

## Research Paper

# Impact of Treatment Strategy on Knee Function, as Well as Physical and Psychological Health, of Athletes with an Anterior Cruciate Ligament Tear



Aynollah Naderi<sup>1</sup>, Narges Manafi Anvar<sup>2\*</sup>

1. Associate Professor, Faculty of Sport Science, Shahrood University of Technology, Shahrood, Semnan, Iran.
2. MSc student of sports injuries and corrective exercises, University Colleague Omran and Tosee, Hamadan, Iran.



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ACL reconstruction  
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## ABSTRACT

**Aims** The present study aimed to compare knee function, as well as physical and psychological health, of athletes who underwent conservative treatment with those who underwent anterior cruciate ligament (ACL) reconstruction.

**Methods & Materials** This cross-sectional study was conducted on 31 athletes with a history of unilateral ACL tear who were placed in two groups: ACL reconstruction (18 people) and conservative treatment (13 people). Single and triple hop tests for distance and knee injury and osteoarthritis outcome score (KOOS) were used for objective and subjective evaluation of knee function, respectively. The physical and psychological health of the athletes was also evaluated by the Patient-Reported Outcomes Measurement Information System 29 (PROMIS-29) questionnaire. Multivariate analysis of covariance was used to analyze the data at a significance level of  $P \leq 0.05$ .

**Findings** Based on the result, the ACL treatment strategy (reconstruction or conservative treatment) had a significant effect on physical performance, ability to participate in social activities, anxiety, and depression of athletes ( $P < 0.05$ ). Regarding the knee function, the obtained results pinpointed that the ACL treatment strategy had a significant effect on knee symptoms and stiffness, activities of *daily living*, sports performance, quality of life, and *limb symmetry index* in hop distance ( $P < 0.05$ ).

**Conclusion** It can be stated that selective treatment after an ACL injury can affect athletes' knee function, sports performance, as well as physical and psychological health. Nonetheless, it is necessary to know that the current study is retrospective and has many limitations that should be considered.

### \* Corresponding Author:

Aynollah Naderi, PhD.

Address: Faculty of Sport Science, Shahrood University of Technology, Shahrood, Semnan, Iran.

Tel: +98 9177217462

E-mail: [ay.naderi@yahoo.com](mailto:ay.naderi@yahoo.com)



## مقاله پژوهشی

# تأثیر استراتژی‌های درمان بر عملکرد زانو، سلامت جسمانی و روانی ورزشکاران با سابقه پارگی ACL

عین اله نادری<sup>۱</sup>، نرگس منافی انور<sup>۲\*</sup>

۱. گروه علوم زیستی، دانشکده علوم ورزشی، دانشگاه صنعتی شاهرود، سمنان، ایران.
۲. گروه علوم ورزشی، موسسه آموزش عالی عمران و توسعه، همدان، ایران.

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## چکیده

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**هدف:** از مطالعه‌ی حاضر مقایسه‌ی عملکرد زانو و سلامت جسمانی و روانی ورزشکارانی است که تحت درمان محافظه‌کارانه‌ی ACL قرار گرفتند.

**مواد و روش‌ها:** پژوهش حاضر از نوع پس‌رویدادی است. آزمودنی‌های مطالعه‌ی حاضر را ۳۱ ورزشکار با سابقه‌ی پارگی ACL یک‌طرفه تشکیل می‌دهند که در دو گروه بازسازی ACL (۱۸ نفر) و درمان محافظه‌کارانه (۱۳ نفر) قرار گرفتند. به‌منظور بررسی عملکرد عینی و ذهنی زانو، به‌ترتیب از آزمون‌های هاپ و مقیاس پیامد آسیب‌های زانو و استنواآرتروز (KOOS) استفاده شد. سلامت جسمانی و روانی ورزشکاران نیز با پرسش‌نامه‌ی پرومیس-۲۹ (PROMIS-29) ارزیابی شد. تجزیه و تحلیل داده‌ها با آزمون تحلیل کوواریانس چندمتغیره (MANCOVA) صورت گرفت.

**یافته‌ها:** نتایج نشان داد که بازسازی ACL نسبت به درمان محافظه‌کارانه، عملکرد جسمانی و ظرفیت مشارکت اجتماعی بهتر و اضطراب و افسردگی کمتری را برای ورزشکاران به همراه دارد ( $P < 0.05$ ). علاوه بر این، بازسازی ACL با عملکرد تفریحی و ورزشی و کیفیت زندگی بهتر و شدت علائم و سفتی زانوی کمتر نیز همراه است ( $P < 0.05$ ).

**نتیجه‌گیری:** بر این اساس، می‌توان گفت که بازسازی ACL می‌تواند عملکرد زانو، عملکرد ورزشی و سلامت روانی و جسمانی ورزشکار را تحت‌تأثیر قرار دهد. باین‌حال، لازم است بدانیم که مطالعه‌ی حاضر از نوع گذشته‌نگر است و محدودیت‌هایی دارد که باید در نظر گرفته شوند.

## کلیدواژه‌ها:

آسیب‌دیدگی زانو  
بهداشت روان  
بهداشت جسمانی  
بازسازی ACL  
درمان محافظه‌کارانه

## \* نویسنده مسئول:

عین اله نادری

نشانی: دانشکده تربیت بدنی و علوم ورزشی، دانشگاه صنعتی شاهرود، سمنان، شاهرود، ایران.

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پست الکترونیکی: [ay.naderi@yahoo.com](mailto:ay.naderi@yahoo.com)

## Introduction

An anterior cruciate ligament (ACL) tear is a common sports injury occurring during multidirectional contact and non-contact activities, mostly among young and physically active people [1, 2]. The ACL tear is associated with knee dysfunction, meniscal damage, articular cartilage lesions, tibiofemoral instability, and finally, knee osteoarthritis. Approximately 200,000 ACL injuries occur in the United States each year, of which 100,000 are treated by ACL reconstruction [2, 3]. Accordingly, approximately 50% of the population that sustains an ACL injury chooses to undergo ACL reconstruction [4]. Nonetheless, some athletes continue to perform well despite the ACL injury (Copers), and others choose to reduce their level of sports or work to avoid giving way to their knee (Adaptors) [5,6]. In general, two types of treatment are available for an ACL tear: surgical and non-surgical. Both treatment strategies aim to restore functional knee stability and prevent osteoarthritis. However, there is considerable controversy in studies regarding the optimal treatment method for ACL tears. A generally accepted strategy for ACL treatment is surgery for young and active people and non-surgical treatment for less active people.

The main function of the ACL is to provide knee rotational stability and limit anterior-posterior displacement of the tibia on the femur. Some authors believe that primary ACL reconstruction can help restore tibiofemoral joint kinematics and reduce the risk of knee joint instability, thereby reducing the possibility of secondary ACL injury and knee osteoarthritis [7]. These researchers are of the belief that it is only a surgical intervention that provides sufficient stability for the knee of an active person or athlete to perform pivot sports activities [7]. On the contrary, research reports in recent years have strongly suggested that performing ACL reconstruction does not reduce the risk of knee OA in the long term [6], and the prevalence of degenerative changes after ACL reconstruction is still high (between 10% and 87%) [8].

In addition, the incidence of complications and re-injury after ACL reconstruction has also been documented by several researchers and should be considered before deciding on ACL reconstruction [9, 10, 11]. Some of these complications include arthrofibrosis, infection, graft failure, donor site morbidity, pain, and surgery costs [7]. Therefore, the final and real consequences of ACL reconstruction are still unknown [12]. Some other studies have suggested that a careful neuromuscular rehabilitation program can provide effective recovery for this population without increasing the risks of

degenerative damage in the long term [13,14]. Regardless of the treatment method, the ultimate goal of implementing a rehabilitation program after an ACL injury is usually to restore the functional stability of the knee so that the athletes can return to their desired activity level [15,16]. Regarding this, Linko et al. (2005), in a systematic review, concluded that there is no sufficient evidence of the superiority of ACL reconstruction over conservative treatment [17].

In a randomized control trial, Froebel et al. compared the two- and five-year follow-up results of ACL reconstruction with non-surgical treatment and concluded that there was no significant difference between the rate of osteoarthritis, patient-reported outcomes, and the number of meniscal surgeries in those who had early or delayed ACL reconstruction and those who chose non-surgical treatment [18, 19]. Accordingly, they encourage physicians and patients to consider conservative ACL treatment as a primary treatment for an ACL tear. Reports on return-to-sport rates after ACL reconstruction range from 65%-88%, while non-surgical treatment ranges from 19%-82%, with no significant difference between the two treatment strategies [20, 21].

Some authors believe that ACL reconstruction can restore tibiofemoral joint kinematics and reduce the risk of joint instability, thereby reducing the possibility of secondary joint injury and osteoarthritis. These advocates believe that only surgery can provide sufficient stability to the knee joint of an active person who wants to return to core sports activities [7]. Usually, chronic anterior-posterior knee instability is observed in 8%-50% and 75%-87% of cases after surgical reconstruction of ACL and after conservative treatment, respectively [22]. Anterior-posterior instability of the knee is associated with an increased risk of knee osteoarthritis (prevalence from 24.5%-51.2%) [23], limitation of knee function due to reduced activity level (17% of competitive athletes do not return to competitive level) [24] and reduced quality of life (score of 54-77 in the KOOS quality of life subscale compared to 81-92 in the healthy population) [25]. Approximately 83% of competitive athletes who undergo ACL reconstruction can return to their pre-injury level of athletic activity, while this rate varies by sport [24]. In a similar vein, 80% of amateur athletes return to their sport after ACL reconstruction [26]. Nevertheless, without ACL reconstruction, only 19% of athletes can return to their previous athletic level [27]. In principle, the consequences of conservative treatment are related to the athlete' level of activity and motivation [28].

Even though ACL reconstruction is the recommended treatment for physically active individuals after an ACL tear, there is no sufficient information in the research literature regarding the superiority of ACL reconstruction

over conservative management. Considering that no research has compared the functional, physical, and psychological consequences of ACL reconstructions with conservative treatment, this retrospective study tries to investigate this issue.

## Materials and Methods

This retrospective study was conducted cross-sectionally in Hamadan city from 2021-2022. The participants of the study were 31 athletes with a history of unilateral ACL tear whose injury occurred during a game or training. These participants were selected by convenience sampling method. Among these participants, 18 cases had undergone ACL reconstruction for treatment, and 13 subjects had received conservative treatment.

The inclusion criteria were as follows: an age range of  $\geq 18$  years, a history of ACL reconstruction for one leg, at least six months have passed since the ACL reconstruction, completion of the prescribed rehabilitation program, and permission to return to sports from an orthopedic surgeon or physiotherapist [4,6]. On the other hand, the exclusion criteria entailed taking any drug that affects the athlete's sports performance and balance, any severe deformity on the lower limb that can affect the athlete's performance, any disease that affects the participants' ability to participate in sports, using a walker or cane to walk, and leaning on objects or grabbing the walls and fences to get up or stand [4, 6, 12].

To conduct the research, its proposal was initially examined and approved by the Physical Education Department of Omran Tose'e University. Following that, the researcher obtained the necessary permissions from the physical education department to collect research data from physiotherapy centers, sports clubs, and athletes. The researcher referred to the physiotherapy centers and sports clubs of the city and got the contact numbers of some athletes. After identifying the athletes, the researcher called them and talked about the research. If an athlete wanted to participate in the research, necessary arrangements were made with her/him to refer to the university gym at a specific time for assessment. To collect some data, an online questionnaire was already designed by Google Forms, and the link of this questionnaire was sent to the athlete through communication tools (WhatsApp, Telegram, Instagram, and email). By clicking on this electronic link, the participants were directed to a page that included 1) instructions for completing the questionnaires and 2) a consent form. After the participants completed and confirmed the informed consent, they could complete the main parts

of the questionnaire.

To evaluate the objective and subjective function of the knee, hop tests and knee injury and osteoarthritis outcome scores (KOOS) were used, respectively [29, 30, 31]. To evaluate the objective function of the knee, single-leg hop for distance and triple hop for distance tests were utilized. To perform the one-legged hop test, we placed a tape measure on the ground for a distance of one meter. Thereafter, we asked the subject to stand on one leg facing forward on the zero point of the measuring tape, jump forward as far as possible, and land on the same leg. The jump distance was measured from the zero-meter point to the point where the heel hits the ground as a person's record. Athletes repeated this task three times, and each time, their records were documented. We also placed a tape measure on the ground to perform the triple hop test for distance. Following that, we asked the subject to stand on one leg facing forward on the zero point of the measuring tape, jump forward three times as much as possible, and land on the same leg. The jump distance from the zero point to the point where the heel hits the ground was measured as a person's record. The athlete repeated this test three times, and each time, his record was documented.

The KOOS test was used for the subjective evaluation of knee function. This tool contains five subscales: knee symptoms and stiffness (7 items), knee pain (9 items), performance during daily life activities (17 items), performance during sports activities (5 items), and quality of life (4 items). Each item of this questionnaire was scored on a 5-item Likert scale ranging from 0-4. The score of each subscale was calculated by summing the score of each question. The total score was expressed as a percentage. The lower the percentage of the score, the greater the amount of disability [32, 33].

The Patient-Reported Outcomes Measurement Information System 29 (PROMIS-29) questionnaire was used to evaluate the psychological and physical health of athletes. This questionnaire comprises 29 items on physical performance (4 items), anxiety (4 items), depression (4 items), fatigue (4 items), sleep disorder (4 items), ability to participate in social roles and activities (4 items), pain interference (4 items), and pain intensity (1 item). Each item of this questionnaire was scored on a 5-point Likert scale. The score of each subscale was calculated and evaluated in the final analysis [34].

The data were analyzed in SPSS software (version 21) using descriptive and inferential statistical methods. Multivariate analysis of covariance (MANCOVA) test was used to compare the mean of dependent variables

(knee function and psychological and physical variables) between athletes who underwent ACL reconstruction and those who received conservative treatment. This statistical test was performed for each dependent variable separately. If a significant difference was observed, the desired variable was determined using the one-variable analysis of covariance (ANCOVA) test. All evaluations were performed at a significance level of  $P \leq 0.05$ .

## Results

The results of the demographic data analysis of the participants, including age, height, weight and body mass index, are presented in Table 1.

**Table 1.** Demographic characteristics of participants

Variables	with a history of ACL reconstruction (mean $\pm$ SD)	without a history of ACL reconstruction (mean $\pm$ SD)	t	p-value
Age (y)	33.7 $\pm$ 8.8	35.8 $\pm$ 8.7	0.66	0.51
Height (cm)	172.9 $\pm$ 5.3	177.6 $\pm$ 6.5	0.75	0.46
Weight (kg)	72.1 $\pm$ 7.0	72.7 $\pm$ 8.1	0.25	0.80
BMI (kg/m <sup>2</sup> )	24.1 $\pm$ 1.4	23.9 $\pm$ 2.7	0.23	0.81

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**Table 2.** Some descriptive characteristics of participants

Variables	Group	Frequency (percentage)
Gender	With a history of ACL reconstruction	Women =6 (33.3%) Men = 12 (66.7%)
	Without a history of ACL reconstruction	Women =4 (30.7%) Men = 9 (69.3%)
Smoking status	With a history of ACL reconstruction	Yes= 0 (0%) No= 18 (100%)
	Without a history of ACL reconstruction	Yes= 0 (0%) No= 13 (100%)
Mechanism of ACL injury	With a history of ACL reconstruction	Contact = 7 (38.9%) Noncontact = 11 (61.1 %)
	Without a history of ACL reconstruction	Contact = 6 (38.9%) Noncontact = 7 (61.1 %)
Involved lower extremity	With a history of ACL reconstruction	Dominance= 11 (61.1%) Non-dominance = 7 (38.9%)
	Without a history of ACL reconstruction	Dominance= 8 (61.5%) Non-dominance = 5 (38.5%)

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The results of the analysis of research variables by multivariate analysis of variance test demonstrated a statistically significant difference between the psychological and physical health of athletes who underwent ACL reconstruction and those who did not perform reconstruction ( $F(8, 22) = 3.7, p < .007$ ; Wilk's  $\Lambda = 0.43$ , partial  $\eta^2 = .57$ ). The results of the univariate variance analysis illustrated that ACL treatment strategies (reconstruction or no reconstruction) had a statistically significant effect on physical performance ( $F=6.6, p=0.02$ ), ability to participate in social activities

Table 2 demonstrates some other demographic characteristics of participants, including gender, the lower extremity injury mechanism, the involved lower limb (the knee for which surgery was performed), and the smoking status for each group separately. Based on Table 2, the percentage of male athletes is higher than that of female athletes for both groups. It is worth noting that there was no smoker in any group. The mechanism of injury indicated that approximately 61% and 54% of injuries for the groups with and without a history of ACL reconstruction injuries were of the contact type. In addition, the results of the study pinpointed that approximately 61% of ACL injuries for both groups involved the dominant limb.

( $F=5.2, p=0.03$ ), anxiety ( $F=7.5, p=0.01$ ), and depression ( $F=6.9, p=0.01$ ) of athletes. In comparison, the treatment strategies had no significant effect on fatigue, sleep disorder, pain interference, and pain intensity of athletes who suffered from ACL tears ( $P > .05$ ) (Table 3). The results of multivariate analysis of variance pointed to a statistically significant difference between the knee function of athletes who underwent ACL reconstruction and those who did not perform reconstruction ( $F(9, 21) = 3.9, P < .01$ ; Wilk's  $\Lambda = 0.62$ , partial  $\eta^2 = .38$ ) (Table 4).



**Table 3.** Comparison of the mean of psychological and physical health between athletes with a history of ACL reconstruction and those without a history of ACL reconstruction

Variables	with a history of ACL reconstruction (mean ± SD)	without a history of ACL reconstruction (mean ± SD)	F	p-value
Physical function	13.9 ± 3.6	10.8 ± 2.9	6.6	0.02
Ability to participate in social roles/activities	13.1 ± 2.7	10.5 ± 3.6	5.2	0.03
anxiety	6.7 ± 2.4	9.0 ± 2.2	7.5	0.01
depression	6.4 ± 2.8	8.7 ± 1.8	6.9	0.01
Fatigue	6.3 ± 2.5	7.6 ± 1.9	2.4	0.13
Sleep disorder	6.5 ± 2.5	7.4 ± 2.9	0.8	0.4
Pain interference	5.1 ± 1.4	5.5 ± 1.9	0.7	0.4
Pain intensity	1.7 ± 1.7	2.8 ± 1.3	3.8	0.06

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**Table 4.** Comparison of the mean of knee function between athletes with a history of ACL reconstruction and those without a history of ACL reconstruction

Variables	With a history of ACL reconstruction (mean ± SD)	Without a history of ACL reconstruction (mean ± SD)	F	p-value
Pain intensity	82.8±10.9	86.8±10.9	1.01	0.3
Level of symptoms and stiffness	83.7 ± 8.1	70.6±5.6	7.24	0.001
daily life function	86.7±9.5	77.6±10.1	5.6	0.02
Sports and recreational performance	73.9±7.3	69.7 ± 5.1	9.7	0.01
Quality of Life	71.8±7.4	64.1±10.6	5.5	0.02
The absolute value of the distance traveled during a single-leg hop	106.4 ± 20.1	99.8±27.4	0.5	0.5
The absolute value of the distance traveled during the triple hop	333.1 ± 62.5	310.6 ± 76.6	0.4	0.6
Symmetry index during single-legged hop	93.5±9.0	82.3±10.5	10.3	0.003
Symmetry index during triple-hop	92.9±10.3	83.5±9.7	5.6	0.01

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ACL treatment strategies (reconstruction or non-reconstruction) had a statistically significant effect on the level of symptoms and stiffness of the knee ( $F= 24.7$ ;  $P=0.001$ ), daily life activities ( $F= 6.5$ ;  $P=0.02$ ), sports and recreational performance ( $F= 7.9$ ;  $P=0.01$ ), quality of life ( $F= 5.5$ ;  $P=0.02$ ), and limb symmetry index during single leg hop ( $F= 10.3$ ;  $P=0.003$ ), and triple hop ( $F= 6.5$ ;  $P=0.01$ ) of the athletes. Nonetheless, the treatment strategies had no significant effect on pain intensity, the absolute value of the distance traveled during the single-leg hop and during the triple-leg hop of the athletes who suffered ACL injuries ( $P> .05$ ).

## Discussion

The present study aimed to investigate whether the selective treatment strategy after ACL tears can affect athletes' sports performance, knee function, as well as psychological and physical health. The obtained results pointed out that selective treatment strategies can affect the athlete's knee function, sports performance, as well as psychological and physical health, after ACL injury. Therefore, the athletes who undergo ACL reconstruction report fewer knee symptoms and stiffness and experience better daily life activities, sports and recreational

performance, and quality of life compared to those who choose a conservative treatment strategy. In addition, the athletes who undergo ACL reconstruction have a better capacity to participate in social activities and less anxiety and depression than those who choose a conservative treatment strategy.

The results of the present study are in line with those reported by Tsoukas et al. (2016) and Ardern et al. (2017), while they are not inconsistent with the findings of the study by Frobell et al. (2013) and Yperen et al. (2018). In accordance with the present study results, Tsoukas et al. (2016) compared knee function and osteoarthritis manifestations between patients who were treated by ACL reconstruction with hamstring tendon graft and those who received conservative treatment after ACL tears. They concluded that better performance and less joint laxity were observed after ACL reconstruction, compared to conservative treatment [35]. In addition, in agreement with the results of the current study, Ardern et al. (2017) demonstrated that patients who choose ACL reconstruction displayed better results (both before and after surgery) in knee stability, knee symptoms, and function, and knee-related quality of life compared to those who choose non-surgical treatment [4]. On the contrary, Froebel et al. found no evidence of the superiority of anterior

cruciate ligament reconstruction over conservative treatment in two separate studies [18].

The goal of knee joint surgery is to create postoperative stability with stability scores between -0.1 and 2.3 mm, which was not achieved in this study [36]. Nonetheless, data from the study by Frobell et al. on postoperative stability suggested that the quality of the surgical process was poor. The stability scores of KT-1000 illustrated that two years after surgery, the amount of joint laxity is still 6.6 mm, which clinically corresponds to a permanent defect of the ACL [19]. In a study after 20 years of follow-up, Yipern et al. (2018) did not observe a difference between the performance and the incidence of knee osteoarthritis in people who were treated by ACL reconstruction and those who received conservative treatment. In this study, although knee stability was better for the group that underwent ACL reconstruction, functional results did not display a significant difference between the two groups. This inconsistency can be ascribed to the fact that in the study by Yipern et al., patients were included in the ACL reconstruction list if they did not report favorable results after three months of conservative treatment [22].

The ACL reconstruction leads to improved proprioception and better kinematics of the knee joint compared to conservative treatment. Nevertheless, in some patients, this performance improvement during objective measurement is not necessarily reflected in subjective parameters [37]. However, some other researchers have suggested that a neuromuscular rehabilitation program can provide the necessary recovery for this population without increasing the risks of degenerative injuries in the long term [13]. In addition, one of the disadvantages of ACL reconstruction compared to conservative treatment can be an increased risk of surgical side effects, such as arthrofibrosis, infection, graft defects, pain, and costs associated with surgical intervention [7]. The results of previous studies have demonstrated that people who undergo ACL reconstruction are often younger and have a better pre-injury activity level than those who choose conservative treatment [38]. It is also possible that some of the differences between these two groups can be attributed to the differences that existed between the two groups before the treatment and injury. However, Ardern et al., in a longitudinal study and repeated measurements, pinpointed that the magnitude of the mean difference is not the same at different time points, and based on that, they rejected this possibility [4]. Therefore, these results may indicate that younger individuals are more likely to be successful after ACL reconstruction than older ones when the measure of success is returned to the pre-injury activity level.

## Conclusion

As evidenced by the result of this study, the selective treatment after ACL injury can athletes' affect knee function, sports performance, as well as psychological and physical health. However, before recommending surgery for all athletes with ACL injuries based on the results of the present study, it is important to recognize that the present study was retrospective and has many limitations that should be considered.

## Research limitations

Similar to any other research, the current study also has limitations that should be considered. One of the limitations of the current research is that the research design is non-experimental and retrospective. Therefore, although the results of the current research provide the possibility of prediction, it does not establish any causal relationship between the research variables. Accordingly, future studies should examine the subject of the current research prospectively and longitudinally. Another limitation of the present study is that the interpretation of the results can be affected by the small sample size. Therefore, to confirm the results of the present research, studies with a larger sample size are needed. In addition, the participants of the current study are athletes; therefore, the findings of this study cannot be generalized to the non-athlete population. Another thing to consider is that the subgroup of athletes in the current study was not homogeneous (i.e., the ratio of female athletes (33%) to male athletes (67%) was a potential limitation when generalizing to the athlete population). The participants of the present study participated in various rehabilitation programs and were not subjected to the same supervision and rehabilitation; accordingly, future studies should use participants who have received the same rehabilitation program and supervision. Previous studies have demonstrated that quadriceps muscle strength can be an important therapeutic index for people with ACL injuries. We did not have the equipment to assess muscle strength available when we started this study. Future studies could evaluate quadriceps muscle strength as a useful therapeutic index. Even if we assume that about 49% of patients can avoid ACL reconstruction with conservative treatment, this study does not indicate which patients can manage their ACL injury without surgery. Given that past studies have pointed out that delaying ACL reconstruction can significantly increase the risk of subsequent injuries, such as meniscal tears and the prevalence of knee osteoarthritis, this issue is also critical. Therefore, conservative treatment or delayed surgery may be less valuable than early surgery due to an increased risk of secondary injuries, meniscal tears, and the prevalence of knee osteoarthritis, especially in young athletes.

## Ethical Considerations

### Compliance with ethical guidelines

This article has received the ethics code number IR.SHAHROODUT.REC.1401.013 from the Ethics Committee of Sport Sciences Research Institute of Shahrood University of Technology.

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## Authors' contributions

Both authors participated in presenting the initial idea and plan, collecting data, analyzing and interpreting the data, and initially writing the article or revising it. In addition to the final approval of this article, both authors accept responsibility for the accuracy and correctness of the content contained in it.

## Conflicts of interest

The authors declared no conflict of interest.

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