



# Return to sport activity after anterior cruciate ligament reconstruction: A 6–10 years follow-up

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## ABSTRACT

**Background:** Nowadays, patients widely accept anterior cruciate ligament (ACL) reconstructive surgery. However, its long-term complications are still under investigation in athletes. Therefore, the aim of this study was to evaluate long-term ACL reconstruction especially in athletes.

**Methods:** A total of 426 patients with ACL injury were studied during 2008–2012. Demographic characteristics (gender, age, BMI), graft type, chondral lesion, osteoarthritis, meniscus tear, exercise activity, and pain intensity were noted. The effects of these factors on the return to sport activity after ACL reconstruction were also investigated. Lachman test, KT-1000, ACL quality of life (ACL-QOL), KOOS score, IKDC, and LKS were assessed at 2 years post-operation and at final follow-up. Repeated ACL rupture on the same and contralateral sides were also evaluated.

**Results:** knee stability (based on Lachman and KT-1000), knee function (according to KOOS, LKS, and IKDC scores) and ACL-QOL were improved during the 2 years follow-up. The rate of return to sport activity similar to preinjury in patients was 64.08% in final follow-up. Chondral lesion was a limiting factor among the variables that affected the return to sport activity. It caused a return to sport activity similar to pre injury just in 21.24% of the patients. However, meniscus rupture did not affect return to sport activity similar to pre injury. Also, the rate of return to sport activity similar to pre injury was higher in men, patients under 30 years and those who had BMI of 20–25 kg/m<sup>2</sup>. In final follow-up, risk of ACL rupture in the injured knee and contralateral knee was 4.22% and 10.57%, respectively.

**Conclusion:** Despite the recovery of patients after ACL reconstruction during long-term follow-up in athletes, return to sport activity similar to pre-injury in female, older peoples, overweight patients and athletes with chondral lesion were lower. However, these conditions do not apply to the meniscus rupture.

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## 1. Introduction

The time to return to sport is a big challenge for athletics with ACL tear and their physicians. The return to sport can be affected by various factors such as associated lesions, knee pain rate and the type of graft. Several studies have reported different results regarding the effects of chondral lesion and meniscus rupture on the return to sport activity in patients with ACL rupture.<sup>1,2</sup> The results of most studies show that lateral meniscectomy and grade 3–4 of the chondral lesion cause more movement restriction and

pain in patients with ACL rupture.<sup>3</sup> Most athletes with ACL rupture need reconstructive surgery and they should be away from the sport activity for at least six months after surgery.<sup>4</sup> Most studies have focused on surgical techniques of ACL reconstruction with low number of patients. Rates of return to preinjury sport activity are different between various studies.<sup>5,6</sup> A recent systematic review showed that the rate of return to preinjury sport or unlimited activities was 54% after ACL-reconstruction (ACL-R).<sup>7</sup> The rate of return to sport activity was reported as 36% and 74% in the other two studies. Therefore, getting clear information about returning to sport activity after ACL-R and its effective factors is essential.<sup>6</sup> In addition, some studies have reported certain complications such as knee osteoarthritis (OA) and limitation in flexion and extension in the long-term follow-up of ACL-R.<sup>8</sup> Also, some studies have evaluated the relationship between the underlying factors such as age,

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time to return to sport activity, presence of chondral damage or meniscus rupture, type of graft used which affecting these long-term outcomes.<sup>9–11</sup>

Regarding the high incidence of ACL tear in athletes and its subsequent ACL reconstruction, we aimed to investigate the return to sport activity after ACL-R. In addition to examining the effect of chondral damage and meniscus rupture in returning to sport activity after ACL-R, we evaluated the factors affecting the desirable and undesirable results of this conventional therapeutic approach. The results of this study may help orthopedic surgeons to find a better and realistic perspectives of the ACL-R outcome in long term follow up.

## 2. Patients and methods

### 2.1. Study protocol

This study was a retrospective observational study. All patients who underwent surgical treatment for ACL rupture at our academic orthopedic center from 2008 to 2012 and at least 6 years have passed since their surgery were investigated. All patients were operated by the first author as orthopedic surgeon. First, the records of all patients who had been operated at this time period were examined. The inclusion criteria were age more than 16 years and being athletes at regular and/or irregular levels with complete medical record and providing consent form to participate in this study. Exclusion criteria were previous history of any knee surgery and symptomatic ankle or hip. Among 754 patients, 502 patients had complete information and their data was further evaluated.

### 2.2. Formulation of the questionnaire

The variables extracted from patients' records include age, sex, surgical time, type of sport activity, athletic group, simultaneous injury of internal and external meniscus at the time of surgery, obvious chondral damage during surgery, evidence of OA in pre-operative radiographic images before surgery and graft type (allograft of Achilles tendon/4-layer hamstring autograft). In all allograft and autograft patients, ACL-R was done by arthroscopy. The endobutton on the femoral side and the bioabsorbable (Orthomed) interface screw were used to fix the graft. Patients were divided into two groups based on sport activity as regular sports activities and irregular sports activities. Also, group of regular sports activities was divided into 5 subgroups based on the type of sport activity as football, martial arts, wrestling, ball sports including volleyball, basketball and handball, and other sports.

### 2.3. Follow-up

All patients were recalled by phone call after at least 6 years (range 6–10 years) to the orthopedic clinic for follow-up. Among 502 eligible patients, 426 patients returned and repeated ACL rupture on the same and other sides, time to return to sport activity, the quality of return to sport activity as similar to preinjury, weaker, or unable to exercise, knee pain during kneeling and anterior knee pain were evaluated. Also, the effect of underlying factors such as age, sex, BMI, chondral damage, meniscus rupture and graft type used in the quality of return to sport activity in athletes were evaluated. In addition, we used Lachman test and KT 1000 arthrometer to assess the knee stability, IKDS and Lysholm knee score (LKS) score for evaluation of knee function, and ACL quality of life score (ACL-QOL) and KOOS test for assessing the quality of life. The presence of OA was evaluated based on radiological evidence and Kellgren Lawrence grading as Grade I, small osteophytes; Grade II, mild OA with 50% narrowing of the articular space; Grade III,

moderate OA; and Grade IV, severe OA. Also, our protocol was that if the quadriceps and hamstring muscles were more than 90% similar to those of the opposite side muscles, the patient would be allowed to exercise.

### 2.4. Statistical analysis

Data was collected and analyzed using SPSS software version 21. The frequency and 95% confidence interval were used to report the frequency of ACL damage. Chi-Square test was used to compare the frequency and presence of ACL rupture in the first-degree family.  $P < 0.05$  was considered as significant difference.

## 3. Results

In this study, 426 patients with ACL rupture, who referred to the orthopedic center during 2008–2012 and had at least 6 years of follow-up been studied. Of the 426 completed questionnaires, 319 (74.89%) were male and 107 (25.11%) were female. The mean follow-up time was  $8.1 \pm 2.03$  years (range 6–10 years) and the mean age of patients was  $27.2 \pm 0.84$  years. The age range of 20–30 years was the highest age group and patients over 50 years of age was the lowest age group (Table 1).

Patients were evaluated for chondral lesion, meniscus rupture and presence of OA. Among patients with ACL rupture, 275 (64.55%) patients had meniscus rupture in addition to the ACL rupture. Of these, 174 subjects (63.27%) had medial and 101 (36.72%) had lateral meniscus rupture. The type of surgery and graft used was different for patients. Achilles tendon allograft was used in female, patients with high BMI and patients with revision (12%). The rest of the patients were reconstructed using 4-layer hamstring tendon (Table 2).

The quality of return to sport activity, the degree of repeated ACL rupture on the same and other sides were also evaluated (Table 3). We found that pain during kneeling and anterior knee pain in patients 2 years after ACL-R and in final follow-up decreased from 2.82% to 3.75%–1.64% and 2.34%, respectively.

In the clinical evaluation of patients with ACL rupture, we found that patients at two years after ACL-R and in the final follow-up had a significant improvement in IKDC and LKS scores as functional measures of knee compared to pre-operative time ( $P = 0.001$ ). Also, ACL-QOL and KOOS score were increased compared to pre-operative time based on his patient self-report (Table 4). In terms of objective criteria and based on Lachman and KT 1000 tests, we observed acceptable outcomes about knee laxity for long-term follow-up ( $P = 0.001$ , Table 4).

In the athlete's patients, the mean time of return to sport activity after ACL-R was 8 months. In addition, among 426 patients with regular and irregular sport activity 251 (58.92%) patients after 2 years and 273 (64.08%) patients in the final follow-up returned to sport activity similar to preinjury (Table 5). Based on Table 5, it was found that the underlying factors such as sex, age, BMI, chondral lesion, and OA, meniscus rupture and graft type used have different effects in returning to sport activity. Male were almost 1.5 times more likely than female returned to sport activity similar to preinjury at two years after ACL-R and in the final follow-up. Patients in the age group under 30 years were more than 2 times more likely to return to sport activity similar to preinjury than those of other age groups. About BMI, the group with BMI of 20–25 kg/m<sup>2</sup> was about 2 times more likely to return to sport activity similar to preinjury than the other groups. Averagely, 17.33% of patients with chondral lesion were able to follow their sport activity similar to preinjury and were mostly weaker or less active in the last follow up. However, for patients with meniscus rupture, 72.72% of patients performed sport activity similar to preinjury, which was similar to

**Table 1**

Demographic features of all patients with ACL tear.

variable	category	Number(%)
<b>Sex</b>	M/F	319/107
	Total	426
<b>Age (year)</b>	≤30	264(61.97%)
	30–40	102(23.7%)
	40–50	44(10.32%)
	>50	16(3.75%)
<b>BMI (kg/m<sup>2</sup>)</b>	<20	39(9.15%)
	20–25	206(48.35%)
	25–30	120(28.16%)
	30–35	46(10.79%)
	>35	15(3.52%)
<b>Sports activity level</b>	Regular sports activities	<b>Sports type</b> Soccer Basketball and volleyball Martial sports wrestling other Total 290(68.07%)
	Irregular sports activities	136(31.93%)

**Table 2**

Combined injuries of all patients with ACL tear.

variable	category	Number (%)
<b>The level of chondral lesion</b>	Medial Femur	<b>*G1</b> 21(4.92)
	Lateral femur	<b>G2</b> 5(1.17)
	Medial tibia plateau	<b>G3</b> 8(1.87)
	Lateral tibia plateau	<b>G4</b> 5(1.17)
	Patellae	4(0.9)
		3(0.7)
<b>Meniscus tear</b>	Lateral	101(36.72)
	Medial	174(63.27)
	Total	275(64.55)
<b>Osteoarthritic</b>	Grade I	22(5.16)
	Grade II	8(1.87)
	Grade III	—
	Grade IV	—
<b>Graft</b>	Hamstring autograft tendon	375(88.02)
	Achilles allograft tendon	51(11.98)

**Table 3**

Quality of exercise, repeated ACL rupture and pain in all patients with ACL tear.

		2 years after surgery	Last follow up	P
		N (%)	N(%)	
Quality of exercise	Similar	251(58.92%)	273(64.08%)	0.001
	Weaker	109(25.58%)	94(22.06%)	
	Not sport	66(15.49%)	59(13.84%)	
Repeated ACL rupture on the same side		16(3.75%)	18(4.22%)	0.243
Repeated ACL rupture on the other side		36(8.45%)	45(10.56%)	0.033
Pain during kneeling		12(2.81%)	7(1.64%)	0.071
Anterior knee pain		16(3.75%)	10(2.34%)	0.048

**Table 4**

Objective and subjective analysis.

Time	KT-1000 (mm)	ACL-QOL	Lachman (0, +1, +2, +3)	KOOS score	IKDC	LKS
Before	1.09 ± 6.82	3.64 ± 62.29	(0,0,106,320)	4.99 ± 50.86	4.46 ± 75.23	4.63 ± 73.69
2 years after surgery	1.12 ± 2.38	6.02 ± 78.88	(346,72,5,3)	5.31 ± 81.54	5.62 ± 89.09	5.78 ± 87.02
Last follow up	0.89 ± 1.86	4.79 ± 91.55	(366,47,8,5)	4.34 ± 92.32	5.04 ± 95.10	5.10 ± 94.52
P	0.001	0.001	0.001	0.001	0.001	0.001

**Table 5**  
Demographic features of all patients and rate of return to sport activity.

variable			Quality of exercise					
			2 years			Last follow up		
			Similar (N/%)	Weaker (N/%)	Not sport (N/%)	Similar (N/%)	Weaker (N/%)	Not sport (N/%)
Number of patients			251(58.92)	109(25.58)	66(15.49)	273(64.08)	94(22.06)	59(13.84)
sex	M	319	203(63.63)	77(24.13)	39(12.22)	68(65.21)	65(20.37)	35(10.97)
	F	107	48(44.85)	32(29.9)	27(25.23)	54(50.46)	29(27.1)	24(22.42)
	P		0.001			0.001		
age	≤30	264	177(67.04)	55(20.83)	32(12.12)	195(73.86)	46(17.42)	23(8.71)
	30–40	102	50(49.01)	31(30.39)	21(20.58)	56(54.9)	27(26.47)	19(18.62)
	40–50	44	19(43.18)	18(40.9)	7(15.9)	18(40.9)	15(34.09)	11(25)
	>50	16	5(31.25)	5(31.25)	6(37.5)	4(25)	6(37.5)	6(37.5)
	P		0.001			0.001		
BMI	≤20	39	16(41.02)	15(38.46)	8(20.51)	21(53.84)	10(25.64)	8(20.51)
	20–25	206	152(73.78)	40(16.41)	14(6.79)	160(77.66)	34(15.5)	12(5.82)
	25–30	120	57(47.5)	34(28.33)	29(24.16)	63(52.5)	31(25.83)	26(21.66)
	30–35	46	19(41.3)	16(34.78)	11(23.91)	23(50)	13(28.26)	10(21.73)
	35<	15	7(46.66)	4(26.66)	4(26.66)	6(40)	6(40)	3(20)
	P		0.001			0.001		
Graft	Hamstring autograft tendon	375	231(61.6)	98(26.13)	46(12.26)	257(68.53)	75(20)	43(11.47)
	Achilles allograft tendon	51	18(35.29)	11(21.56)	22(43.13)	16(31.37)	19(37.25)	16(31.37)
	P		0.001			0.001		
Chondral lesion	Medial Femur	33	5(15.15)	12(36.36)	16(48.48)	6(18.18)	9(27.27)	18(54.54)
	Lateral femur	5	1(20)	1(20)	3(60)	1(20)	0	4(80)
	Medial tibia plateau	20	3(15)	7(35)	10(50)	2(10)	6(30)	12(60)
	Patellae	17	4(23.52)	5(29.41)	8(47.05)	4(23.52)	3(17.64)	10(58.82)
	P		0.055			0.036		
meniscus	Lateral	101	68(67.32)	21(20.79)	12(11.88)	79(78.21)	12(11.88)	10(9.90)
	Medial	174	109(62.64)	44(25.28)	21(12.06)	121(69.54)	36(20.68)	17(9.77)
	P		0.01			0.01		
OA	Grade I	22	12(54.54)	6(27.27)	4(18.18)	14(63.63)	6(27.27)	2(9.09)
	Grade II	8	2(25)	2(25)	4(50)	2(25)	1(12.5)	5(62.5)
	P		0.156			0.184		

those patients who did not have a meniscus rupture. Patients with OA also had a lower level of return to sport activity with increasing the OA grade. About the type of graft used, the patients with hamstring autograft compared to the Achilles tendon allograft were 1.5 times more likely to return to sport activity similar to preinjury. This may be due to the condition of the patients in the hamstring group. Patients' characteristics are presented in Table 5.

The risk of repeated ACL rupture on the same and other sides in two years after ACL-R was 3.76% and 8.45%, which increased to 4.22% and 10.56% in the final follow-up, respectively. Our results showed that the risk of ACL rupture of the same and other sides in female was >1.5 times more than male, which increased to three times in the final follow-up. Moreover, certain factors such as age, BMI, and level of sport activity were associated with repeated ACL rupture on the same and other sides. Patients in the age group of under 30 years had a three times increase in repeated ACL rupture on the same and other sides two years after ACL-R and in the final follow-up (Table 6). Also, repeated ACL rupture was higher in patients with BMI of 20–25 kg/m<sup>2</sup> and in patients with regular sport activity than other patients (Table 6).

#### 4. Discussion

This study was designed to long-term followed up ACL rupture in athletes and investigate the effects of various factors in returning to sport activity in these patients. Also, we tried to evaluate the effects of chondral lesion and meniscus rupture in addition to the underlying factors in returning to sport activity and the possibility of repeated ACL rupture on the other side. As the main finding of this study, we found that about 80% of patients with ACL-R and

chondral lesion had lower function and lower return to sport activity in comparison with those with no or less change. In the other words, only 20% of patients with chondral lesion were able to return to the sport activity similar to pre injury. Interestingly, more than 70% of patients with meniscus rupture were able to return to sport activity at final follow-up and there was no significant difference between patients with and without meniscus rupture in returning to sport activity. Furthermore, accurate and complete evaluation of the return rate to sport activity was not possible in patients with OA, especially high grade of OA, because they are not surgically treated. Anthony et al. reported that patients with meniscus rupture could perform sport activity similar to preinjury after specific exercises.<sup>12</sup> Various studies reported different rate of return to sport activity after chondral lesions. For instance, Webster et al. found that patients with chondral lesion, especially those with grades 3 and 4, had a lower return to the sport activity similar to pre injury.<sup>3</sup> However, Tandogan et al. reported that there was no significant relationship between the level of sport activity and the severity of meniscus rupture and chondral lesion.<sup>13</sup> It seems that pain and with low importance risk aversion, fear of recurrence or inability are the main reasons for this lack of returning to the sport activity similar to preinjury. However, further studies are needed to investigate these reasons.

Most of 426 patients with an ACL rupture in an 8-years follow-up (61.72%) were soccer players. After that, basketball and volleyball, martial arts and wrestling were the most vulnerable sports for the ACL rupture. Due to the popularity of football at our area and the more willingness of male than female to do this sport, the number of soccer players was higher in this study. Knee injury is one of the most common injuries in soccer players and the ACL

**Table 6**

Demographic features of all patients and patients with repeated ACL rupture on the same side and on the other side.

		Full of the patients	Repeated ACL rupture			
			on the same side		on the other side	
			2 years after surgery	Last follow up	2 years after surgery	Last follow up
		N(%)	N(%)	N(%)	N(%)	N(%)
Number of patients		426(100)	16(3.76)	18(4.22)	36(8.45)	45(10.56)
Sex	male	352(82.62)	12(3.40)	14(3.97)	24(6.81)	30(8.52)
	female	74(17.37)	4(5.40)	4(5.40)	12(16.21)	15(20.27)
	P	—	0.714		0.006	
Age (years)	≤30	264(61.97)	11(4.16)	12(4.54)	25(9.46)	31(11.74)
	30–40	102(23.94)	3(2.94)	4(3.92)	5(4.90)	8(7.84)
	40–50	44(10.32)	1(2.27)	1(2.27)	2(4.54)	3(6.81)
	>50	16(3.75)	0	1(6.25)	1(6.25)	1(6.25)
	P	—	0.075		0.023	
BMI	≤20	39(9.15)	1(2.56)	2(5.12)	8(23.25)	8(17.77)
	20–25	206(48.35)	9(4.36)	12(5.82)	20(55.55)	23(51.11)
	25–30	120(28.16)	3(2.5)	3(2.5)	7(19.44)	13(28.89)
	30–35	46(10.79)	1(2.17)	1(2.17)	1(2.17)	1(2.17)
	>35	15(3.52)	0	0	0	0
	P	—	0.565		0.011	
Sports activity level	Regular sports activities	290(68.07)	12(4.13)	13(4.48)	27(9.31)	33(11.37)
	Irregular sports activities	136(31.92)	4(2.94)	5(3.6729)	9(6.61)	12(8.82)
	P	—	0.133		0.035	

rupture comprises 2% of the total damage. In a study in 2018, Schiffner et al. by examining ACL rupture in athletes, especially in soccer players, showed that football is one of the most important sport activity in the development of ACL rupture.<sup>14</sup> Based on the report of Walden et al. the incidence rate of ACL rupture in the professional soccer players was 0.066 per 1000 h playing. They expressed that 54% of ACL rupture were due to sudden rotation not contact. While other ACL ruptures were due to contact events such as collisions and tackles.<sup>15</sup> On the other hand, it has been reported that sports with sudden rotation such as basketball and volleyball and engaging sports (martial arts) are the sports which prone to ACL rupture.<sup>16</sup> In the evaluation of the risk of ACL rupture in basketball, volleyball and handball players, Vauhnik et al. reported that basketball and volleyball players had the greatest and lowest risk of ACL rupture.<sup>17</sup>

Various studies have reported patients' satisfaction in mid- and long-term follow-up after ACL-R.<sup>18,19</sup> Based on our results, the KT-1000 and Lachman tests as indices of knee stability improved significantly at two year and final follow-up after ACL-R compared to pre-surgery. Also, IKDC and LKS values as well as ACL-QOL and KOOS scores were improved at two years and final follow-up after the ACLR. In similar study, Struwer et al. evaluated the rate of ACL-R using hamstring grafts at two and 10 years follow-ups. They reported that 81% of patients experienced good improvement based on IKDC score after 10 years of reconstruction. Moreover, knee stability based on KT-1000 was less than 3 mm in 70–90% of their patients which comparable with 1.1 mm in final follow-up of our patients(8). Mahmoud et al. also in the 60 months follow-up of patients with ACL-R reported that QOL and KOOS score were improved compared to pre-surgery.<sup>4</sup>

In our study, female had a lower proportion of ACL rupture, which may be related to being less athletic and less at risk of female in our population. On the other hand, the risk of repeated ACL rupture on the same and other sides in the final follow-up was almost three times more likely than male. Based on the Paterno study, the ACL rupture in the other side can be associated with the genetics in addition to the type of patients' movement after ACL-R.<sup>20</sup> Other studies have suggested that the area of intercondylar fossa is also important and some people are congenital and

anatomical are susceptible to ACL rupture.<sup>21</sup> Although the ACL rupture in the same knee at 2 years after ACL-R can be due to lack of appropriate physiotherapy and muscle strengthening, early onset of sport activity or surgical defect, its occurrence at several years after the ACL-R may occur due to sports incidents.

Based on our results in the final follow-up, we found that 68.65% of male versus 50.46% of female were able to return to sport activity similar to preinjury. Therefore, male about 1.5 times more than female can continue their sports activities similar to preinjury. Certain studies have reported that female athletes are more at risk for ACL rupture. Chadwic et al. found that female compared to male almost 3 times more likely to experience ACL rupture in some sports such as basketball and football.<sup>20</sup> In a similar study, it was reported that the rate of return to sport activity in male and female was 81% and 71%, respectively.<sup>22</sup> Female are more susceptible to ACL damage than male due to thinner and weaker ACL with smaller diameter and volume, which also had less reactionability. For these reasons, female less than men may be able to return to sports activities after ACL rupture.<sup>23</sup> Despite the low number of female athletes in our study, a significant increase and triple likelihood of ACL rupture in the other side in female compared to male may be represented a genetic susceptibility to ACL rupture in female against male. ACL rupture in the same knee in female can also be due to the weakness of the ACL and inappropriate care after ACL-R. Limited studies have been done to compare the return to sport activity in male and female and most of studies have focused on return to sport in men and women separately.<sup>24</sup>

Our results showed that most patients who were able to continue sport activity similar to preinjury at 2 years and final follow-up were in the age group of 20–30 years. Also, the repeated ACL rupture on the same and other sides in age group of 20–30 years was more than other age groups. It can be said that more physical activity and athletics of young people are the cause of more ACL-rupture in these patients. Due to increased activity and also due to the mechanism of ACL rupture, the risk of repeated ACL rupture on the same and other sides is higher in young people. Furthermore, ACL rupture of the same knee in younger patients may be due to early onset of sport activity and lack of appropriate care. The most common mechanism of ACL rupture is



hyperextension or external rotation of knee along with knee valgus. In these conditions, the upper extremity of the tibia is driven forward to the thigh or the knee moves heavily to the back.<sup>25</sup> Remarkably, our patients with regular sport activity were more likely to have repeated ACL rupture on the same and other sides. These were three times higher than patients with irregular sports activities and 9 times higher than those with sports inactivity. This indicates the significant effect of sports activities on the recurrent ACL rupture.

After an ACL rupture in athletes, younger patients returned to sport activity more than other age groups. In a study by Webster et al. on the return to sport activity after ACL rupture in athletes, 76% of young patients returned to the sport activity similar to preinjury.<sup>26</sup> Ardern et al. showed that patients who could return to preinjury sport were 3 years younger than patients who could not.<sup>3</sup> It seems that patients with higher age cannot return to sport activity similar to preinjury due to increased age, decreased activity and psychological reasons such as fear of returning to sports activities and injury. Due to muscle atrophy and lower activity levels in patients with higher age, usually their activities are lower than preinjury. Obesity also is considered as a risk factor for injuries of musculoskeletal tissues. Indeed patients with high BMI are at greater risk for ACL rupture.<sup>27</sup> However, our patients with normal BMI of 20–25 kg/m<sup>2</sup> had more ACL rupture due to good activity and being athletes. Additionally, the repeated ACL rupture on the same and other sides in patients with BMI of 20–25 kg/m<sup>2</sup> was approximately 3 times higher than other patients, which can be related to the athleticism of our patients. On the other hand, our results showed that patients with normal weight were more likely to return to sport activity. It has been confirmed that athletes with normal BMI are more likely to return to sport activity than those with high BMI due to their physical strength and greater activity after injury.

As a bias, returning to sport activity similar to preinjury was higher in patients who used hamstring autograft compared to those who used the Achilles allograft for ACL-R. This may be due to use of Achilles allograft in patients with high BMI and revision. Therefore, the return of these patients to sport activity is less than the group treated with hamstring autograft and are not related to the type of graft.

Generally, evaluation of athletes with ACL rupture showed that most athletes could return to sport activity similar to preinjury after ACL-R naturally after the treatment period and passing several years. Although we attempted to investigate more patients in this study, there was no possibility to further investigation and perform MRI. Also, due to the lower number of patients with chondral lesion and meniscus rupture, further investigation was not possible. Other limitations of this study the inability to investigate objective assessment tools such as single hop, triple hop, side hop test and isokinetic testing. Certainly, by performing a more complete study and obtaining more accurate results, it can be confidently decided on the effect of various factors in relation to ACL rupture in athletes and their return to sport activity similar to preinjury.

## 5. Conclusion

This study showed that long-term results of ACL-R in athletes are satisfactory and meniscus rupture had no significant effect on returning to sport activity similar to preinjury. However, female, people with overweight, and athletes with chondral lesion had lower rate of return to sport activity similar to preinjury.

## Declaration of competing interest

The authors declare that they have no conflict of interest.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jcot.2019.09.023>.

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