

## CLINICAL COMMENTARY

## AN INTERVAL KICKING PROGRESSION FOR RETURN TO SOCCER FOLLOWING LOWER EXTREMITY INJURY

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## ABSTRACT

**Background and Purpose:** The majority of all soccer injuries affect the lower extremities. Regardless of whether the injured limb is an athlete's preferred kicking or stance leg, a lower extremity injury may affect their ability to impact the ball. Sport-specific biomechanical progressions to augment loading and gradually reintroduce a player to the demands of sport have been developed for upper extremity sports such as baseball, softball, tennis, and golf. Generalized return to soccer progressions have also been published in order to assist clinicians in safely returning athletes to sport; however, there are no specific progressions for the early stages of kicking designed to introduce stance leg loading and kicking leg impact. Thus, the purpose of this clinical commentary was to review the existing literature elucidating the biomechanics of kicking a soccer ball and propose a progressive kicking program to support clinicians in safely returning their soccer athletes to the demands of sport.

**Description of Topic:** The interval kicking program (IKP) describes clinical guidelines for readiness to begin a kicking program as well as possible readiness to return to sport measures. The program is performed on alternate days integrating therapeutic exercise and cardiovascular fitness. The IKP gradually introduces a player to the loading and impact of kicking. The progression increases kicking distance (using the markings of a soccer field as a guide), volume, and intensity and uses proposed soreness rules, effusion guidelines, and player feedback in order to assist clinicians in determining readiness for advancement through the stages. The IKP also recommends utility of specific tests and measures to determine readiness for return to sport.

**Discussion:** Gradual reintroduction to sport specific demands is essential for a safe return to soccer. This return to sport progression provides a framework integrating injury specific therapeutic exercise, cardiovascular fitness, and the return to kicking progression, to assist clinicians in initiating an athletes' return to soccer.

**Keywords:** Kicking, Lower Extremity Injury, Soccer

**Level Of Evidence:** Level 5

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## INTRODUCTION

Approximately 265 million people play soccer, making it the most popular sport in the world.<sup>1</sup> Unfortunately, the demands of the sport place the lower extremities at high risk for injury.<sup>2,3</sup> Sport-specific biomechanical progressions can augment loading, reducing the risk of re-injury as an athlete attempts to return to sport. Interval programs, integrated as part of a return to sports progression, gradually expose upper extremity athletes to the demands of their sports as they return to baseball, softball, golf, and tennis.<sup>4,6</sup> Similarly, interval running programs are also common, gradually reintroducing the biomechanical and cardiovascular demands of running.<sup>7,8</sup> However, to the authors' knowledge there are no published interval kicking programs to prepare soccer players for return to sport after sustaining a lower extremity injury. Therefore, the purpose of this clinical commentary was to examine the existing literature relevant to kicking in soccer and propose an interval kicking program (IKP) that can be used as a framework to return an athlete to kicking a soccer ball following lower extremity injury.

## INJURIES IN SOCCER

Injuries occur at a rate of 8.0 per 1000 player hours in European men's professional soccer for an average of two injuries per player per season,<sup>2,9</sup> which for a team of 25 players, translates to 50 injuries of varying severity per season, resulting in significant medical costs, diminished club performance, and lost playing time. Between 60-87% of soccer injuries involve the lower extremities.<sup>2,3,10</sup> The majority of injuries are acute or traumatic,<sup>11</sup> with chronic or reinjures accounting for only a small proportion of all injuries.<sup>3,10,12</sup> Approximately 57-80%<sup>2,9,11,12</sup> of injuries occur in matches, up to one quarter of these<sup>2,11,13</sup> stemming from foul play. These rates of injury are similar for amateur and youth players. Among youth players injury incidence increases with age, women between the ages of 15-19 having the highest incidence.<sup>14-16</sup> Goalkeepers at all levels have a lower injury incidence than field players.<sup>14,17-19</sup>

Studies examining soccer injury incidence indicate that injuries occur more frequently in games than in training sessions,<sup>2,3,10,11,13</sup> but some professional leagues have unique patterns of injury occurrence across a season. In European men's professional soccer, for

instance, injury occurrence increases both in the latter portion of the season and when game frequency increases.<sup>2,9,10</sup> Women's professional soccer in Germany shows a similar trend, with a higher overall number of injuries occurring in the second half of the season.<sup>13</sup> In contrast, injury occurrence in US men's professional soccer spikes twice, once early in the season and then again in mid to late season.<sup>19</sup>

Muscle strains account for 31% of all injuries in women's soccer,<sup>10</sup> and approximately 35% in men's soccer.<sup>2</sup> In men's soccer the risk of muscle injury increases with age,<sup>12,17,20</sup> history of injury,<sup>12</sup> and during the later portions of a game.<sup>20</sup> Injuries to the thigh region are the most common, with hamstrings strains accounting for 16% of all reported injuries.<sup>2,3,9</sup> The adductors are the next most commonly injured muscle group, followed by quadriceps and calf muscles.<sup>9</sup> Furthermore, patterns of injury occurrence vary by muscle group, with adductor strains stemming from overuse rather than trauma.<sup>20</sup> Quadriceps strains are more commonly seen on the kicking leg,<sup>20</sup> often occurring during preseason, in contrast to adductor and calf injuries which occur later in the season.<sup>12</sup> In European men's professional soccer, hamstrings injuries are sustained more commonly late in the season,<sup>20</sup> whereas in US men's professional soccer hamstrings injuries are reported more often early in the season.<sup>19</sup>

Ligament sprains make up a smaller portion of all injuries; 19.1% in women's soccer<sup>10</sup> and 18% in men's soccer.<sup>2</sup> In men's soccer the majority of these sprains occur at the ankle, representing 51% of all sprains and 6.9-7.5% of all injuries.<sup>3,9,10</sup> Knee sprains are less common than ankle sprains in both men's and women's soccer, though often more serious. In men's soccer, isolated medial collateral ligament (MCL) sprains are the most common knee ligamentous injury,<sup>2,9</sup> in contrast to women's soccer where anterior cruciate ligament (ACL) injuries are the most common. ACL injuries are a significant problem in women's soccer, with injuries in professional soccer occurring at a rate of 0.09 per 1000 playing hours<sup>10</sup> and between 0.1-0.31 per 1000 playing hours in amateur and collegiate soccer.<sup>14,21-24</sup> The risk of ACL injury for adolescent female players has been reported to be even higher, at 1.0 per 1000 playing hours.<sup>25</sup>

Lower extremity injuries may affect the kinematics of kicking, as the kicking leg requires adequate range of motion (ROM), muscle strength, and neuromuscular control in order to move through the kicking motion, in addition to having the stability to withstand and dissipate the impact force of striking a ball. The health of the stance leg is of equal importance, as its ROM, strength and neuromuscular control are essential to stabilizing the body throughout the kicking motion. Regardless of whether the injury involved the stance or the kicking limb, both limbs should be analyzed for pathokinematic patterns potentially involved in the development of the initial injury.

### OVERVIEW OF KICKING BIOMECHANICS

The three common kicking techniques in soccer are the instep kick, the curved kick (a variation of the instep kick which generates ball spin and a curved flight pattern of the ball), and the side-foot kick. During an instep kick (Figure 1b) a player strikes the

ball with the laces of the shoe, along the first metatarsal. In contrast, during a side-foot kick (Figure 1a) a player uses the medial side of the foot, striking the ball with the medial arch. Brophy et al describe five phases of kicking (Table 1 and Figure 2) that are proportionally the same duration for instep and side-foot kicking; however, instep kicks occur at a higher velocity.<sup>26</sup>

Other important soccer-specific techniques include dribbling, volleying, and juggling (for additional detail see Appendix 1). Dribbling is the use of numerous small touches of the ball with the foot/feet allowing a player to run with the ball at his or her feet. Players generally use the distal lateral dorsum of the foot to push the ball, though all surfaces of the foot can be used, especially when attempting to evade a defender. Volleying is a technique using the side or instep of the foot in order to strike a lofted or airborne ball. Juggling uses the feet, thighs, chest, head, and occasionally other body parts to



**Figure 1.** Example of Side-foot and Instep kick. a.) Side-foot kick: A kick using medial side of the foot, particularly the medial arch, to strike the ball. b.) Instep kick: A kick using the dorsum of the foot, particularly along the first metatarsal, to strike the ball. Both techniques can be used for short or long distance kicking, however the instep kick is more frequently used for long distances and/or higher speeds.



**Table 1.** *The Start and End Point of the Phases of Kicking*

	Phase	Start of phase*	End of phase*
1	Preparation	Heel strike	Toe-off
2	Backswing	Toe-off	Maximum hip extension
3	Leg Cocking	Maximum hip extension	Maximum knee flexion
4	Leg Acceleration	Maximum knee flexion	Ball contact
5	Follow Through	Ball contact	Heel strike

\*Events all occur on the kicking leg.

keep the ball in the air. Rarely used in games, juggling is commonly used to practice controlled and accurate touches of the ball. In addition to each of the aforementioned techniques, Goalkeepers use one additional technique which will not be covered in this paper, the drop-kick or punt. The drop-kick is similar to that used in Aussie Rules Football, rugby, or American football, though there are slight variations due to the shape of the ball.

Players often take two to four steps at an angle of 42-45°<sup>27,28</sup> leading up to a kick (with the last step being the longest, particularly for long-range kicks<sup>29,30</sup>) with their bodies inclining posteriorly and laterally towards the side of the support leg by 25° (Figure 2: Preparation).<sup>31</sup> This angle of approach coupled with the angle of the support leg facilitates a steeper swing plane for the kicking leg, allowing greater extension of the kicking leg at ball contact, thereby creating higher foot velocities and better ball contact, as well as a more stable support-leg position.<sup>32</sup>

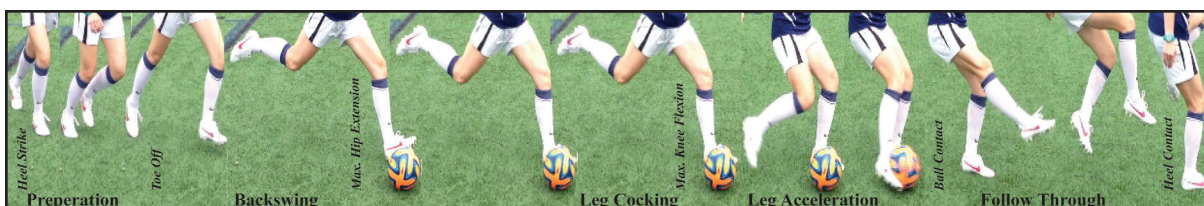
At backswing the arm of the support leg is abducted and gradually adducts as the body moves through leg cocking and leg acceleration (Figure 2: Backswing). The trunk also rotates in preparation for the kick, returning to neutral as the athlete progresses towards the ball.<sup>33</sup> Elevation of the arm has been hypothesized as a technique for providing a

counterbalance to stabilize the body or for creating an arc of tension to use potential energy. The arc is created by increased tension from abduction of the arm, rotation of the trunk, and extension of the hip in backswing. Through a stretch shortening cycle potential energy is converted as the leg swings forward and arm adducts.<sup>32,33</sup> Skilled players use a greater hip and arm range of motion, allowing them to create greater ball speeds without expending additional energy.<sup>33</sup>

Pelvic protraction and posterior tilting occurs as the body progresses towards ball contact. During backswing, the pelvis of the kicking leg begins lowered relative to the support leg and rises to a position superior to the support leg at ball contact facilitating greater knee extension of the kicking leg, greater foot speed (Figure 2: Backswing, Leg Cocking, Leg Acceleration),<sup>32,34</sup> and avoidance of catching the toes on the ground.<sup>35</sup> Brophy et al report that women have significantly more hip adduction on the support leg than men, particularly during backswing, leg cocking, and leg acceleration; however, overall pelvic obliquity remains the same.<sup>36</sup>

At the beginning of backswing, the support leg knee is flexed at approximately 26° and continues flexing until ball contact in order to absorb the force of landing and provide stability (Figure 2: Backswing, Leg Cocking, Leg Acceleration). Immediately following ball contact the knee begins to extend slowly, allowing for stability, muscle fiber recruitment, and the generation of additional force (Figure 2: Follow Through).<sup>37</sup> This eccentric action of the quadriceps during most of the stance phase allows the stance leg more stability and thus generation of greater kicking speed.<sup>35</sup>

During an instep kick the hip is the primary mover, contributing more to the angular acceleration of the shank than the knee.<sup>38</sup> In a side-foot kick, however,

**Figure 2.** *The Phases of Kicking*

the knee has higher power, likely due to the effort required at the hip to maintain the foot position.<sup>38</sup> A strong relationship exists between foot-swing velocity and resultant ball velocity. The findings of Nunome et al indicating that the foot continues to accelerate through ball contact<sup>39</sup> are consistent with traditional coaching advice to “kick through the ball.”<sup>32</sup>

Ball impact lasts 10ms and occurs near the center of gravity of the foot.<sup>39</sup> For a ball moving at 16.3 m/s the peak impact force at the foot is 1200N,<sup>40</sup> but peak foot impact force can reach as high as 2900N.<sup>41,42</sup> Upon impact the foot is passively plantarflexed (unless barefoot, in which case the foot is already in maximal plantar flexion),<sup>42</sup> everted and abducted.<sup>32,42</sup> Men experience less plantar flexion angular displacement during ball impact than women.<sup>42</sup> Some studies have reported men also achieve higher average ball velocities<sup>36,43</sup> and ball-to-foot velocity ratios.<sup>43</sup> This may be due to smaller plantar flexion displacement, such a mechanism would be similar to the higher velocities achieved when kicking barefoot as compared to shod. Nevertheless, because there is no normative data on kicking, further research is needed in order to fully understand all mechanics involved in this action.

Instep kick ground reaction forces (GRF) through the stance leg have been reported as follows: vertical

GRF 2.1-2.4 times the player's body weight (xBW),<sup>31,44</sup> posterior GRF 1.9-2.4 xBW, and medial GRF 0.5-1.2 xBW.<sup>45,46</sup> The vertical and posterior GRFs of kicking are larger than running at a speed equivalent to the approach steps (vertical 1.7 xBW, posterior 0.39 xBW).<sup>35</sup> Instep kick vertical GRF is smaller than that observed in other sporting activities such as javelin throwing,<sup>47</sup> basketball layup or jump shot landing,<sup>48</sup> and cricket fast bowling.<sup>35,49</sup>

Muscle activity varies by muscle group as well as by leg (Tables 2 and 3).<sup>26</sup> A side-foot kick requires greater hamstrings activation (62% of maximal volitional isometric contraction-MVIC) during follow through than an instep kick (50% MVIC), while the instep kick requires greater overall iliacus, vastus medialis, gastrocnemius, and adductor activation (Tables 2 and 3). On the support leg, a side foot kick requires higher gastrocnemius activation (84% MVIC) during leg acceleration than an instep kick (74% MVIC).<sup>26</sup> Overall, men have greater gluteus medius (124% MVIC) and vastus medialis (139% MVIC) muscle activation (women have 55% MVIC and 69% MVIC respectively) on their support limb and greater iliacus activation (123% MVIC) on their kicking limb as compared to women (34% MVIC).<sup>36</sup> Although greater iliacus activation may be protective at the knee it may contribute to a higher risk of

**Table 2.** Muscle activity as a percent of maximal volitional isometric contraction (% MVIC) as measured by electromyography during each phase of an instep kick based on data from Brophy et al (2007).

% MVIC	Preparation	Backswing	Leg Cocking	Leg Acceleration	Follow Through
Iliacus	57	96	149	131	95
	46	17	30	36	30
Gluteus Medius	104	75	57	71	89
	74	84	109	119	82
Gluteus Maximus	148	74	73	114	129
	65	78	99	94	70
Hamstrings	63	39	26	33	50
	30	72	104	94	64
Vastus Lateralis	60	36	50	87	52
	37	38	93	107	49
Vastus Medialis	128	23	78	100	69
	37	60	202	228	90
Gastrocnemius	99	33	42	57	67
	14	40	75	70	41

Kicking Leg	0-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%	>101%*
Support Leg	0-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%	>101%*

\*Values greater than 100% represents muscle activity that exceeded measured during maximal volitional isometric contraction

**Table 3.** Muscle activity as a percent of maximal volitional isometric contraction (% MVIC) as measured by electromyography during each phase of a side-foot kick based on data from Brophy et al (2007)

% MVIC	Preparation	Backswing	Leg Cocking	Leg Acceleration	Follow Through
<b>Iliacus</b>	28	65	128	106	95
	51	19	34	37	26
<b>Gluteus Medius</b>	100	63	72	106	82
	73	70	103	114	79
<b>Gluteus Maximus</b>	127	57	77	115	120
	59	59	109	96	69
<b>Hamstrings</b>	59	35	20	41	62
	26	78	108	74	55
<b>Vastus Lateralis</b>	48	24	58	90	47
	34	28	87	96	57
<b>Vastus Medialis</b>	115	15	50	99	71
	38	54	182	228	99
<b>Gastrocnemius</b>	82	22	19	34	68
	12	32	84	56	37

Kicking Leg	0-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%	>101%*
Support Leg	0-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%	>101%*

\*Greater than 100% represents muscle activity greater than that measured during maximal volitional isometric contraction

hip and groin pathology.<sup>36</sup> Hip extension during an instep kick not generated from higher gluteus maximus activation, may necessitate increased iliopus activation in order to flex the hip farther and faster.<sup>26</sup>

Greater foot speeds and ball speeds are achieved kicking with the dominant leg,<sup>35,50</sup> however, there are no differences between the dominant and non-dominant limbs in support limb vertical, braking, or medial-lateral GRF.<sup>35</sup> The linear velocity of the kicking leg knee is similar, for both the dominant and non-dominant leg, but the shank angular velocity is greater on the dominant leg, meaning more work is done on the shank of that leg.<sup>50</sup> In any case, there is no difference in muscle moment or rate of force development.<sup>50</sup> Clagg et al found that women kicking with their non-dominant leg used greater amounts of braking torque (hip, knee, and ankle extension, external rotation, and abduction); in contrast, greater pulling torque (flexion, internal rotation, and adduction) was exerted when kicking with their dominant leg.<sup>51</sup> While there seems to be little kinematic differences between the dominant and non-dominant legs when kicking a stationary ball as compared to a rolling ball, further research is needed to assess kinetic differences.<sup>52</sup>

### PROPOSED CLINICAL MEASURES

Although some objective measurements related to kicking exist, many are not relevant to an IKP. Thus, the authors have separated clinical measures into two categories; readiness for a return to kicking program and readiness for return to sport.

#### Readiness for a return to kicking program:

Because the IKP is designed to be performed in conjunction with rehabilitation and cardiovascular training it should only be initiated when an athlete has been cleared to begin running, cutting, pivoting, and sport-specific rehabilitation. Athletes should have no pain, full range of motion, and no effusion as measured by reliable techniques such as the Modified Stroke Test<sup>53</sup> for the knee or the Figure 8 circumferential measurement method for the ankle.<sup>54</sup> There are currently no valid/reliable tests for measurement of effusion in the hip. Muscle strength, if measured by manual muscle testing should be equal bilaterally. Due to the decreased sensitivity of manual muscle testing as an accurate determinant of strength, the authors recommend quantifying muscle strength using hand-held or electromechanical dynamometers.<sup>55,56</sup> Eighty percent strength performance of the involved limb (compared to the

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performance of the uninjured limb) is recommended as a goal when considering readiness for running, a gradual initiation of light plyometric (e.g. hopping), agility, and return to sport activities.<sup>57,58</sup> Because running is integral to the lead steps of a kick and the GRFs of kicking are slightly larger than those of running,<sup>35</sup> it is critical that an athlete be able to run with even step lengths and without pain prior to kicking. Step length and impact forces should be assessed for symmetry either clinically, by visually examining step symmetry and ball speed, or if available in a laboratory.

**Readiness for return to sport:** The decision to allow an athlete to return to full team training sessions, contact, and eventually game-play is multifactorial, and, all too often made with few or no objective measures. Objective measures, particularly those with normative values, are essential for making an informed decision concerning an athlete's readiness. While many objective criteria for return to sport have been discussed in the literature there is little agreement on standardization, thus many institutions and practitioners use their own criteria or some combination of criteria. The authors recommend that before returning to full team training with contact an athlete should meet objective criteria that include both performance-based and patient reported outcome measures. An example of such criteria used after ACL injury or surgery is greater than or equal to 90% (performance of the involved limb compared to the performance of the uninjured limb) on the single, triple, and cross-over hop for distance and the 6-meter timed hop test; greater than or equal to 90% isokinetic quadriceps strength; and a score of greater than or equal to 90% on the Global Ratings Scale, and Knee Outcomes Survey- Activities of Daily Living Scale (KOS-ADLS).<sup>58,59</sup>

Patient reported outcome measures are important objective tools in order to understand a player's perceived function. Some measures helpful in assessing function include: the Global Ratings of Change Scales,<sup>60</sup> Knee Injury and Osteoarthritis Outcomes Scale (KOOS) (particularly the sports subscale),<sup>61,62</sup> the International Knee Documentation Committee 2000 Subjective Knee form (IKDC2000),<sup>63</sup> and the Foot and Ankle Ability Measure.<sup>64,65</sup> Further, scales that assess kinesiophobia, such as the Modi-

fied Tampa Scale of Kinesiophobia-11 (TSK-11),<sup>66</sup> or confidence and risk appraisal, such as the Anterior Cruciate Ligament-Return to Sport after Injury Scale (ACL-RSI),<sup>67</sup> may also be valuable in assessing an athlete's readiness and likelihood to return to sport.<sup>68</sup> By comparing a player's current scores to baseline scores and normative data, these self-report measures can allow the rehabilitation team to judge a player's progress as well as readiness for sport.

Numerous assessments of passing, shooting and kicking are available to assess an athlete's ability to perform soccer-specific tasks. Yet because of the speed of play, the pressure from opponents, and the endurance soccer requires it is difficult to create an objective measure that accurately captures the behavior, accuracy, or performance of a player in competition. Furthermore, many soccer tests require prohibitive amounts of equipment, space, and player/tester training. Two of the most researched tests are the Loughborough Soccer Passing Test and Loughborough Soccer Shooting Test. These were the first, and currently only, tests validated for adolescents and women.<sup>69,70</sup> The Loughborough Soccer Passing Test is used to assess a player's performance when fatigued, as well as a player's perception and cognitive decision making processes.<sup>71</sup> No normative data exists on either test and no validated "passing" cut-off score has been established.

Similar to its use in assessing the performance of a baseball pitcher, a radar gun can determine the velocity of a kicked ball, providing information on a player's ability to contact the ball and whether or not pain occurred. This measure requires baseline data for comparison, and is not generalizable to either practice or game play. Due to the limited use of juggling in an actual game, counting the number of times a player can juggle, has poor construct validity;<sup>72</sup> similarly counting the times a player can volley a ball against a wall without its hitting the ground can be used to assess passing accuracy and control, but lacks ecological validity.<sup>72</sup> Testing a player's ability to dribble in a figure eight pattern is a valid and reliable indicator of technique.<sup>72</sup> In the case of return to kicking, such a test could be used to assess speed, agility and readiness for higher level dribbling activities. Other soccer-specific tests include shooting at a plywood target covered in carbon paper. Though



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a reliable measure of accuracy,<sup>73</sup> this test is limited because it requires extensive equipment. Russell et al developed a reliable and valid measure of ball speed and precision involving dribbling, passing, and shooting.<sup>74</sup> The test has more reliability than the Loughborough Soccer Shooting Test, but is complex in administration requiring both player and tester training.<sup>74</sup>

Finally, a qualitative assessment of a player's actual performance during kicking is crucial both during the IKP and prior to return to sport. Knowledge of a player's prior abilities and playing style is useful, but general knowledge of what a soccer kick should look like is sufficient to observe for antalgic gait or abnormal movement patterns. In a highly competitive atmosphere this qualitative assessment should be performed by unbiased individuals whose primary concern is the player's health rather than a timeline for their expected return to playing.

### **THE INTERVAL KICKING PROGRAM**

The IKP is designed to be performed in conjunction with rehabilitation exercises and cardiovascular training. Della Villa et al<sup>75</sup> and Bizini et al<sup>76</sup> provide examples of broad return to soccer progressions within which the IKP could be integrated. Systematic progression through the IKP (Table 4) should be individualized and based on a player's response, feedback and injury. In particular, soreness of the surrounding musculature, is to be expected after initiating a kicking program and the proposed soreness rules should be observed in order to determine readiness for progression (Table 5).<sup>6</sup> Similarly, effusion guidelines such as those in White et al<sup>58</sup> should also guide progression. Clinicians may also adapt the IKP based on a player's injury. For example, a clinician may decrease the number or the intensity of side-foot kicks performed by a player recovering from a MCL injury or adductor strain where as a player with deltoid ligament injury or iliopsoas/rectus femoris strain may require an even more gradual introduction to in-step kicking.

Similar to upper extremity interval sports programs the IKP is designed to be performed on alternate days.<sup>4</sup> The IKP, injury specific strengthening, plyometrics, and neuromuscular control drills should be performed on one day and cardiovascular training

and core strengthening performed on the off days. This alternating structure is designed to allow the lower extremities to recover from the re-introduction of kicking, therapeutic exercises, and any plyometric or neuromuscular drills completed. The authors recommend that the IKP be performed prior to other exercises so that it is performed prior to the lower extremities becoming fatigued and to ensure proper form. Swimming, pool running, cycling, or AlterG treadmill running can be used for cardiovascular conditioning to decrease the repetitive impact of running.

A soccer ball should be integrated into exercises at the initial stages of rehabilitation. Once an athlete can demonstrate proper biomechanical movement in basic and simulating exercises, adding a ball increases degree of difficulty. Activities such as single-leg balance while gently pushing a ball anteriorly-posteriorly or medially-laterally with the contralateral foot, are low risk/low force exercises that help progress a player's proprioception while maintaining touch/feel for the ball. Incorporating heading, or in the case of goalkeepers catching/throwing, can also make rehabilitation exercises sport specific and enjoyable. Further, soccer related exercises may improve an athlete's mood, confidence, and motivation; all factors linked to a higher likelihood of an athlete returning to sport.<sup>68</sup>

When a player is deemed ready to begin the IKP it is crucial that all kicking techniques are performed with proper biomechanics. Coaches may aid the rehabilitation team in observing a player's ability with respect to length of passes, lofting balls, and shooting in order to preclude abnormal compensation patterns from being learned, adopted, or reinstated. A player should perform the IKP in soccer-specific cleats or shoes, as shoes designed for running often have a larger, more elevated sole that may impede stability in landing on the support foot thereby placing the ankle and knee at risk for injury. A soccer ball is required to perform the IKP, but multiple balls are recommended as this allows for more continuous kicking as opposed to time spent retrieving balls. The IKP is based on soccer field distances (Appendix 2), thus performing on a lined a soccer field will reduce set up time. A goal is also useful for the later stages when a player resumes shooting.



**Table 4. The Interval Kicking Program**

Basic Kicking and Passing		
<p>Step 1:</p> <ul style="list-style-type: none"> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• Two touch passing, 5.5 meters (5 min)</li> <li>• Rest (5 min)</li> <li>• Warm-up dribbling or juggling, performing opposite activity from start (5 min)</li> <li>• One touch passing, 5.5 meters (5 min)</li> </ul>	<p>Step 2:</p> <ul style="list-style-type: none"> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• Two touch passing, maximum 16.5m (5 min)</li> <li>• Rest (5 min)</li> <li>• Warm-up dribbling or juggling, performing opposite activity from start (5 min)</li> <li>• One touch passing, maximum 16.5 meters (5 min)</li> </ul>	<p>Step 3:</p> <ul style="list-style-type: none"> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• Two touch passing, maximum 16.5 meters (5 min)</li> <li>• Rest (5-10 min)</li> <li>• Warm-up dribbling or juggling(5 min)</li> <li>• One touch passing, maximum 16.5 meters (5 min)</li> <li>• Rest (5-10min)</li> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• One or two touch passing with a maximum 16.5 meters (5 min)</li> </ul>
Passing and Basic Shooting		
<p>Step 4:</p> <ul style="list-style-type: none"> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• Two touch passing, maximum 36 meters (5 min)</li> <li>• Rest (5 min)</li> <li>• Warm-up dribbling or juggling, performing opposite activity from start (5 min)</li> <li>• One touch passing, maximum 36 meters (5 min)</li> </ul>	<p>Step 5:</p> <ul style="list-style-type: none"> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• Two touch passing, maximum 36 meters (5 min)</li> <li>• Rest (5-10 min)</li> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• One touch passing, maximum 36 meters (5 min)</li> <li>• Rest (5-10min)</li> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• One or Two touch passing with a maximum 36 meters (5 min)</li> </ul>	<p>Step 6:</p> <ul style="list-style-type: none"> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• One or two touch passing, maximum 36 meters (5 min)</li> <li>• Rest (5-10 min)</li> <li>• Warm-up dribbling or juggling, (5 min)</li> <li>• Shooting (10 shots) and chipped/lofted balls, maximum 11 meters (2-3 min)</li> <li>• Rest (5-10 min)</li> <li>• Warm-up dribbling or juggling, (5 min)</li> <li>• One or two touch passing, maximum 36 meters (5 min)</li> </ul>
Advanced Shooting		
<p>Step 7:</p> <ul style="list-style-type: none"> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• One or two touch passing, maximum 36 meters (5 min)</li> <li>• Rest (5-10 min)</li> <li>• Warm-up dribbling or juggling, (5 min)</li> <li>• Shooting (10 shots) and chipped/lofted balls, maximum 11 meters (2-3 min)</li> <li>• Rest (5-10 min)</li> <li>• Warm-up dribbling or juggling, (5 min)</li> <li>• Shooting (10 shots) and chipped/lofted balls, maximum 11 meters (2-3 min)</li> </ul>	<p>Step 8:</p> <ul style="list-style-type: none"> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• One or two touch passing, maximum 36 meters (5 min)</li> <li>• Rest (5-10 min)</li> <li>• Warm-up dribbling or juggling, (5 min)</li> <li>• Shooting (10 shots) and chipped/lofted balls, maximum 16.5 meters (2-3 min)</li> <li>• Rest (5-10min)</li> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• One or Two touch passing with a maximum 36 meters (5 min)</li> </ul>	<p>Step 9:</p> <ul style="list-style-type: none"> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• One or two touch passing, maximum 36 meters (5 min)</li> <li>• Rest (5-10 min)</li> <li>• Warm-up dribbling or juggling, (5 min)</li> <li>• Shooting (10 shots) and chipped/lofted balls, maximum 16.5 meters (2-3 min)</li> <li>• Rest (5-10min)</li> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• Shooting (10 shots) and chipped/lofted balls, maximum 16.5 meters (2-3 min)</li> </ul>

<b>Table 4. The Interval Kicking Program (continued)</b>		
<b>Increased Intensity and Distance</b>		
<p>Step 10*:</p> <ul style="list-style-type: none"> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• One or two touch passing, maximum 36 meters (5 min)</li> <li>• Rest (5-10 min)</li> <li>• Warm-up dribbling or juggling, (5 min)</li> <li>• Shooting (10 shots) and chipped/lofted balls, maximum 36 meters (2-3 min)</li> <li>• Rest (5-10min)</li> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• Shooting (10 shots) and chipped/lofted balls max 16.5m (2-3min) <u>or</u> One or two touch passing, maximum 36 meters (5 min)</li> </ul>	<p>Step 11:</p> <ul style="list-style-type: none"> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• One or two touch passing, maximum 36 meters (5 min)</li> <li>• Rest (5-10 min)</li> <li>• Warm-up dribbling or juggling, (5 min)</li> <li>• Shooting (10 shots) and chipped/lofted balls, maximum 36 meters (2-3 min)</li> <li>• Rest (5-10min)</li> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• Shooting (10 shots) and chipped/lofted balls, maximum 36 meters (2-3 min)</li> </ul>	<p>Step 12:</p> <ul style="list-style-type: none"> <li>• Warm-up dribbling or juggling (5 min)</li> <li>• One or two touch passing, maximum 36 meters (5 min)</li> <li>• Rest (5-10 min)</li> <li>• Warm-up dribbling or juggling, (5 min)</li> <li>• Lofted driven ball maximum 45 meters (25 times)</li> <li>• Rest (5-10 min)</li> <li>• Warm-up dribbling or juggling, (5 min)</li> <li>• Shooting (10 shots) and chipped/lofted balls, maximum 36 meters (2-3 min) <u>or</u> One or two touch passing, maximum 36 meters (5 min)</li> </ul>
<b>Initiating Return to Sport</b>		
<p>Step 13:</p> <ul style="list-style-type: none"> <li>• At this point goalkeepers should begin work on punting and drop kicking</li> <li>• Field players may begin to perform &gt;20 min technical portions of practices with their teams as well as shooting and other drills.</li> </ul>	<p>Step 14**:</p> <ul style="list-style-type: none"> <li>• When cleared by medical team player may begin full practices with their team, initially non-contact and progressing to contact.</li> </ul>	<p>Step 15***:</p> <ul style="list-style-type: none"> <li>• Reintroduce game-play first through scrimmages in practice then with gradually increasing periods of game time.</li> </ul>
<p><b>The distances listed in each of these steps are maximum distances. Clinicians and players should not spend the entire time passing or shooting at this maximum distance, but rather vary the passing/shooting distances throughout the allotted time.</b></p> <p>*Alternatively, once a player reaches step 10 (if cleared by the medical team) a percentage of time spent in warm-up dribbling/juggling and one- or two- touch passing drills (maximum 20 minutes) may be spent working on technical drills with their team, followed by performing the shooting or lofted driven ball practice defined by the progression (with appropriate rest between). This alternative should only be used if the medical team is confident that both player and coach are cognizant of all precautions such as only performing small sided technical drills involving passing and dribbling and avoiding player contact.</p> <p>†Unlike steps 1-13, steps 14 and 15 require more than one day in between. It is at the rehabilitation team's discretion to progress a player through these stages.</p> <p>‡ A gradual increase in game time will allow a player to adjust to the intensity and speed of play, while reducing the amount of time they are exposed to the higher risk game environment.</p>		

**Table 5. Proposed Soreness Rules for Progression through the Interval Kicking Program, adapted from Axe et al (2001).**

If no soreness:	Advance to next stage
If sore during warm-up but soreness is gone during dribbling and juggling warm-up:	Repeat previous stage.
If sore during warm-up and soreness continues through dribbling and juggling warm-up:	Stop; take 2 days off, and upon return to IKP, drop down one stage
If sore more than 1 hour after kicking, or the next day:	Take 1 day off; repeat most recent stage.

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Proper warm-up of the muscles and cardiovascular system is necessary; the authors recommend a dynamic warm-up that integrates stretching, low-level strengthening, and movement. The FIFA 11+ is a soccer-specific warm-up developed as an injury prevention tool.<sup>77</sup> The FIFA11+ is designed to warm up all of the major muscle groups in the lower extremity, and can serve also as a teaching tool to reinforce proper alignment and mechanics. Proper cool-down is also important following performance of the kicking program. This may include stretching, light jogging, and cryotherapy.

**Position specific modifications:** Unlike rehabilitation in sports such as baseball and softball, little position-specific rehabilitation is needed in soccer. Goalkeepers must be confident and skillful with a ball at their feet, thus in these initial stages of returning to soccer the IKP is as important for goalkeepers as it is for field players. The rehabilitation team may modify later stages of the kicking program for goalkeepers, omitting shooting in favor of similar distance goal kicks (long/lofted instep kicks) or punts. Goalies may also add jumping, catching, diving for and retrieving balls from the air as part of their dribbling or juggling warm-ups. One example of an alternative for goalkeepers is side shuffling along a line 11m long. Each time the goalkeeper reaches the end of the line they receive either a ball on the ground, which they must pass back with their feet, or a ball in the air, which they must catch and throw back. Adding plyometric and diving activities, however, is at the discretion of the rehabilitation team.

The cardiovascular and intensity demands of soccer differ by position. During games mid-fielders, often wide midfielders, cover the most distance of any field player and cover the most distance at high speeds.<sup>78,79</sup> In contrast, central defenders cover the least distance and least distance at high intensities.<sup>78,79</sup> Attackers and central defenders may also have more recovery time between their bouts of high intensity.<sup>78</sup> Consequently the rehabilitation team should modify cardiovascular training to prepare a player for return to sport taking into consideration position, fitness prior to injury, and age.

## CONCLUSION

Regardless of whether an injury effects an athlete's dominant kicking or stance leg, any lower extrem-

ity injury may influence the ability to kick. The IKP presents a novel return to kicking framework specific to the sport of soccer. Similar to return to throwing progressions developed for athletes in upper extremity sports,<sup>4,6</sup> this return to kicking progression guides clinicians from readiness to begin kicking through an athlete's return to sport. The IKP format integrates a return to kicking into therapeutic exercise and cardiovascular fitness in order to address the broader needs of an athlete. While the IKP presents a starting point for athletes to begin their return to soccer, future research is needed to determine the optimal rehabilitation techniques and additional outcome measures and criteria that will ensure a safe return to sport.

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