Kicking Power

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SUMMARY

KICKING IS AN INTEGRAL MANEUVER IN MANY TEAM SPORTS. THERE ARE DIFFERENT TYPES OF KICKS SUCH AS THE INSTEP KICK, SIDE-FOOT KICK, AND DROP-PUNT KICK. BY EXAMINING THE DIFFERENT SEGMENTS OF A KICK, ONE CAN DETERMINE THE PROPERTIES THAT ALLOW FOR OPTIMAL PERFORMANCE. THE BASIC TENANTS OF KICKING PERFORMANCE INVOLVE ANGULAR VELOCITY OF THE HIP GENERATED THROUGH A STRETCH-SHORTENING CYCLE AND THE LINEAR VELOCITY OF THE FOOT IN COMBINATION WITH THE FORCE APPLIED TO THE BALL, WHICH DETERMINES KICKING POWER. THE STRENGTH AND CONDITIONING PROFESSIONAL CAN USE THIS INFORMATION TO DESIGN A TRAINING PROGRAM THAT OPTIMIZES KICKING PERFORMANCE.

INTRODUCTION

Kicking is an integral maneuver in many team sports such as soccer, Australian Rules football, rugby, and football. Kicking is an open-chain kinetic movement involving co-ordination and movement of the whole body. There are different types of kicks such as the instep kick, side-foot kick, and drop-punt kick. Each style of kick is utilized for a different objective (distance versus accuracy) and includes sequenced phases. By examining the different segments of a kick, one can determine the properties that allow for optimal performance. The basic tenants of kicking performance involve angular velocity of the hip generated through a stretch-shortening cycle (SSC) and the linear velocity of the foot in combination with the force applied to the ball, which determines kicking power (Figure 1). Kicking power then determines the velocity of the ball and in combination with the angle of projection determines the ball's flight path. The strength and conditioning professional can use this information to design a training program that optimizes kicking performance by optimizing the force applied to the ball at a given velocity during contact. This would include strength, power, plyometric (SSC), and speed training.

PHASES OF KICKING

Both the side-foot kick and instep kick occur in the following 5 phases: "preparation, backswing, limb cocking, acceleration, and follow-through" (see Supplemental Digital Content 1, http://links.lww.com/SCJ/A76, which overviews the 5 phases) (3). The preparation phase includes the approach to the ball and the planting of the support foot. Three-dimensional analysis has shown that skilled soccer players use an S-shaped path to the ball rather than a straightforward approach (40). The self-selected approach was found to be around a starting angle of 35–45° (16,19). The approach starts from 2 to 4 steps out with an approaching speed of 3–4 m/s (19). The player plants his/her support foot to the side and slightly behind the ball. The placement of the support foot can vary depending on the type of kick (30). During the backswing phase, the player extends the kicking-side hip to the desired range-of-motion. There is smaller backswing during the side-foot kick than the instep kick, mainly due to less power needing to be produced (28). However, side-foot kicking displays larger limb cocking. The limb-cocking phase starts when then the knee flexes to the desired maximal range-of-motion. The combination of hip extension and knee flexion is referred to as the "tension arc" (40) (see Supplemental Digital Content 2, http://links.lww.com/SCJ/A77, which shows the preparation and limb-cocking phases). When the leg starts to move forward, it is considered the acceleration phase or "fast release of tension." This fast release of tension is described as a whip-like movement where the proximal segment, the thigh, reaches its maximal velocity before the distal segment, the lower leg (14,46). Contact time is a brief time, only about 10 m/s, when the foot makes contact with the ball (19). Previous studies without extremely high-speed videography have been limited in examining variables related to the contact time due to the short time frame. After the ball leaves the foot, the follow-through phase begins. The leg continues to accelerate and then quickly decelerates. The duration of the follow-through phase depends on the type of kick, where a side-foot kick for short passing may result in a shorter phase, whereas an instep kick for a powerful shot may take longer. Many

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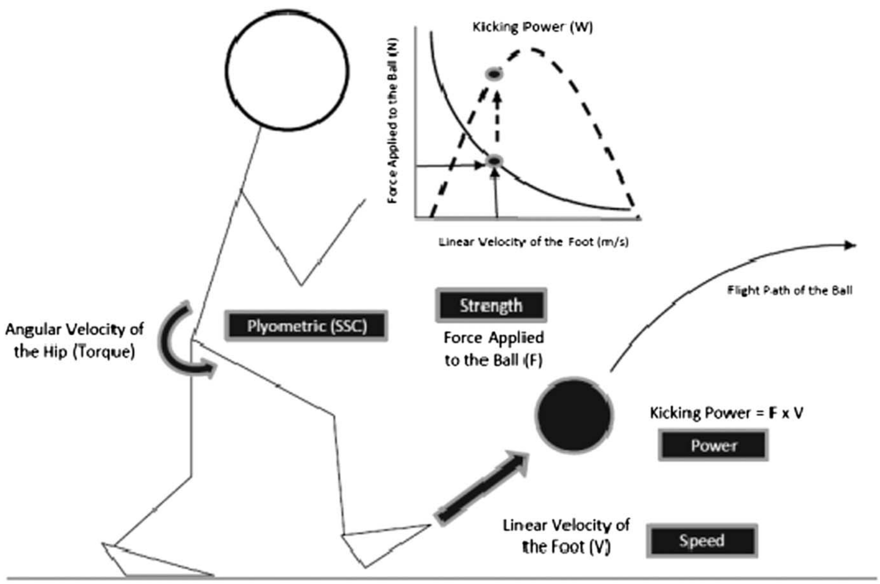

Figure 1. Components of kicking power (strength, power, speed, and plyometrics [SSC]). SSC = stretch-shortening cycle.

coaches try to tell their players to "kick through the ball" to ensure they perform a proper follow-through (see Supplemental Digital Content 3, http://links.lww.com/SCJ/A78, which shows the acceleration and follow-through phases).

SIDE-FOOT KICK VERSUS INSTEP KICK

The side-foot kick is mainly used in soccer for passing the ball from one teammate to another but can be used for scoring as well. The side-foot kick is utilized for accuracy and short distance more than power, with the ball contacting the medial aspect of the foot (28,40). To make such contact, the leg has to externally rotate at the hip. In Kawamoto's investigation, experienced soccer players demonstrated ball speeds of 22.5–23.4 m/s from the side-foot kick (15). The instep kick is mainly used in soccer for shooting and passing longer distances. The instep kick creates a faster velocity of the ball, but accuracy is often sacrificed. The ball makes contact with the dorsal arch area of the foot although the ankle is in plantar flexion. Because contact is being made head-on, external rotation of the leg is not necessary as with the side-foot kick. Higher ball speeds of up to 35 m/s have been reported while using the instep kick (see Supplemental Digital Content 4 and 5, http://links.lww.com/SCJ/A79 and http://links.lww.com/SCJ/A80) (14–16,30).

DROP-PUNT KICK

The drop-punt kick is utilized in Australian Rules Football and football with the main objective being to cover maximal distance. Although similar mechanics to the side-foot kick and instep kick, the drop-punt kick incorporates 2 additionl phases of ball drop and support land (2). The player is initially holding the ball and drops the ball to make contact with it before hitting the ground. The foot speed at ball contact of the drop-punt kick in professional Australian Rules Football (~26.4 m/s) is similar to the foot speed for elite soccer players (25.6–28 m/s) (2).

OTHER FACTORS

As well as differences between styles of kicking, there are also variances in kicking between males and females and between experienced and inexperienced players. Movement of the upper body has been shown to be necessary though not thoroughly examined in the phases of kicking. When observing differences between males and females, there is a distinctive postural difference in the upper body (14,40). Males create more of a tension arc during the backswing phase, allowing for increased activity via the SSC. During contact with the ball, males were in a more upright position than females and followed through more than females (40). The reasons for these discrepancies are not fully understood but may be due to structural differences. Also, the biomechanics of kicking differ in experienced versus inexperienced players. As expected, experienced players have a significantly faster ball speed. Inexperienced players have less of an S-shaped approach in the preparation phase and a shorter tension arc in the backswing phase (15,19). It is theorized that the inexperienced players are inefficient at creating and transferring throughout the dynamic movement of kicking to generate a faster ball speed.

Training

Regardless of the style of kicking, the hip is the prime mover for the kick. When comparing power of the hip and knee during a kick, Lees et al. (19) discovered 113 J of power produced at the hip and only 5 J at the knee of the kicking leg. Furthermore, strong positive correlations have been shown between foot swing velocity and increased ball velocity (15,19). The angular component of force production around the hip has been reported to be approximately 168 Nm for experienced kickers in comparison to 94 Nm for inexperienced kickers (15). Therefore, to kick the ball with more velocity, foot velocity created during the acceleration phase generated by torque around the hip is critical. This would translate into the amount of force applied to the ball. Given the basic tenants of kicking performance variables, it is then clear that strength and conditioning coaches should focus on developing strength, power, and speed of the lower body musculature which would include plyometric training for optimal utilization of the SSC (Figure 2).

Strength

Gains in strength with training are optimized when utilizing loading at 80% or more of maximal one repetition strength (1RM) (33,36). From a cross-sectional perspective, strength has been positively correlated with sprint times in basketball players, softball players, track and field sprinters, sprint cyclists, and football players (5,23,27,35). In addition, strength has been positively correlated with luge start times, swimming sprint times, forward grinding performance in sailors, and club head velocity in golfers (8,31,32,44). In a longitudinal sense, strength gains with training have coincided with increased performance times in rowers, increased golf ball velocity at contact in golfers, and increased sprint velocity in handball players (1,10,11,17,18,41). Specific to soccer, strength has been associated with faster sprint times and increased single jump and 5 repeated jump height as a result of strength training (45). Thus, strength training is a vital component to improving power-related activities, which include kicking power.

Power

Power training, which typically involves weightlifting (clean and jerk, snatch) and ballistic movements (jump squats, medicine ball throws) has been associated with improvements in on-field performance as well. Loads that optimize power output in weightlifting are approximately 70% of 1RM, 0% of 1RM in jump squat, and 50% of 1RM in the squat (7). Power output has been positively correlated with rock climbing ability, sprinting ability, swimming starts, skating speed in ice hockey, and jumping performance (9,20,29,34,35,44). Power training has been shown to result in increased jumping performance, agility test times, and sprinting ability (6,23,24). Thus, incorporation of power training is most likely an important component of kicking ability.

Plyometrics

A major component of power activities is the SSC. All power activities have some SSC component to them. Plyometrics is a specific form of training utilized to optimize SSC performance. Plyometric drills are a viable exercise for development of power output and can be performed on the sports field. Campo et al (4) investigated the effects of plyometric training on elite female soccer players that consisted of hurdle jumps, drop jumps, and horizontal jumps for 12 weeks, 3 times a week. Both vertical jump height and kicking distance significantly increased after the plyometric training as compared with a control group. Rubley et al. (38) examined the effects of kicking distance from a low-impact low-frequency plyometric program on adolescent female soccer players. Players who incorporated the plyometric exercise were able to significantly increase their kicking distance from 25.9 ± 2.6 m to 33.0 ± 3.7 m as compared with a control group (38). Plyometric training has also been shown to increase kicking

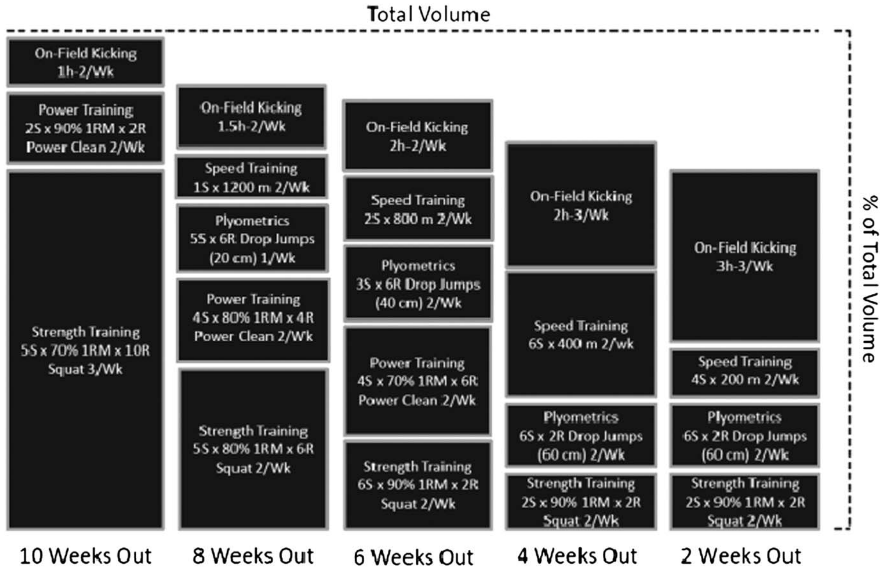

Figure 2. Preseason Training (R = Repetitions; S = Sets).

speed (39). Also, general running speed and jumping ability has been shown to increase in kicking-related sports with plyometric training (25,37).

Speed

This variable is obviously a concern for kicking activities as a kick involves a high rate of limb velocity (14,43). Sprint training has been shown to improve in a general sense the athletic performance (21,22). Soccer performance has been shown to improve with speed training (13), including soccer-specific 15-m sprint performance (26). Soccer 40-m top speed and repeated sprint speed has been shown to increase with speed training as well (42). In Australian Rules, football players' intermittent running speed was improved with repeated sprint training (12). Maximal linear velocity of the hip in kicking has been shown to be 5.5 m/s (14) similar to that in sprinting. Thus, any improvements in general sprinting ability is likely to coincide with kicking performance.

CONCLUSIONS

The kinematic and kinetic aspects of kicking power and thus kicking performance can obviously be improved through strength and conditioning, especially a periodized sequence of strength, power, plyometric (SSC), and speed training. Each component must be incorporated into a training program to maximize potential kicking ability.

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