Can Talented Youth Soccer Players Who Have Undergone Anterior Cruciate Ligament Reconstruction Reach the Elite Level?

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Background: Anterior cruciate ligament (ACL) ruptures are common in soccer players, and reconstructive surgery is often performed to restore knee stability and enable a return to play.

Purpose: To investigate whether an ACL reconstruction for talented youth soccer players affects their potential to become elite players at the senior level.

Study Design: Cohort study; Level of evidence, 3.

Methods: All soccer players who participated in the Swedish National Elite Camp for 15-year-old players between 2005 and 2011 (N = 5285 players; 2631 boys and 2654 girls) were matched with the Swedish National Knee Ligament Registry to identify the players who had undergone ACL reconstruction. Information on player participation in Swedish league games and level of play was collected from the Swedish Football Association's administrative data system. The players with an ACL reconstruction who were injured at the ages of 15 to 19 years were compared with the rest of the players who participated in the National Elite Camp to see whether an early ACL reconstruction affected whether they remained active as soccer players and their chance to play at the elite level as seniors.

Results: A total of 524 (9.9%) players had undergone an ACL reconstruction, and 292 (5.5%; 75 male and 217 female) had sustained their injury at age 15 to 19 years. During the follow-up period, 122 (23.3%) players underwent ACL reconstruction: revision (11.5%; n = 60) or contralateral (11.8%; n = 62). Male and female soccer players undergoing an ACL reconstruction at age 15 to 19 years experienced no significant effect on being active or playing at the elite level in the season that they turned 21 years old. Of the youth players who underwent ACL reconstruction, 12% of the male players and 11.5% of the female players progressed to the elite level at the age of 21 years compared with 10.3% of the men and 11.1% of the women among the uninjured players.

Conclusion: ACL reconstructive surgery in talented youth soccer players offers them the opportunity to become elite players as seniors and permits an activity level on a par with that of their uninjured peers. However, almost 1 in 4 requires further ACL surgery, so the players' future knee health should be considered when deciding on a return to play.

Keywords: ACL; sports performance; soccer, football

An anterior cruciate ligament (ACL) injury is a common ligament injury among young soccer players. The high frequency of knee-straining movements makes soccer a high-risk activity for ACL injuries. This is reflected in the Scandinavian ACL registries, where 41% of the ACL injuries were reported to be caused by playing soccer.[7] A highly demanding pivoting sport such as soccer requires good knee stability, and for this reason, ACL reconstruction is recommended by most orthopaedic surgeons for players with a desire to return to play.[14] This is reflected in a study of male professional players by Waldén et al,[27] reporting that 138 of 140 (99%) players with total ACL ruptures underwent reconstructive surgery.

In an athletic population, one important measurement of the success of a surgical intervention is whether it enables a return to sports. For the players already at the elite level, the return rate is very high, with almost all players returning to soccer.[23,28,33] However, most soccer players who undergo ACL reconstruction do not play professionally. In a 10-year follow-up of soccer players from the Swedish National Knee Ligament Registry (SNKLR), only 1% played in the top division before the ACL injury. In contrast, 33% of all soccer players who underwent ACL reconstruction were $\leq$20 years old.[23] The same study also revealed that almost

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30% of the players who returned to soccer had a second ACL injury. Similarly, high rates of second ACL injuries are seen in young patients returning to pivoting sports.[31,32]

Given the high rate of further ACL injuries in young patients involved in pivoting sports, investigating whether it is possible for them to reach the elite level has been identified as being vital to giving them sound, evidence-based counseling regarding treatment and return to sports.[8] As such, we hypothesized that having an ACL reconstruction would have a negative effect on the chance of talented youth soccer players progressing to the elite level as seniors. In the present study, we aimed to contribute to this avenue of inquiry by investigating soccer-playing boys and girls who participated in the Swedish Football Association special U15 talent program. Specifically, we investigated the following research questions: (1) Does an ACL reconstruction for teenage soccer players affect their potential to remain as soccer players and to become elite players at the senior level? (2) Is the soccer career affected differently if the player is injured in the early or late teens? (3) Are players who belong to the youth team of an elite club at 15 years of age more prone to ACL injuries?

METHODS

Patient Selection

The present study follows up on male and female soccer players who participated in the Swedish National Elite Camp for 15-year-old players between 2005 and 2011. A total of 5285 players, 2631 boys and 2654 girls, born between 1990 and 1996 were included in the follow-up. By using the national identity number, the players were matched with the SNKLR to identify those who had had an ACL reconstruction. Information on player participation in Swedish league games and level of play was collected from the Swedish Football Association's (FA) administrative data system (FOGIS). The players with an ACL reconstruction who were injured when aged between 15 and 19 years were compared with the rest of the players who participated in the national development camps to see how an early ACL reconstruction affected whether they remained active as soccer players and their chance of playing at the elite level as seniors. The study was approved by the regional ethics board (2018/68-31 and 2019-01962).

Swedish National Knee Ligament Registry

The SNKLR was established in 2005 as a national surgical registry for the prospective data collection of knee ligament reconstruction and associated surgery. The surgeon enters information on the procedure and the occurrence of any associated injuries, such as meniscal and cartilage lesions. The registry also contains information on age, sex, etiology of the injury, date of injury and surgery, and patient-reported outcome measurements. More than 90% of all ACL reconstructions performed in Sweden are registered in the SNKLR.[26] The inception of the SNKLR in 2005 was used as the starting point for the follow-up of the soccer players from the National Elite Camp to make it possible to identify players who had had an ACL reconstruction.

National Elite Camp

Every year, each of the 24 soccer districts in Sweden identifies 16 boys and 16 girls from local clubs in the region with the potential to develop into elite soccer players. These district teams (ie, regional teams), which consist of 15-year-old athletes, play against one another at a national annual elite training camp. The players on the district teams serve as the recruiting base for building not only the national U15 teams but also future senior elite teams.[20]

Data Collection

FOGIS is the comprehensive administrative data system used by the Swedish FA. It is used for player licensing, player transfers, and the administration of cups and leagues. For this study, the following information was collected on all players who were born between 1990 and 1996 and participated in the National Elite Camp: the district in which they played, whether they played on the youth team for an elite club at the age of 15 years, whether they played for an elite team at the age of 21 years, and whether they were still active at the age of 21 years. Data were collected in 2018 and 2019. Date of birth has been found to influence the selection of children and youth to elite development systems as well as their future sporting careers.[2,18,25] To account for the influence of a possible relative age effect, the players were divided into 4 quartiles (Q1-Q4) according to when in the year they were born. The pool of participants in a region appears to be related to the potential to reach the elite level.[5] To adjust for the effect of the size of the district, the players were divided into 4 groups: D1 for the smallest district, ascending to D4 for players from the largest district (D1-D4).

Outcomes

The primary dependent variable in this study was whether the participants played on an elite senior team at the age of

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TABLE 1
Descriptive Statistics of the ACL Reconstructions for Soccer Players Who Participated in the Swedish National Elite Camp Between 2005 and 2011[a]

	Male (n = 2631)		Female (n = 2654)		Total (N = 5285)	
	No.	%	No.	%	No.	%
ACL reconstruction	173	6.6	351	13.2	524	9.9
Age, y[b]						
Injury	20.2 ± 3.0		18.4 ± 2.9			
Surgery	20.7 ± 3.0		18.9 ± 2.9			
Second ACL surgery						
Total	31	17.9	91	25.9	122	23.3
Revision	16	9.2	44	12.5	60	11.5
Contralateral	15	8.7	47	13.4	62	11.8
Age at time of injury, y						
15-19	75	2.9	217	8.2	292	5.5
15	3		47			
16	13		46			
17	13		48			
18	28		48			
19	18		28			
Age at injury for those playing at an elite club at age 21 y, y						
15-19	9	0.3	25	0.9	34	0.6
15	0		5			
16	3		3			
17	0		6			
18	4		7			
19	2		4			

[a]ACL, anterior cruciate ligament.
[b]Mean ± SD.

21 years, enabling us to investigate whether an early ACL reconstruction affects a player's chance of becoming an elite player. In this study, an elite team was defined as a team that played in 1 of the top 2 national divisions in the season in which the player turned 21 years old. The player had to participate in at least 1 official game for the team during the year. A secondary dependent variable was whether they were still active at 21 years of age, which was defined as the player participating in at least 1 official game during the year.

Statistics

All the statistical analyses were performed using SPSS Version 26 (IBM Corp). Descriptive statistics were calculated for all study variables. The outcome variables in the current study were binary, and as a result, we used multiple logistic regression to analyze the data. Adjusted odds ratios and 95% CIs were calculated for all the covariates that were included in the models. A P value $<.05$ was considered statistically significant. Separate analyses were conducted for female and male players to examine sex-specific associations.

RESULTS

Of the 5285 soccer players who had participated in the National Elite Camp, 524 (9.9%) had an ACL reconstruction registered in the SNKLR; 23.3% (n = 122) of those players had either a revision ACL reconstruction (11.5%; n = 60) or a contralateral ACL reconstruction (11.8%; n = 62). As compared with male players, twice as many female players had an ACL reconstruction. For 55.7% of the soccer players, the ACL injuries occurred between 15 and 19 years of age. More descriptive statistics are presented in Table 1.

During the season in which the players turned 21 years old, 570 (10.8%) players who participated in the National Elite Camp were playing at the elite level (296 female, 11.2%; 274 male, 10.4%). The analysis showed that having an ACL reconstruction during the ages of 15 to 19 years did not have a statistically significant effect on playing in an elite team at age 21 years (Tables 2 and 3). Among the players who had an ACL reconstruction at 15 to 19 years of age, 9 (12%) out of 75 male athletes and 25 (11.5%) out of 217 female athletes were playing on an elite team at 21 years of age. Playing for the youth team of an elite club at age 15 years was a strong predictor of playing for an elite club at age 21 years for male and female players. A reversed relative age effect was observed in the male players such that players born later in the year were more likely to play for an elite team at 21 years of age. For female players, birth quartile did not have a statistically significant effect on becoming an elite player. Players from larger districts at the age of 15 years were more likely to be playing at an elite level at 21 years of age.

TABLE 2
Multiple Logistic Regression: Elite Club Play at Age 21 Years for Male Soccer Players[a]

Category[b]	OR	95% CI		*P* Value
		LL	UL	
Elite club at age 15 y				
No (n = 2037; 77%)	Ref			
Yes (n = 594; 23%)	2.43	1.81	3.27	<.001
ACLR age, 15-19 y				
No (n = 2556; 97%)	Ref			
Yes (n = 75; 3%)	0.90	0.43	1.90	.786
Quartile				
Q1 (n = 1078; 41%)	Ref			
Q2 (n = 809; 31%)	1.41	1.02	1.95	.036
Q3 (n = 468; 18%)	1.50	1.04	2.18	.032
Q4 (n = 276; 10%)	2.40	1.58	3.66	<.001
District size				
D1 (n = 871; 33%)	Ref			
D2 (n = 549; 21%)	1.68	1.05	2.69	.032
D3 (n = 655; 25%)	2.02	1.32	3.08	.001
D4 (n = 556; 21%)	5.30	3.52	7.97	<.001

[a]Effect of playing in the youth team of an elite club at 15 years of age, ACLR age (15-19 years), district size, and relative age effect on playing in an elite club at 21 years of age for male soccer players (n = 2631). ACLR, anterior cruciate ligament reconstruction; LL, lower limit; OR, odds ratio; Ref, reference; UL, upper limit.
[b]Dependent variable: playing for an elite club at age 21 years (yes, 274 players [10%]; no, 2357 players).

TABLE 3
Multiple Logistic Regression: Elite Club Play at Age 21 Years for Female Soccer Players[a]

Category[b]	OR	95% CI		*P* Value
		LL	UL	
Elite club at age 15 y				
No (n = 2333; 88%)	Ref			
Yes (n = 320; 12%)	1.48	1.07	2.05	.017
ACLR age, 15-19 y				
No (n = 2436; 92%)	Ref			
Yes (n = 217; 8%)	0.96	0.62	1.50	.862
Quartile				
Q1 (n = 935; 35%)	Ref			
Q2 (n = 782; 30%)	1.09	0.79	1.49	.602
Q3 (n = 588; 22%)	1.29	0.93	1.79	.131
Q4 (n = 348; 13%)	1.20	0.81	1.79	.363
District size				
D1 (n = 882; 33%)	Ref			
D2 (n = 781; 29%)	1.79	1.23	2.60	.002
D3 (n = 550; 21%)	2.72	1.87	3.97	<.001
D4 (n = 440; 17%)	4.07	2.79	5.93	<.001

[a]Effect of playing in the youth team of an elite club at the age of 15 years, ACLR age (15-19 years), district size, and relative age effect on playing in an elite club at age 21 years for female soccer players (n = 2654). ACLR, anterior cruciate ligament reconstruction; LL, lower limit; OR, odds ratio; Ref, reference; UL, upper limit.
[b]Dependent variable: playing for an elite club at age 21 years (yes, n = 296 players [11%]; no, n = 2358 players).

The potential to be playing in an elite club at the age of 21 years was not significantly affected by whether the ACL injury occurred in the early or late teenage years (15-17 vs 18-19 years) (Table 4). Playing for the youth team of an elite club at 15 years of age, district size, and the quartile in which the players were born did not influence the risk of sustaining an ACL injury between 15 and 19 years of age for either sex (Tables 5 and 6).

In total 72% of the players were still actively playing soccer during the season in which they turned 21 years old. More male players than female players were still active (82% vs 63%). The analysis showed that an ACL reconstruction between the ages of 15 and 19 years did not have a statistically significant effect on whether the player was still active at 21 years. Girls playing for the youth team of an elite club at the age of 15 years were less likely to still be active later, whereas boys playing for the youth team of an elite club at the age of 15 years were more likely to be active later (Table 7).

TABLE 4
Multiple Logistic Regression: Elite Club Play at Age 21 Years Depending on Age of ACLR and Elite Club at Age 15 Years[a]

Category[b]	OR	95% CI		*P* Value
		LL	UL	
Elite club at age 15 y				
No (n = 235; 80%)	Ref			
Yes (n = 57; 20%)	2.76	1.24	6.13	.013
ACLR age, y				
18-19 (n = 122; 42%)	Ref			
15-17 (n = 170; 58%)	1.55	0.74	3.25	.250
Sex				
Male (n = 75; 26%)	Ref			
Female (n = 217; 74%)	1.33	0.56	3.16	.524

[a]Effect of playing for the youth team of an elite club at the age of 15 years, undergoing ACLR in early or late teens (age, 15-17 vs 18-19 years), and sex on playing in an elite club at age 21 years (n = 292). ACLR, anterior cruciate ligament reconstruction; LL, lower limit; OR, odds ratio; Ref, reference; UL, upper limit.
[b]Dependent variable: playing for an elite club at age 21 years (yes, n = 34 [12%]; no, n = 258).

DISCUSSION

The main finding in this study was that talented soccer players who had an ACL reconstruction between the ages of 15 to 19 years were as likely to be playing at an elite club at the age of 21 years as the other players who had participated in the National Elite Camp at 15 years of age. Whether the ACL injury occurred in the early or late teenage years (15-17 vs 18-19 years) was not a significant factor. In addition, the analysis showed that playing for the youth team of an elite club at 15 years of age, district size, and the quartile in which the players were

TABLE 5
Multiple Logistic Regression: ACL Injury Age 15-19 Years for Male Soccer Players[a]

Category[b]	OR	95% CI		*P* Value
		LL	UL	
Elite club at age 15 y				
No (n = 2037)	Ref			
Yes (n = 594)	1.44	0.83	2.51	.193
Quartile				
Q1 (n = 1078)	Ref			
Q2 (n = 809)	0.94	0.54	1.64	.836
Q3 (n = 468)	0.95	0.49	1.83	.872
Q4 (n = 276)	1.04	0.47	2.30	.919
District size				
D1 (n = 871)	Ref			
D2 (n = 549)	1.16	0.57	2.40	.680
D3 (n = 655)	1.49	0.78	2.84	.224
D4 (n = 556)	1.72	0.86	3.41	.123

[a]The effect of playing in the youth team of an elite club at the age of 15 years, district size, and relative age effect on the risk of ACL injury between the ages 15 and 19 years for male soccer players. ACL, anterior cruciate ligament; LL, lower limit; OR, odds ratio; Ref, reference; UL, upper limit.

[b]Dependent variable: ACL injury between the ages of 15 and 19 years (yes, n = 75 players; no, n = 2556 players).

TABLE 6
Multiple Logistic Regression: ACL Injury Age 15 to 19 Years for Female Soccer Players[a]

Category[b]	OR	95% CI		*P* Value
		LL	UL	
Elite club at age 15 y				
No (n = 2334)	Ref			
Yes (n = 320)	1.23	0.82	1.84	.318
Quartile				
Q1 (n = 935)	Ref			
Q2 (n = 783)	1.13	0.78	1.63	.517
Q3 (n = 588)	1.59	1.10	2.30	.013
Q4 (n = 348)	1.51	0.98	2.35	.063
District size				
D1 (n = 883)	Ref			
D2 (n = 781)	1.08	0.75	1.57	.670
D3 (n = 550)	1.44	0.99	2.11	.060
D4 (n = 440)	1.13	0.73	1.74	.577

[a]The effect of playing in the youth team of an elite club at the age of 15 years, district size, and relative age effect on the risk of ACL injury between the ages 15 and 19 years for female soccer players. ACL, anterior cruciate ligament; LL, lower limit; OR, odds ratio; Ref, reference; UL, upper limit.

[b]Dependent variable: ACL injury between the ages of 15 and 19 years (yes, n = 217 players; no, n = 2437 players).

born did not influence the risk of sustaining an ACL injury between 15 and 19 years of age for either sex. It appears that the ACL reconstruction restores knee function sufficiently for the players to return to soccer to compete at a similar level to that of their peers and that the long rehabilitation period does not mean that the players fall too far behind. However, even for this cohort of players, considered to be the best in the country at 15 years of age, the likelihood of playing at the elite level at 21 years of age was 1 in 10. A total of 34 players, 9 male and 25 female, who had an ACL reconstruction between the ages of 15 to 19 years played at the elite level at the age of 21 years. Participating at the elite level at the age of 21 years does not necessarily mean that the players will establish themselves at the elite level and have careers as professional players; a large step still remains to reach the national team and the highest echelon of the sport.

In a study of patients <20 years old who underwent ACL reconstruction, 65% of those returning to their preinjury levels of sports reported that they believed they could perform as well as before the injury.[31] Among professional players, studies have suggested that the statistical playing performance and career length decrease after a return to soccer.[3,17,27] We are, however, unaware of any previous study of how ACL reconstructions in teenage patients affect the opportunity to become elite athletes as adults. One of the main strengths of the present study was the large number of soccer players <20 years of age who underwent ACL reconstruction, as identified within a large well-defined cohort of young talented soccer players with a high probability of reaching the elite level. The high inclusion rate in the SNKLR and the coverage of all national soccer activities by the Swedish FA made it possible to obtain reliable data on the ACL surgery, level of

TABLE 7
Multiple Logistic Regression: Soccer Players Still Active at Age 21 Years[a]

Category[b]	OR	95% CI		*P* Value
		LL	UL	
Male (n = 2631)				
Elite club at age 15 y				
No (n = 2037)	Ref			
Yes (n = 594)	1.33	1.04	1.71	.025
ACLR age, 15-19 y				
No (n = 2556)	Ref			
Yes (n = 75)	1.43	0.73	2.81	.296
Female (n = 2654)				
Elite club at age 15 y				
No (n = 2334)	Ref			
Yes (n = 320)	0.65	0.51	0.82	<.001
ACLR age, 15-19 y				
No (n = 2437)	Ref			
Yes (n = 217)	0.89	0.67	1.19	.439

[a]The effect of playing for the youth team of an elite club at the age of 15 years and undergoing ACLR at the age of 15-19 years on still playing soccer at age 21 years for male and female soccer players. ACLR, anterior cruciate ligament reconstruction; LL, lower limit; OR, odds ratio; Ref, reference; UL, upper limit.

[b]Dependent variable: men active at age 21 years (yes, n = 2148 players [82%]; no, n = 483 players); women active at age 21 years (yes, n = 1662 players [63%]; no, n = 992 players).

play, and future soccer activity among the players from the National Elite Camps.

One in 10 soccer players in the present study had had an ACL reconstruction in the follow-up. This should be a matter of concern for the young players and coaching staff and highlights the need to broadly implement the preventive programs that have been proven to reduce the risk of ACL injuries by roughly 50%.[9] We found that twice as many female players had an ACL reconstruction in total and 3 times as many in the age group of 15 to 19 years. This higher risk of ACL injuries in female soccer players is consistent with that reported in the literature.[13,16,22] The female players were about 2 years younger on average when they sustained their ACL injury, which is similar to previous data from the SNKLR.[1,11]

Return to play is often presented in outcome studies of soccer players who underwent ACL reconstruction, and the return rates vary with the level of play and age, with younger players and elite players more likely to return to soccer.[4,23,28,33] Long-term soccer participation is less well-studied and seldom includes a control group, which would provide a context and help us understand the significance of the activity level presented. In professional male players, 86% were still playing 3 years after an ACL reconstruction,[27] and in a study of soccer players from the United States, 38% of the male athletes and 31% of the female athletes were still playing 7 years after ACL reconstruction.[4] In a study of female soccer players, which included a matched control group, the players with ACL reconstructions were reported to be more likely to have quit playing at the 2-year follow-up than players without ACL reconstruction.[6] Knee-related physical issues and fear of reinjury are often reported as reasons for not returning to or quitting soccer.[10,23,24] In this study, we found a decline in the number who were still active over time, but that decline was not significantly affected by whether the player had had an ACL reconstruction. For individual players, the reason for quitting soccer may well be entirely related to their knee, but for most, regardless of ACL injury, it is most likely multifactorial. Even in this group of talented young soccer players, just 72% were still active at the age of 21 years. The activity levels were considerably lower in the female players, which is consistent with previous studies of dropouts from soccer.[15]

This study shows that it is possible for young soccer players with ACL reconstructions to reach the elite level as adults, but that chance is fairly small for any young soccer players, regardless of whether or not they have had surgery. Only 1 in 10 of these, the best players in the country at 15 years of age, participated in at least 1 game in 1 of the top 2 national divisions at the age of 21 years. We found that roughly 1 in 4 of the soccer players with ACL reconstructions had undergone a second ACL operation. This follow-up does not include the entire careers of the players and includes only surgically treated injuries, so the true rate of further ACL injury is likely even higher. This very high risk of further ACL injury for young athletes and players returning to soccer after ACL reconstruction is well-documented in the previous literature.[19,23,29,30,32] The small chance of becoming a professional soccer player and the serious concerns for future knee health after ACL reconstruction must be considered by the player and the medical professionals when deciding on a return to play.

Limitations

One limitation was that we were able to follow soccer players only in the national divisions. That means that players who had moved abroad to play soccer would be deemed no longer active according to the method used in the study. Furthermore, because of clerical errors (eg, national identity numbers filled out incorrectly), not all players from the National Elite Camp could be identified. If all the districts sent a full squad to all the camps, a total of 5376 would have participated over the years, which means that we have a potential loss to follow-up of 1.7%. However, given the large number of players followed in this study, we believe that these minor uncertainties did not significantly affect the results obtained.

This study is limited to the follow-up of the early part of the players' soccer careers, so the effect of the ACL reconstructions on the longevity of the playing career for those who reach the elite level could not be determined. Now that we have seen that the youth players with ACL reconstructions are able to reach the elite level, a longer follow-up of the same cohort in a future study would provide a more comprehensive answer to the way that an entire soccer career is affected by an early ACL reconstruction. In addition, the small number of players reaching the elite level after ACL reconstruction limits the power in some of the analyses, and the lack of preregistration prohibited us from determining if the nonsignificant effects indicate statistical equivalence or an inconclusive outcome. We encourage researchers to preregister the smallest effect size of interest and its corresponding equivalence bounds[21] in future studies to be able to determine if nonsignificant effects indicate statistical equivalence (eg, no meaningful effect of ACL reconstruction) or an inconclusive outcome.[12]

CONCLUSION

ACL reconstructive surgery in talented youth soccer players offers them the opportunity to become elite players as seniors and permits an activity level on a par with that of their uninjured peers. However, almost 1 in 4 requires further ACL surgery, so the players' future knee health should also be considered when deciding on a return to play.

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