ACL Injuries in Elite Female Soccer Players

The Anterior Cruciate Ligament (ACL) is one of four ligaments located in the knee that provide protection and stabilization of the joint (Fig 1 in Appendix A). The ACL's primary responsibility is to provide stability to prevent anterior translation of the tibia on the femur[1]. The ACL also resists internal rotation of the tibia[2]. When an injury to the ACL has occurred, the knee will have increased laxity due to the tibia having increased translation on the femur[1]. This increased laxity can cause pain, the feeling of the knee "giving way," and injury to other soft tissue structures in the knee[1]. ACL tears are a common injury in athletes, especially female athletes. ACL tears are one of the most common knee injuries resulting in over 100,000 reconstructive surgeries in the U.S. every year and costing more than $1 billion on the health care system[3-4]. Much research has been conducted to investigate the risk factors for ACL injuries, the best surgical and rehabilitation procedures following an ACL rupture, and prevention strategies to reduce the number of ACL injuries. The information discussed in this paper will focus on elite female soccer players because they have a higher incidence and risk of ACL injury than many other athletes.

Soccer is the most popular sport in the world with approximately 200 million professional and amateur players worldwide[5-6]. In 2011, 29 million women participated in soccer and this number continues to increase as the popularity of women's soccer rises[7]. In the U.S. alone, nearly 18 million people play soccer and this number is expected to grow up to 20% annually[8]. Due to the popularity of soccer and increased number of female soccer players, it is no surprise that these athletes account for a large portion of injuries. The highest cost for all knee injuries is in female soccer players, which is most likely due to their high incidence of ACL tears[9]. Not only does an ACL tear result in significant medical costs, but it also results in significant missed time from sport and further knee problems over time. More than 50% of adolescents and young adults who injure their ACL have knee osteoarthritis 5 to 15 years after the injury[4]. For these reasons, elite female soccer players are commonly used in ACL research to determine how to best help this group of athletes avoid injuries.

ACL tears typically occur during sudden acceleration or deceleration actions, quick changes of direction, jumping/landing, and during unanticipated rapid movements[10]. Soccer demands all of those activities to be repeatedly performed with extremely high forces, especially at the elite level. Nearly 75% of ACL injuries in female soccer players occur during matches, rather than during practice or training[5]. Also, the majority of ACL injuries occur from non-contact movements compared to contact injuries[5]. In a study of 2,329 professional European soccer players, the most common scenarios for ACL tears were turning the trunk while the foot is fixed to the ground or landing from a jump[5]. Some research has shown that midfielders are at the highest risk of non-contact ACL injury due to the high demands for cutting, running and jumping during the game, while strikers and defenders are at higher risk of contact ACL injuries due to the increased incidence of aggressive contact between these players[8]. Despite the position, however, simply being a female appears to be a stronger risk factor for ACL injury.

Female athletes are up to 9 times more likely to tear their ACL than male athletes and are also more likely to reinjure their ACL after reconstruction[11]. ACL ruptures in female elite soccer players account for over 40% of all missed time from play[12]. One proposed explanation for why females have such an increased risk of ACL tears than males is the hamstring to quadriceps strength ratio. The quadriceps produce a substantial anteriorly directed shear force on the tibia when contracting to move into knee extension[13]. The only way to counteract that shear force is by hamstring coactivation and the ACL[13]. Without the appropriate hamstring strength and, more importantly, rate of force development, the ACL will undergo more stress in order to counter the large shear force created by the quadriceps[13]. This study demonstrated that women may be at higher risk of ACL injury, not because they lack hamstring strength, but because the rate of force production may be slower than males[13]. The average time for an ACL injury to occur is within the first 17-50 milliseconds after ground contact and during this initial contact, the hamstrings are only 30-50% of their maximum contraction in females[13]. This decreased hamstring force production can result in failure of the ACL when the anterior shear force of the tibia overpowers the resistance provided from the ACL.

In addition to the decreased force production rate of the hamstrings, some studies have shown that women produce greater quadriceps forces relative to their maximum contraction than men when running and cutting[14]. The increased quadriceps contraction creates a larger shear force that must be resisted by the ACL, potentially leading to increased risk of failure. In an EMG study, female soccer players also demonstrated greater gastrocnemius activation than their male counterparts which the authors conclude is likely a result of the female knee needing more protection due to increased laxity in female joints compared to males[14]. The combination of quadriceps and gastrocnemius contractions results in increased muscle force production directed on the knee. The increased muscle force can lead to increased knee stiffness and strain on the ACL during cutting activities[14].

There is also further evidence that examines the anatomical differences between males and females that may predispose females to increased risk of injury. One anatomical difference is that women have smaller intercondylar notch width and ACL than males[7]. With a smaller attachment site and reduced cross-sectional area of the ligament, the female ACL could be more likely to fail at a lesser amount of strain than a male ACL. Females, on average, also tend to have a higher prevalence of hypermobility in the knee than males which can lead to higher risk of ACL injury when performing the same tasks (i.e. soccer)[7]. Increased mobility in the knee could indicate increased laxity in the ACL or increased stress imposed on the ACL during sport-specific movements. Females also tend to have larger quadriceps angles (Q-angle) due to the anatomy of the female pelvis that results in increased knee valgus moments[7]. An increased valgus moment will place additional strain on the ACL since one of the primary roles of this ligament is to resist rotation in the knee. In addition to an increased Q-angle, female soccer players also land with less hip and knee flexion than males which results in increased quadriceps force relative to hamstring force[7]. As discussed previously, a quadriceps to hamstrings imbalance places increased stress on the ACL leading to increased risk of failure. Finally, there is some additional evidence that hormone fluctuations during the pre-ovulatory phase of the menstrual cycle can also predispose females to increased risk of injury because the change in hormone levels can negatively impact neuromuscular control and function[7]. These anatomical differences help to explain why the incidence of ACL ruptures is so much higher in female soccer players than male soccer players.

Although the risk factors discussed thus far are nearly impossible to control or correct, there are some risk factors of ACL tears that can be addressed to reduce injury risk. Neuromuscular fatigue is often a factor in non-contact ACL ruptures because it decreases the muscles ability to assist with joint stability and increases the role of the ACL in maintaining knee stability[10]. This negative effect of fatigue appears to be greatest in young female soccer players compared to adults[10]. When soccer-specific fatigue sets in, the activation reaction time of muscles (especially the hamstrings) is reduced[10]. As discussed, without appropriate hamstring activation, the ACL must resist more stress leading to increased risk of failure. It is important to recognize signs of fatigue in these athletes in order to provide appropriate rest to prevent injury. These researchers further investigated the long-term effect of neuromuscular fatigue and found that the neuromuscular feedback mechanisms can remain fatigued longer than the muscles[10]. This suggests that even after the athlete feels like they have recovered from the game and/or practice, the neuromuscular function may still be impaired and, therefore, they remain at a higher risk of injury[10]. The authors suggest that the effects of fatigue can be addressed by implementing ACL prevention programs in the middle and/or end of training sessions in order to train for prevention during the time of fatigue instead of just using an injury prevention warm up[10]. Appropriately addressing fatigue in elite female soccer players is a modifiable way to reduce the risk of ACL tears in these athletes.

When a female soccer player suffers a knee injury, there are several different diagnostic tests that can be used to determine if the ACL is damaged. The gold standard for diagnosing an ACL tear is arthroscopic visualization[15]. Although this is the gold standard, this is not a feasible method for diagnostic purposes due to the increased cost and risk to the patient. Magnetic resonance imaging (MRI) is a valid, reliable, and non-invasive method of diagnosing ACL tears[15]. Imaging, however, is also extremely expensive and time consuming and, therefore, not the most feasible option for patients. Clinical diagnostic tests including the Lachman test, Anterior Drawer test, Pivot Shift test, and Lever Sign test are more reasonable to use for evaluating an injured athlete because they are non-invasive, easy and quick to administer, and have no additional cost[15]. The Lachman test is commonly used in this population and is a valid and reliable test. This test has a sensitivity of 0.86, specificity of 0.91, and a high negative predictive value[16]. This indicates that clinicians can be confident in the results from this test when determining if the ACL is intact or not. The Anterior Drawer test is also sometimes used and has a sensitivity of 0.62 and specificity of 0.88[16]. This indicates that this test is better at ruling in an ACL tear and there is increased risk of getting false negative results. The Pivot Shift test has a sensitivity of 0.48, specificity of 0.97, and a high positive predictive value[16]. This means that a clinician can be confident that a positive test indicates an ACL injury, however, a negative test cannot confidently be used to rule out an ACL injury. Although these tests have good psychometric properties, they also have some drawbacks. There most significant drawbacks are that patient guarding is common and can influence the results and they are not as accurate at diagnosing partial tears[15]. A newer diagnostic test, the Lever Sign, was created to overcome the drawbacks of the other tests[15]. In this test, the patient remains relaxed in supine and the clinician only has to apply controlled downward force on the quadriceps instead of rapid pulling or twisting motions on the knee that are used in the other tests that result in increased muscle guarding of the injured knee[15]. One study was found that demonstrated that the Lever Sign outperformed all other clinical tests and recognized all partial and full ACL tears without any false results in 400 patients[15]. This demonstrates that the Lever Sign is far superior to all other clinical tests, however, there is increased risk of bias in these results because this study was conducted by the clinician who developed this test. Overall, there are several reliable and valid clinical tests that can be used with confidence to diagnosis ACL injuries.

Once athletes receive a diagnosis of an ACL rupture, they will begin the process of preparing for reconstructive surgery and rehabilitation to return to sport. There are several different surgical options that can be chosen with little consensus in the research for which is better. The most common grafts for ACL reconstruction are autografts of the patellar tendon and semitendinosus-gracilis hamstring but there are currently no criteria to determine which graft should be used for different athletes[11]. There is also conflicting research for which is the superior graft. Each graft requires different techniques for harvesting, preparing, and fixing the graft so it is typically left up to the surgeons' choice for which surgical procedure is most appropriate[11]. A prospective study comparing these 2 graft options found that there was no difference in Lysholm knee score, joint laxity, or incidence of postoperative complications between the 2 graft types[11]. The patellar tendon graft, however, resulted in significantly higher pain reports throughout the entire rehabilitation process[11]. The hamstring graft resulted in quicker return of full range of motion, had better patient satisfaction, and was the most cost-effective technique[11]. These differences are likely due to the increased pain following patellar tendon graft resulting in slower return of function. Despite these differences, there was no significant difference in final outcome or time to return to sport[11].

Another study reported that hamstring grafts are up to 2 times more likely to need revision than patellar tendon grafts, but yet, they still remain the most popular graft choice for most female patients[17]. The authors concluded that the increased risk of revision of hamstring grafts is likely due to the fact that the fixation techniques are newer and there may still be a learning curve and that other confounding factors such as age and BMI may be the primary cause of the revision, not the graft[17]. These results could also be due to the significant difference in number of subjects that were evaluated with patellar tendon grafts versus hamstring tendon grafts. Gifstad et al. supported these findings by reporting that there is a reduced risk of revision following patellar tendon grafts compared to hamstring tendon grafts[18]. Out of over 45,000 patients who underwent ACL reconstruction, only 2.8% of the patellar tendon grafts and 4.2% of the hamstring tendon grafts needed a revision[18]. Although they found a significant difference, the rates of revision are still low for both groups. One concern of using the semitendinosus tendon for an ACL graft is that the semitendinosus plays a major role as an ACL agonist and a study showed that using this tendon results in decreased hamstring power and hamstring-quadriceps ratio for up to 3 years after the surgery[19]. When a piece of tendon is being removed and transformed into a new ACL, there will always be mechanical changes. However, there is high satisfaction with hamstring tendon grafts and both types of grafts result in similar outcomes and successful returns to sport[4,11]. It is suggested that age, not graft type may be a stronger predictor of reinjury because 1 in every 3.5 patients under the age of 20 who had ACL reconstruction had a subsequent ACL injury to either knee within 5 years[20]. Therefore, the graft type may not be as important as the individual patient characteristics and prevention training programs.

In addition to autografts, there are also options for an allograft and an autograft-allograft hybrid. These typically result in poorer outcomes but are still deemed appropriate and selected for some patients. An allograft is when a tissue from a cadaver is used to reconstruct the ACL instead of using another tissue from the patient[21]. When an allograft is harvested it must go through a process that ensures it is safe for the patient to receive it and the new graft will be successful. This process includes either processing the tissue aseptically, discarding parts of the tissues based on discovery of certain organisms, bulk tissue gamma radiation treatment on the entire tissue, or terminal irradiation on the tissue[21]. This process is much more extensive than the process to harvest an autograft. Allografts are also over 2 times more likely to rerupture and require a revision surgery than autografts[21]. These grafts are typically not able to withstand high level sports function for more than 2 years before reinjury occurs[21]. Autograft-allograft hybrids have been attempted in cases where the hamstring tendon may be too small to make an ACL with sufficient cross-sectional area to withstand the forces produced in sports[3]. This hybrid graft is created by mixing allograft material with the hamstring and gracilis of the patient[3]. Although this saves the surgeon from having to harvest additional hamstring tendon tissue from the contralateral leg, this procedure results in significantly higher rates of failure than autograft hamstring reconstructions[3]. Although allograft and hybrid options are available, these would likely not be appropriate choices for elite female soccer players with goals to return to sport.

After having an ACL reconstruction procedure, athletes need a rehabilitation program to promote healing and regain function in order to return to sport. ACL injuries are one of the most serious injuries observed in soccer and can potentially end an elite athlete's career[22]. Despite the potential devastating effects of an ACL tear, there is very little consensus on the best rehabilitation protocol to provide the best chance of returning to sport at the same elite level. Most of the current descriptive protocols are not appropriate and detailed enough to be successful for soccer players returning to elite competition[22]. Elite soccer players are especially challenging to rehab because the sport itself demands repeated near maximal muscle actions with short recovery periods and consideration must be given to the intensity of the training and game schedules[22]. Also, the movements in soccer place high demands on the neuromuscular system and without including proper retraining of that system, the athlete will be at higher risk of injury[22]. For these reasons, traditional ACL rehab protocols may not be appropriate for this population of athletes.

A soccer specific ACL reconstruction protocol has been suggested by Bizzini, Hancock, and Impellizzeri to prepare athletes to successfully return to elite competition[22]. They suggest a program that provides a one-on-one approach with close communication and cooperation between all members of the treatment team, the athlete, and the coach[22]. They have developed a 4 phase protocol over the course of about 6 months that takes the athlete from immediate post-op to full return to sport (Fig 2 in Appendix A)[22]. The first phase focuses on protection of the joint, controlled swelling, recovery of motion, and gait training[22]. The second phase focuses on soccer-specific neuromuscular retraining with an emphasis on lower extremity alignment[22]. This phase should utilize uneven surfaces, different environmental conditions, various footwear, and blocked/random practice[22]. Pool exercises can also be beneficial during this phase[22]. Phase 3 focuses on complex soccer-specific movements and activities[22]. They suggest a progression of drills which can be found in Figure 3 in Appendix A[22]. The Star Run Drill (Fig 4 in Appendix A), quick feet, sprints, cutting, and rapid body rotations are important to integrate in this phase[22]. Once deemed appropriate, it is also important to include contact in the activities, including slide tackles, because it is always better to introduce these in a controlled rehab environment than in the unpredictable environment of practice or games[22]. Phase 4 is the return to sport phase which will be discussed in further detail next in this paper. It is also advised to use a soccer ball and soccer specific equipment as much as possible throughout the rehab process to make the interventions more relatable to the sport environment that they are returning to and also to encourage a positive psychological attitude during the rehabilitation process[22]. Integrating sport-specific training that attempts to challenge the athlete near the level they will be challenged during practice and games will ensure the athlete is safe to return to play and decrease the risk of reinjury once the athlete returns.

One of the most challenging and poorly understood aspects of ACL rehabilitation is determining when the athlete is ready and safe to return to sport. There are several different factors that can impact an athlete's success when returning to sport. Psychological factors can strongly influence the outcome of returning to sport[23]. Athletes who have increased fear of reinjury or do not trust their knee to be able to withstand the demands of the sport are at higher risk of reinjury and reduced level of performance upon return[23]. If an elite athlete doubts the capabilities and strength of her knee, she will likely alter her mechanics and in-game decisions which can lead to poor performance or injury. The level of competition and financial implications of competition can also impact return to sport success[23]. Athletes playing at the highest levels have more successful returns likely because their identity is strongly associated with their sport and returning to the sport is worth the risks[23]. Athletes who are paid to play either through salaries or collegiate scholarships also have more successful returns to sport because the financial compensations can act as an external motivator to return and perform at the highest level[23]. Over 85% of elite collegiate level female soccer players successfully return to sport following ACL reconstruction[23]. In order for these athletes to successfully return to sport, they not only needed motivation and a positive mindset, but also the physical capability. There are several techniques that have been suggested to determine if the athlete is physically ready to return to sport.

Cutting is one of the most common maneuvers that result in ACL tears in female soccer players[24]. This is because during cutting there is a large knee abduction moment and rotational force that is created when the foot is planted which in turn places increased strain on the ACL[24]. Since this is a common mechanism of injury, it would seem appropriate to evaluate cutting form before clearing a female soccer player to return to sport. Although cutting is a critical movement in soccer and must be able to be performed with rapid speed and large forces, modifying the amount of knee abduction moment produced during cutting can reduce the risk of ACL reinjury[24]. Athletes should be able to perform routine appropriate cutting mechanics before returning to sport to reduce risk of injury. Increased knee valgus in landing can also increase the strain on the ACL[25]. Many people use the vertical drop jump to screen for knee valgus when determining return to sport eligibility in elite female soccer players[25]. Although excessive valgus knee displacement is associated with increased risk of ACL ruptures, the vertical drop jump test has poor sensitivity and specificity when used as a return to sport assessment[25]. Although it may not be beneficial for determining readiness to return to sport, it is still a useful test for analyzing landing mechanics to reduce risk of ACL injury.

As with the rehabilitation protocol, general return to sport criteria is likely not effective with elite soccer players due to the intense nature of the sport. Typically, once a rehabilitation process is complete, athletes are given the green light to return to sport at their discretion. Bizzini et al suggests a gradual return to sport protocol that begins with return to non-contact team training, then return to full contact team training, then return to "friendly" partial games, and finally return to full competitive matches[22]. In order to progress to the next level of activity, the athlete must demonstrate appropriate physical and psychological performance without any injuries at each level[22]. There are no validated return to sport tests specifically for soccer, however, the Yo-Yo intermittent recovery test. repeated shuttle-sprint ability test, speed dribbling, passing, and shooting tests have shown to be useful when determining the readiness for an elite female soccer athlete to begin the process to return to competition[22].

Finally, due to the seriousness of ACL injuries, the future implications on the knee, the time it takes from participation, and the financial burden on the health care system, it is important to have injury prevention strategies for all athletes, whether uninjured or returning from injury. One of the greatest risk factors for future injury is a prior injury. Elite female soccer players are up to 9 times more likely to have a knee injury if they have a history of an ACL injury[26]. Multi-component programs that include plyometrics, dynamic balance, strengthening, stretching, proprioception, decision-making, abdominal control, and jumping/landing training have shown to be successful at preventing non-contact ACL injuries in female soccer players[27].

Prevention programs should be used as pre-season training and also in-season maintenance to prevent injury[27]. Plyometrics are one of the most effective prevention tools in female athletes and should be incorporated in training that attempts to replicate game time scenarios[27]. Injury prevention programs including the Perform and Enhance Performance and 11+ have been well established and include both cardiovascular and injury prevention exercises combined in a feasible warm up[22]. Appropriate cardiovascular training can also prevent ACL injuries that are a result of fatigue[22]. In addition to injury prevention training, it is also vital to allow for appropriate recovery time following competition, ensure the proper use of protective equipment during all training and game activities, play only on good field conditions, and abide by the rules of the game in order to also reduce risk of injury[28]. Integrating injury prevention strategies throughout the course of a season can help to reduce the number of injuries seen in elite female soccer players.

In conclusion, the ACL is a vital structure for knee stability and performance of the high-level activities involved in soccer. ACL tears are far more common in female athletes than male athletes for various reasons, some which are modifiable. There are various reconstructive techniques that can be used for these athletes and most have very good outcomes. Some ACL injuries in elite female soccer players will be inevitable and those who do suffer ACL injures should undergo an intense sport-specific rehabilitation process in order to return to their competitive level of play. ACL injuries can be detrimental for elite athletes; therefore, every measure should be taken to identify athletes at risk and prevent injuries in this population.

Appendix A

Figure 1[29]: This figure shows the anatomical location of the ACL as well as the surrounding soft tissue structures in the knee. The location and structure of the ACL allows it to resist anterior translation of the tibia and rotation within the knee.

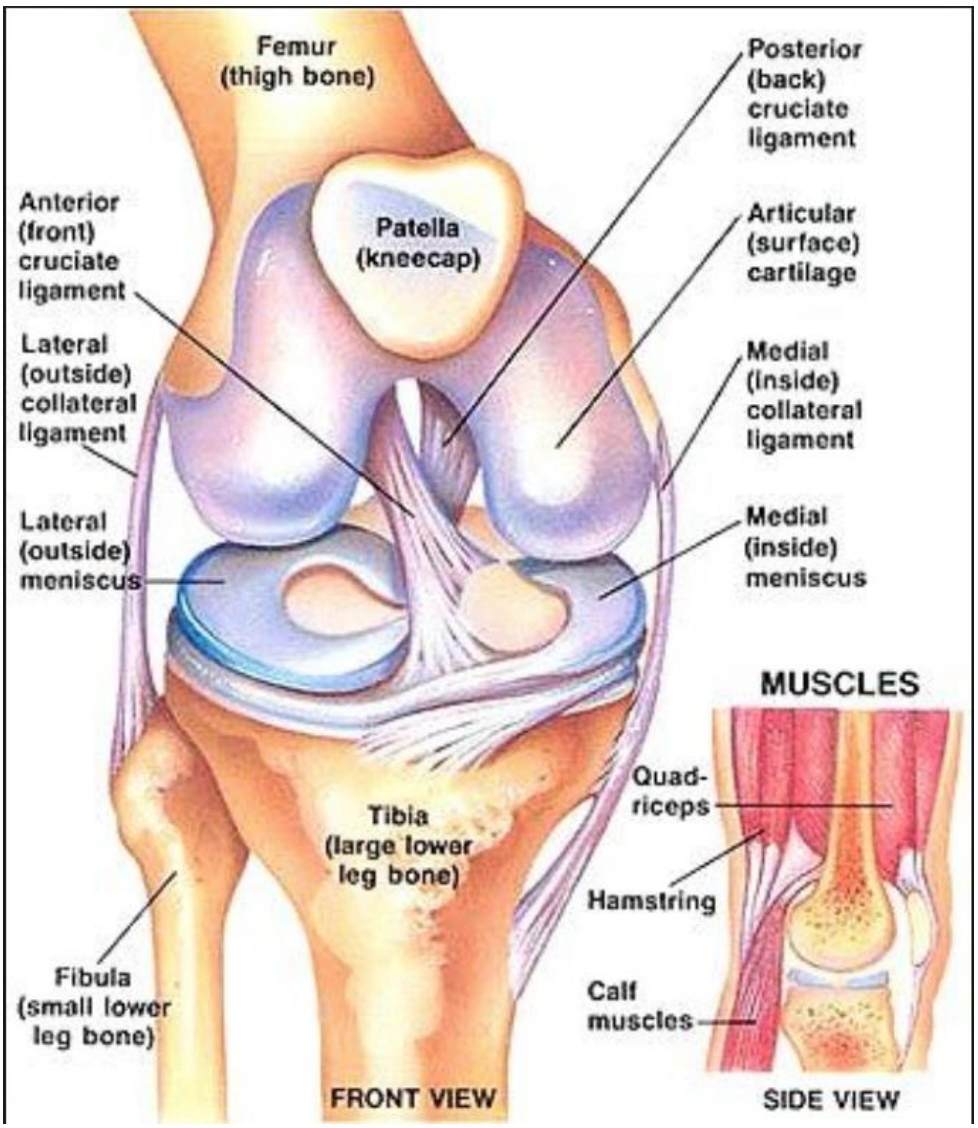


Figure 2[22]: The following chart displays the 4 phase rehabilitation protocol for elite female athletes with ACL reconstruction. Each phase has descriptive criteria for the average time frame, goals, appropriate training interventions, and pool activities.

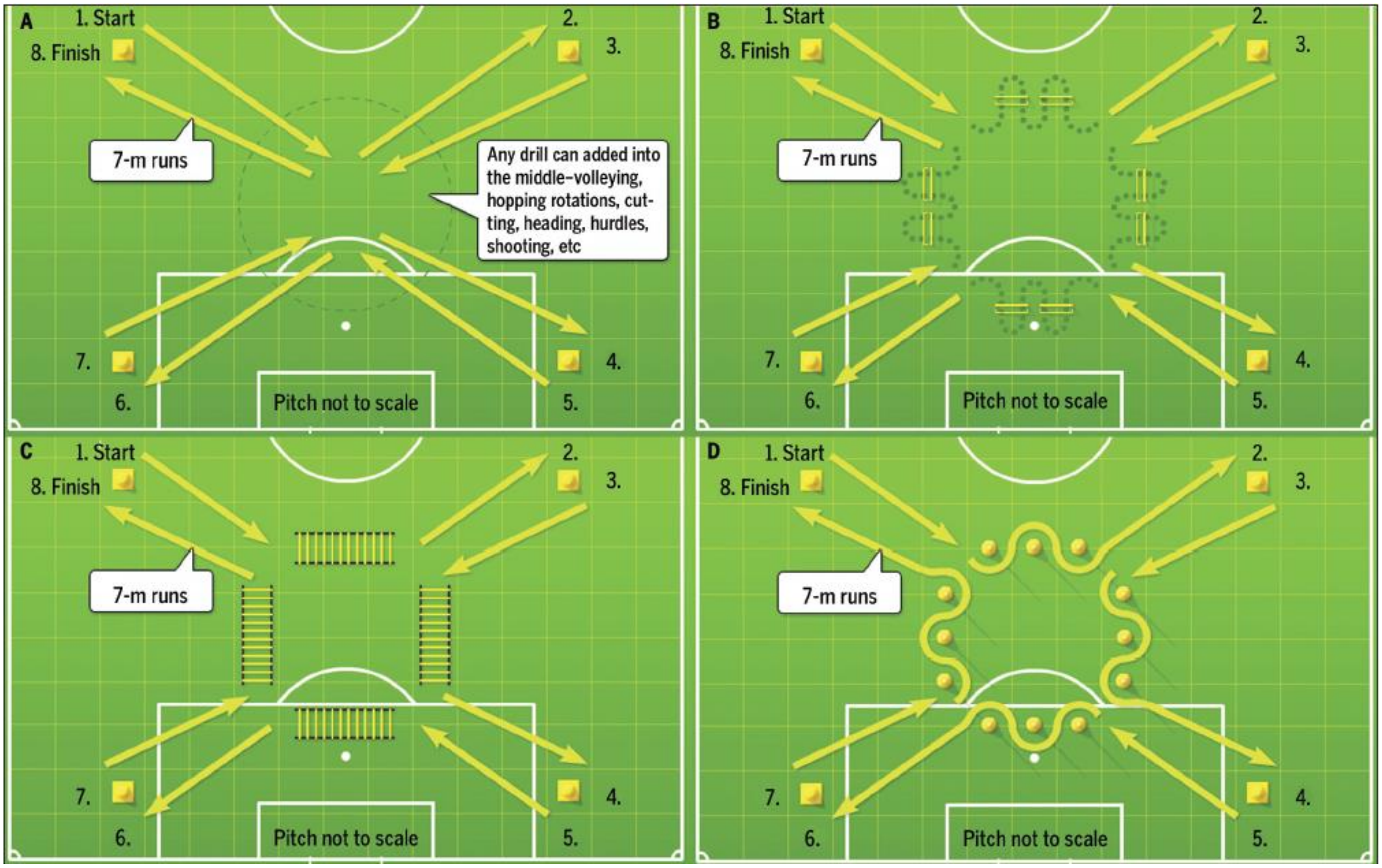
				Phase 4	
	Phase 1	**Phase 2**	**Phase 3**	**Return to Reduced Soccer Practice**	**Return to Full Soccer Practice**
Timing*	4-6 wk	4-6 to 8-12 wk	8-12 to 16-24 wk	16-24 to ? wk	
Criteria to enter this phase		• Minimal pain/swelling • Near full ROM • Good patella mobility • Sufficient quadriceps control • Normal gait pattern	• No pain/swelling • Full ROM • Good neuromuscular control at knee, hip, trunk • Quadriceps and hamstrings strength >75% of noninvolved limb • Good hop/jump and landing techniques	• No pain/swelling • Symmetrical ROM • Optimal soccer-specific neuromuscular control • Quadriceps and hamstrings strength >85% of noninvolved limb • Hop index >80% of noninvolved limb	• No pain/swelling • Symmetrical ROM • Optimal soccer-specific neuromuscular control • Quadriceps and hamstrings strength >95% of noninvolved limb • Hop index >90% of noninvolved limb • Satisfactory Yo-Yo and RSSA test results
Goals of this phase	• Control pain/swelling • Improve ROM • Quadriceps activation • ADL activities	• Prepare basic soccer-specific neuromuscular control • Prepare the player for the more intense phase 3	• Optimize soccer-specific neuromuscular control • Prepare the player for return to team practice	• Bring the player back to unrestricted team practice, with full possession of his soccer skills and conditioning	• Final preparation of the player for the needs and demands of competitive soccer
Functional training†					
Additional training	• Strengthen noninvolved limb • Trunk and hip basic core stability exercises • Cardiovascular (upper-body ergometer)	• Core stability • Strengthen involved limb (open/closed chain) • Cardiovascular training (basic, bike) • Flexibility	• Core stability/strength • Strength training (body-machine exercise) • Cardiovascular soccer-specific training (interval, bike) • Flexibility	• Core stability/strength • Strength training (body-machine exercise) focused on addressing remaining deficits • Flexibility	• Continue additional training, in the form of a soccer-specific warm-up (11+)
Pool activities	• Gait training • Simple exercises (ROM, balance)	• Progression toward water running (wet vest) • Flexibility/ROM • Simulated basic soccer drills (heading the ball)	• Water running: endurance training		

Abbreviations: ADL, activities of daily living; ROM, range of motion; RSSA, repeated-shuttle-sprint-ability test; Yo-Yo, Yo-Yo intermittent recovery test.
**The timing of each phase is dependent on additional surgical procedures and individual progress in rehabilitation/training.*
†Details provided in the text.

Figure 3[22]: This chart includes recommendations for activity progression during the phase 3 sport-specific training of ACL reconstruction rehabilitation.

	Part 1	Part 2	Part 3
Level 1	Running: straight line a. Endurance (time/distance) b. Player-specific runs, midfield/center forwards distances c. Shorter distances d. Gradually increasing speed e. Forward/backward runs: 1:4 min run-rest ratio building up to 1:1 min (×4) and 2:1 (×3) to train the anaerobic lactate threshold. A long recovery time is needed between each set of exercises (4 min)	Passing Side footing: start with standing ball and move through the progressions, then progress to a moving ball both on the floor and on the volley. a. Short distances b. Longer distances c. Greater velocity on the pass	Dribbling a. Straight-line ball control b. Forward/backward turns c. Instep ball control d. Outstep ball control
Level 2	Running: figure-of-eight runs With the same progressions as straight line	Passing: forefoot (on the laces) a. Short distances b. Longer distances c. Greater velocity on the pass: same as with the side-foot pass once, moved through the progressions, progress to moving the ball on the floor first to eventually on the volley a. Volleys side foot/laces/outside of foot b. Volleys with quick-feet: incorporate quick-feet and volley to ladders/hurdles/left-right foot on command, quick reaction volley drills	Lateral dribbling movements a. Long distances b. Short distances c. At speed d. Side movement with the ball, changing direction on command, at speed
Level 3	Running: open lateral zigzag runs a. Endurance base with long turns b. Gradually reducing distance between cones c. Increase number of turns and increase speed of turn	Corners Goal kicks from the hands to on the floor Follow the above kicking progressions	
Level 4	Running: rotations a. Without the ball b. With the ball c. Including pass increase as with the above Progressions: endurance/distance/repetitions/speed	Free kicks Follow the above progressions on kicking the ball (distance/force/speed) Shooting As above with regard to progression	Rotation dribbling movements a. Long rotations with the ball at the feet b. Short rotations with the ball c. Quick, sharp turns with the ball to both left and right sides d. Sharp turns on receiving a pass or volley

Figure 4[22]: This figure shows an example of the Star Run Drill that can be used during phase 3 of the rehabilitation phase for elite female soccer players.



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