the center of mass during contact) (6,16). If this technical checklist can be accomplished, the athlete will deliver large amounts of vertical force into the ground in a short contact time, and maximal velocity can be optimized (6,8). Table 1 lists a technical checklist for both acceleration and maximal velocity.

TRAINING TO IMPROVE MAXIMAL VELOCITY

As with acceleration, a number of training strategies have been shown to improve maximal velocity, including both general methods and specific methods (21). For general training methods, the goal is again to improve force application in relation to bodyweight. However, because force application during top speed running may be more dependent on leg swing mechanics and stiffness upon ground contact as opposed to pure "weight room strength," resistance training for maximal velocity should reflect this (6,8). Exercise selection should include movements that incorporate eccentric muscle actions to match the initial force absorption portion of the ground contact phase. Also, because the posterior chain is important in high-speed running, including exercises such as the Romanian deadlift, one-leg Romanian deadlift, and other versions of straight-leg hip extensions may be especially important for maximal velocity development (3,12). Furthermore, to help prevent hamstring strains during high-speed running, coaches may want to incorporate exercises such as the eccentric Nordic hamstring curl (1). Plyometrics for this phase of sprinting should emphasize relatively shorter ground contact times and stiff ground contact mechanics. Therefore, depending on the level of athlete, simple but effective plyometrics for improving maximal velocity include in-place pogo jumps, one- and two-leg mini-hurdle jumps, and forward one-leg hops.

Specific training for enhancing maximal velocity include technical drills such as step-overs, straight-leg bounding, and mini-hurdle "wicket" runs (Figure 5) (30). Simply sprinting at maximal or near-maximal velocity may also elicit improvements, especially in populations of developmental athletes (5). Maximal velocity sprinting can include several types of drills, including flying sprints, technical build-ups, and sprint-float-sprints. Flying sprints consist of a gradual acceleration of 20 – 30 yd followed by a maximal velocity zone of 10 – 20 yd (Figure 6). Technical build-ups are similar to flying sprints with the addition that the coach provides the athlete with one technical cue to focus on for the duration of the sprint; typically, this cue is related to posture, leg swing mechanics, and/or ground contact. Sprint-float-sprints may extend slightly longer than 40 yd, and can help add short speed endurance to maximal velocity development. These typically consist of a gradual acceleration to approach maximal velocity from 30 – 40 yd, a 10-yard "float" zone from 40 – 50 yd, where the athlete runs at approximately 90% top speed while staying relaxed and focusing on correct mechanics, and then a re-acceleration to run at top speed for another 10 yd from 50 – 60 yd (Figure 7).

IMPLEMENTING SPEED TRAINING

There are several important considerations when designing speed development programs. First, the amount of time available to develop linear speed during the off-season, pre-season, or in-season is highly dependent on the level of play, the rules of the governing body, and the amount of training time allotted toward other physical capacities (e.g., strength, agility, conditioning, etc.). For the purposes of simplicity, this article will present an example program appropriate for an upper level high school or collegiate athlete who is completing speed training during the winter months prior to spring football, or during the summer months leading up to the season. A sample six-week training program is listed in Table 2, with two total hours per week devoted to linear speed training, one day focused on acceleration, and the other day focused on maximal velocity development. This example program assumes the athlete has already completed a dynamic warm-up, and does not include programming for general strength, agility, or fitness as these are outside the scope of this article.

The second important consideration relates to rest time between sprints. Regardless of whether acceleration or maximal velocity training is being performed, it is critical that the emphasis is on full recovery between sprints. Coaches should avoid the urge to rush recovery times and perform maximal effort sprints on incomplete rest, as this may be detrimental to performance since athletes may practice incorrect mechanics when fatigued (2). A good rule of thumb for recovery times is one minute rest for every 10 yd run, or one minute rest for every one second of work. Thus, the rest times should be 1 – 2 min for unassisted acceleration sprints, 2 – 3 min for resisted acceleration sprints, and 3 – 5 min for maximal velocity sprints. The emphasis for both acceleration and maximal velocity training should be low volumes of high quality sprints. With regard to plyometric volume for speed development, although about 80 total ground contacts per session may optimize speed improvement, this number must be carefully considered in context with the other loading demands on the athlete, and fewer ground contacts per session may be warranted (27).

SUMMARY

With enhanced team speed a constant priority, coaches who can conduct effective speed training programs are at a distinct advantage. Although acceleration is the primary form of linear speed demonstrated in football games, it may be worthwhile to address both acceleration and maximal velocity training. Through small volumes of high-intensity sprint efforts, executed with proper technique, athletes should demonstrate enhanced sprinting performance over time. It is hoped that this article provides the foundation for coaches to design and implement their own speed training.

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ABOUT THE AUTHOR

Ken Clark is an Assistant Professor in the Department of Kinesiology at West Chester University, where he teaches classes in biomechanics and motor learning. Clark's research focuses on the mechanical factors underlying athletic performance and injury mechanisms. In addition to teaching and conducting research, Clark has over a decade of experience as a strength and conditioning coach. He has coached in the private sector, at the high school level, and in the collegiate setting. Clark's interest in speed development for football began during his playing days, where he was a two-time All-Centennial Conference running back for Swarthmore College from 1999 – 2000.

FIGURE 1. WALL DRILL

Example of a wall drill. The athlete leans into the wall at about a 45 – 60° angle and executes a series of drills aimed at providing context for the posture, body angles, and leg mechanics necessary for proper acceleration mechanics. Examples of these wall drills include marches, runs, and single- or double-exchanges.

FIGURE 2. RESISTED SPRINTING

Resisted sprint training using a weighted sled. The resistance allows the athlete to maintain an aggressive lean while striking underneath the body with a forceful ground contact.

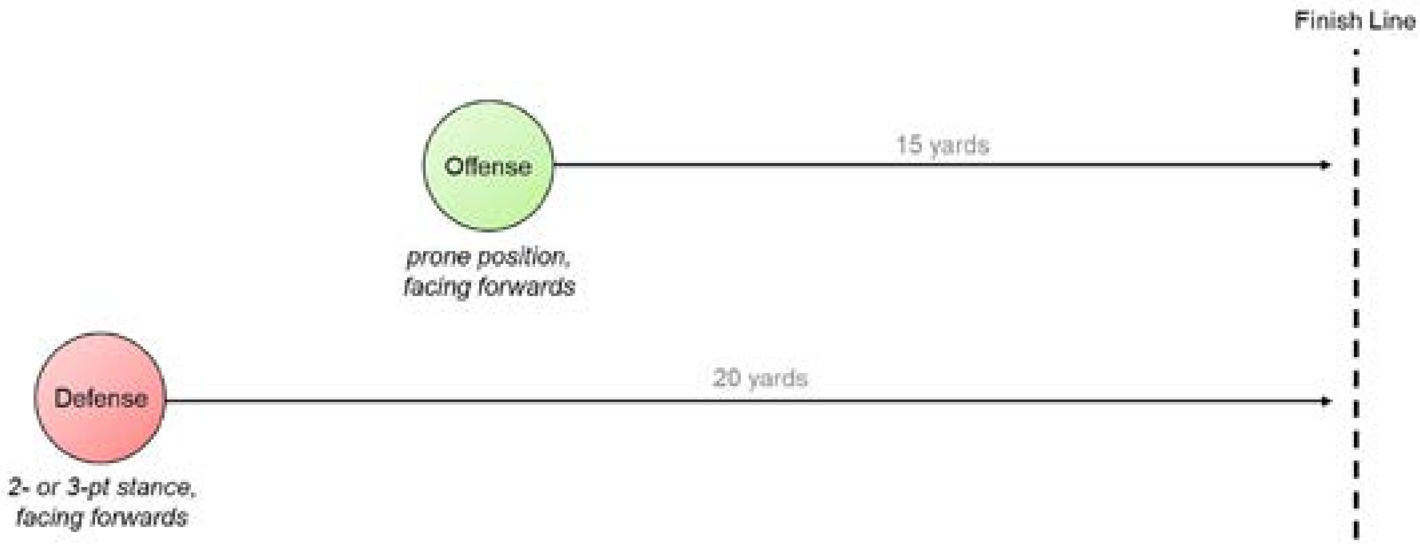

FIGURE 3. OFFENSE-DEFENSE ACCELERATION DRILL—VERSION A

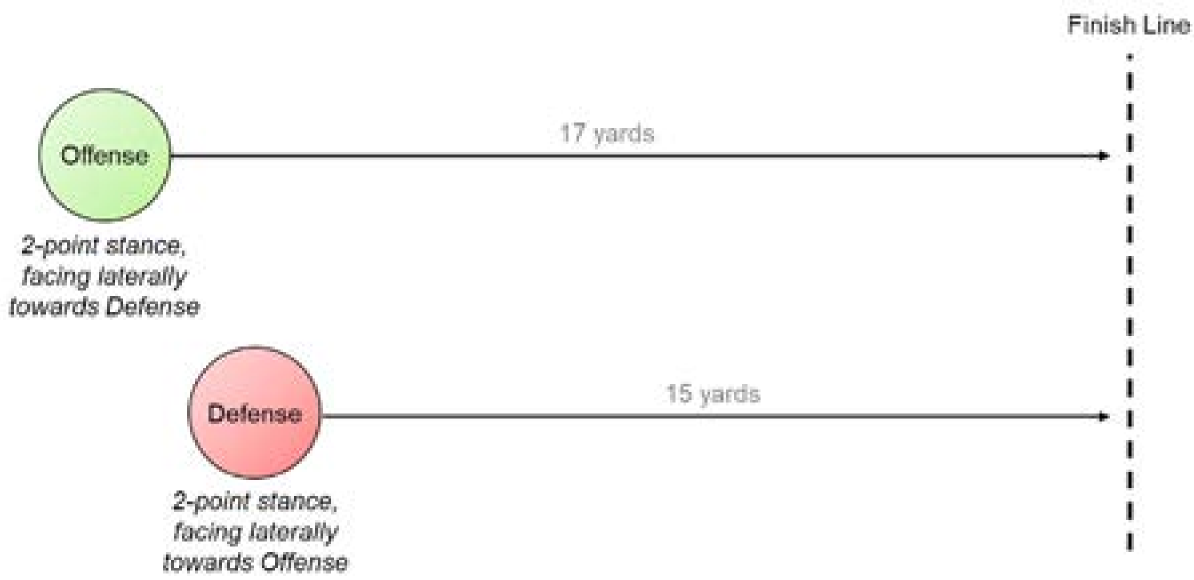

FIGURE 4. OFFENSE-DEFENSE ACCELERATION DRILL—VERSION B

There are two versions of offense-defense competition drills to develop acceleration. (A) The offensive player starts in a prone position, 15 yards from the finish line. The defensive player starts in a two- or three-point stance, 20 yd from the finish line. The offensive player initiates the start whenever he wants and pushes up to sprint, at which point the defensive player reacts and sprints. Both players race through the finish line. (B) The offensive player starts in a lateral position, 17 yd from the finish line (two yards behind the defensive player). The defensive player starts in a lateral position, 15 yd from the finish line. The offensive player initiates the start whenever he wants, at which point the defensive player reacts and sprints. Both players race through the finish line.

FIGURE 5. WICKET DRILL

The mini-hurdle "wicket" drill utilized to improve top speed mechanics. Athletes sprint over a series of six-inch hurdles at measured places on the track or turf. The faster or taller the athlete, the longer the spacing between the mini-hurdles. The mini-hurdles serve as environmental cues to ensure upright posture, minimal backside thigh swing, and powerful knee lift.

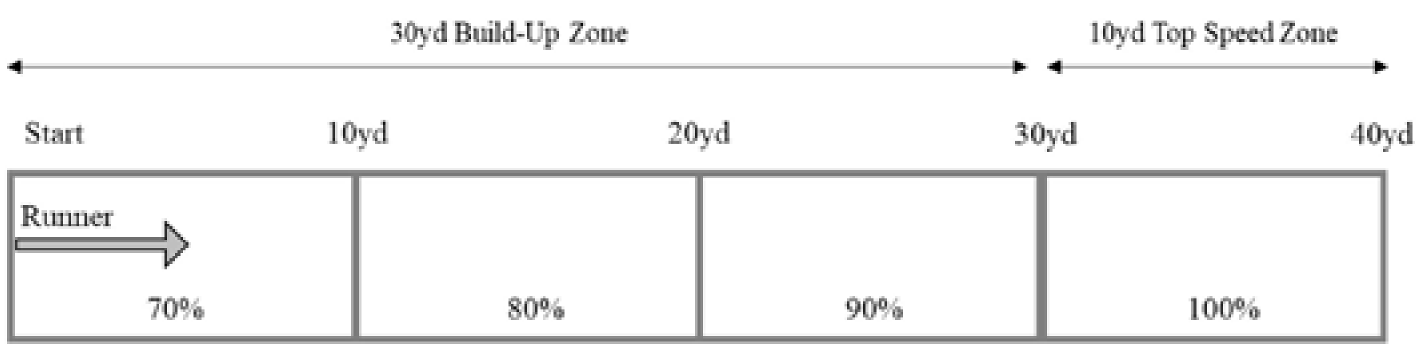

FIGURE 6. FLY DRILL

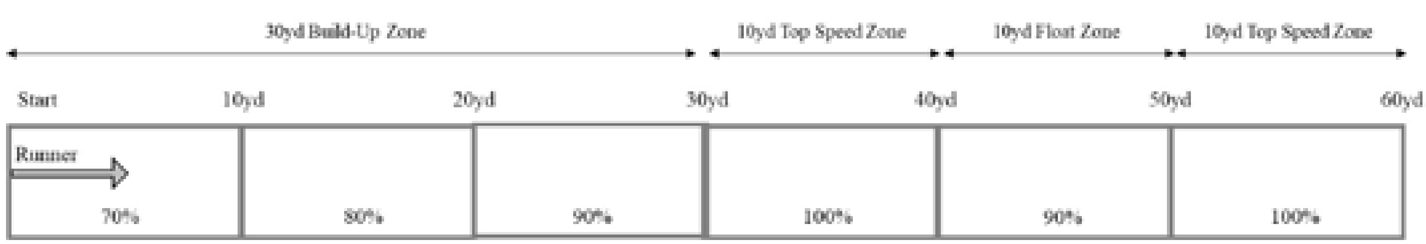

FIGURE 7. SPRINT-FLOAT-SPRINT DRILL

These are two types of drills to enhance top speed. (A) The 10-yd fly drill: the athlete begins in a two-point starting stance and gradually accelerates from 0 – 30 yd. From the 30 – 40 yd, the athlete sprints at top speed with proper mechanics. These trials may be timed with an automatic timing system for an easy method of monitoring improvements in top speed. (B) The sprint-float-sprint drill: the athlete begins in a two-point starting stance and gradually accelerates from 0 – 30 yd. The athlete sprints maximally from 30 – 40 yd, relaxes and sprints at about 90% from 40 – 50 yd, and then reaccelerates to sprint maximally from 50 – 60 yd.

TABLE 1. COACHING TECHNIQUE CHECKLIST FOR BOTH ACCELERATION AND MAXIMAL VELOCITY SPRINTING

	ACCELERATION	MAXIMAL VELOCITY
Posture and Hips	Leaning forward, with straight line from shoulder to hip to knee to foot	Trunk upright with minimal lean and hips pointed forward
Arm Drive	Big sweeping drive that originates from the shoulder; minimize excessive cross-body arm-swing	Slightly smaller range of motion than acceleration, but arm drive is still powerful and originates from shoulder
Leg Mechanics	Piston-like with thighs executing powerful scissor action (flexion-extension)	More circular; minimize thigh swing behind torso and maximize thigh lift in front of torso
Ground Contact	Stiff strike on ball of foot, contacting ground underneath hips	Attack the ground, stiff strike on ball of foot, aim to contact under hips

TABLE 2. EXAMPLE SIX-WEEK TRAINING PROGRAM FOR DEVELOPING LINEAR SPEED FOR A HIGH SCHOOL OR COLLEGIATE ATHLETE WHO PLAYS A SKILL OR BIG SKILL POSITION

DAY	WORKOUT SEGMENT	WEEK 1	WEEK 2	WEEK 3
Day 1 Acceleration	**Plyometrics**	Single broad jumps 4 x 6 Power skips 4 x 20 yd	Single broad jumps 4 x 6 Power skips 4 x 20 yd	Single broad jumps 4 x 6 Power skips 4 x 20 yd
	Technical drills	Wall drill one-leg (Figure 1) 2 x 5 reps on each leg Partner harness march 2 x 10 yd	Wall one-leg flexion 2 x 5 reps each leg Partner harness march 2 x 10 yd	Wall march 2 x 5 reps on each leg Partner harness skip 2 x 10 yd
	Resisted sprints	Sled pull (Figure 2) with 20% bodyweight 6 x 10 yd	Sled pull with 20% bodyweight 6 x 15 yd	Sled pull with 30% bodyweight 6 x 10 yd
	Reactive or competitive	Partner races from various start positions 4 x 15 yd	Partner off/defense chase drill (Figure 3) 4 reps	Partner off/defense chase drill (Figure 4) 4 reps
Day 2 Max Velocity	**Plyometrics**	Two-leg pogo jumps 4 sets x 6 reps Two-leg forward mini-hurdle jumps 4 sets x 6 reps	Two-leg pogo jumps 4 sets x 6 reps Two-leg forward mini-hurdle jumps 4 sets x 6 reps	One-leg pogo hops 2 sets x 6 reps each leg One-leg forward mini-hurdle hops 2 x 6 reps each leg
	Technical drills	Step-over knee drill 2 x 15 yd Straight-leg run 2 x 15 yd	Step-over knee drill 2 x 20 yd Straight-leg run 2 x 20 yd	Wicket runs (Figure 5) 3 x 9 mini-hurdles (or 20 yd)
	Fly sprints	10-yd with 30-yd build-up (Figure 6) 3 reps	10-yd fly sprint with 30-yd build-up, 3 reps	20-yard fly sprint with 30-yd build-up, 3 reps

Note: Day one is focused on acceleration development and day two is focused on maximal velocity development. Training exercises and volumes may need to be adjusted/individualized based on the athlete and position.

TABLE 2 (CONTINUED). EXAMPLE SIX-WEEK TRAINING PROGRAM FOR DEVELOPING LINEAR SPEED FOR A HIGH SCHOOL OR COLLEGIATE ATHLETE WHO PLAYS A SKILL OR BIG SKILL POSITION

DAY	WORKOUT SEGMENT	WEEK 4	WEEK 5	WEEK 6
Day 1 Acceleration	**Plyometrics**	Repeat broad jump, 4 x 6 Sprint bounds 4 x 20 yd	Repeat broad jump 4 x 6 Sprint bounds 4 x 20 yd	Repeat broad jump 4 x 6 Sprint bounds 4 x 20 yd
	Technical drills	Wall march 2 x 5 reps each leg Partner harness skip 2 x 10 yd	Wall single exchange 2 x 5 reps each leg Partner harness sprint 2 x 10 yd	Wall single exchange 2 x 5 reps each leg Partner harness sprint 2 x 10 yd
	Resisted sprints	Sled pull with 30% bodyweight 6 x 15 yd	Sled pull with 40% bodyweight 6 x 10 yd	Sled pull with 40% bodyweight 6 x 15 yd
	Reactive or competitive	Partner races from various start positions 6 x 15 yd	Partner off/defense chase drill (Figure 3) 6 reps	Partner off/defense chase drill (Figure 4) 6 reps
Day 2 Max Velocity	**Plyometrics**	One-leg pogo hops 2 sets x 6 reps each leg One-leg forward mini-hurdle hops 2 x 6 reps each leg	One-leg pogo hops 2 sets x 6 reps each leg One-leg forward mini-hurdle hops 2 x 6 reps each leg	One-leg pogo hops 2 sets x 6 reps each leg One-leg forward mini-hurdle hops 2 x 6 reps each leg
	Technical drills	Wicket runs (Figure 5) 3 x 9 mini-hurdles (or 20 yd)	Wicket runs 3 x 12 mini-hurdles (or 25 yd)	Wicket runs 3 x 12 mini-hurdles (or 25 yd)
	Fly sprints	20-yd fly sprint with 30-yd build-up 3 reps	Sprint-float-sprint (Figure 7) 3 reps	Sprint-float-sprint (Figure 7) 3 reps

Note: Day one is focused on acceleration development and day two is focused on maximal velocity development. Training exercises and volumes may need to be adjusted/individualized based on the athlete and position.