

Original Research Article

Magnetic resonance imaging knee joint measurements for the prediction of the population at risk of anterior cruciate ligament tear injuries

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ABSTRACT

Background: This study aims to investigate whether patient-related anterior cruciate ligament (ACL) damage is associated with measures of various knee joint components.

Methods: Patients who had magnetic resonance imaging (MRI) and suffered from ACL injuries were included in this retrospective case-control study. There was also a control group of individuals who had normal MRI results for knee diseases. The following 14 knee variables were gathered: lateral and medial (MFC) femoral condyle sphere diameter; lateral and medial tibial plateau length; patella tendon horizontal and vertical diameter; lateral meniscus (LM) posterior horn height, length, depth, and volume; and medial meniscus (MM) posterior horn height, length, depth, and volume. The two groups were compared using a multivariate logistic regression that took into account the patella tendon horizontal diameter, MFC sphere diameter, MM posterior horn length, MM volume, LM posterior horn depth, and receiver operating characteristic curve.

Results: We enrolled 98 patients in total; 48 had ACL injuries, and 50 had normal knee MRIs as a comparison group. The results of the logistic regression analysis showed that the following factors independently predicted the risk of ACL rupture: decreased MM posterior horn length (OR=0.45; 95% CI=0.33-0.630; $p<0.001$), increased LM posterior horn depth (OR=1.78; 95% CI=1.37- 2.03; $p<0.001$), and MFC sphere diameter (OR=1.27; 95% CI=1.01-1.60; $p=0.0354$).

Conclusions: Individuals with an ACL injury had shorter MM posterior horns, deeper LM posterior horns, larger MFC sphere diameters.

Keywords: Anterior cruciate ligament, Magnetic resonance imaging, Medial meniscus

INTRODUCTION

One of the two cruciate ligaments that supports knee joint stabilization is the anterior cruciate ligament. Football, soccer, and basketball players frequently sustain injuries to this knee ligament, which is the most prevalent one. The medial component of the lateral femoral condyle is connected to the knee by the anterior cruciate ligament (ACL) via the medial tibial eminence and the intercondylar fossa.¹ Due to its outstanding sensitivity and specificity, magnetic resonance imaging (MRI) is the ideal imaging tool for diagnosing injuries to the knee and ACL.² ACL

and medial meniscus anterior horn join anterior to intercondylar eminence at anteroposterior distance of 11–17 mm.³ The ACL's main purpose is anterior translation confinement. The main purpose of the ACL is anterior translation confinement. However, the ACL also prevents lateral rotation, varus and valgus stress, and hypertension.¹ ACL injuries comprise between 100,000 and 200,000 of all knee injuries that occur each year in the United States.⁴ Sports and activities connected to sports are the main cause of ACL injury.⁵ This injury has been steadily increasing because to the growing interest in organized sports, particularly among women, and it disproportionately

affects the younger population, particularly teenagers and college-age individuals.⁶ They could even choose to give up on the sport earlier than they otherwise would have due to the negative psychological and physical impacts of this.^{7,8} Moreover, regardless of the course of treatment, it may increase the risk of functional limitation and early-onset post-traumatic osteoarthritis.⁹ Since non-contact injuries make up more than 75% of all injuries, it is important to identify risk factors in order to concentrate preventive efforts.¹⁰ In an attempt to reduce the risk of ACL injury, a variety of risk factors have been investigated, including female gender, genetic susceptibility, hormone levels, prior ACL repair, lower extremity biomechanics, and impaired neuromuscular control.^{6,11-13} Recent implementation of preventative programs for ACL injuries has demonstrated a reduction in injury rates due to the cost-effectiveness of concentrating on modifiable risk factors in at-risk populations.¹³⁻¹⁵ Few studies have examined the connection between individual differences in anatomy and ACL injury, despite the fact that a variety of anatomical traits have been identified as risk factors for ACL damage.¹⁶⁻²¹ Thus, it is important to investigate the anatomical variations between patients with ACL injuries and healthy individuals in order to possibly apply appropriate surgeries or alter lifestyle choices for people, particularly those who participate in high-risk sports. In order to ascertain whether there is a relationship between these measurements and an ACL injury in the affected individuals, the study will compare the measurements of several knee joint anatomical components across patients with and without ACL injuries.

METHODS

Study design

A three-year retrospective case-control study starting from December 2021 to January 2024 on patients who had ACL tear and underwent ACL reconstruction after suffering from tears was conducted in a 600-bed tertiary care teaching hospital. A control group of patients without any disorders and normal MRI findings was included for evaluation.

Inclusion and exclusion criteria

The study's target group consisted of patients who were 18 years of age or older, had an ACL tear injury in one or both knees, had their MRI done at East Point Hospital, and whose results were stored in the East Point Hospital database.

Patients below the age of 18 years, with no current ACL pathologies, who have had their MRIs taken outside of the East Point Hospital and were admitted for ACL revision, having poor image quality of their MRIs making it difficult to conduct appropriate and accurate measurements were excluded from the target population for the study.

Data collection process

The MRI scans for the target population were obtained using the East Point Hospital medsynapse picture archiving and communication system (PACS) system, and the pictures were analyzed using built-in measuring tools.

All 14 metrics were given precise definitions in order to guard against any possible prejudice and data or measurement errors. The data collection and measurements were carried out by 2 trained medical interns. The calculations were saved and attached to their specific MRI images and the final list of measurements done and data obtained were reviewed by two senior orthopaedic consultants to ensure efficient and accurate data collection and measurements techniques were followed throughout. All measurement paperwork was completed only on East Point Hospital property, in the orthopaedics department, in order to protect patient privacy.

MRI protocol

A 3.0-Tesla MRI (Siemens Company, Munich, Germany) was used to assess the patients. With the patient's knees bent at a 10-degree angle and the patella's inferior pole positioned in the middle of the knee coil, all MRI pictures were taken of the subjects while they were supine. Since the ACL is best photographed utilising several planes to visualise its full length, at least 20-30 slices were acquired for each of the three planes-axial, coronal, and sagittal-for the purpose of acquiring pictures. There was a 0.4-1 mm interslice gap and a 3 mm slice thickness. 14-16×15.1-27.2 cm was the field of view, while 520-320×437-266 cm was the matrix size.

Acquiring the MRI image measurements

Each participant's 14 knee characteristics were examined using MRI imaging. This included the following: the patella tendon's horizontal and vertical diameter; the lateral meniscus (LM) and medial meniscus (MM) posterior horn height, length, depth, and volume; the sphere diameters of the lateral (LFC) and medial (MFC) femoral condyles; and the lateral (LTP) and medial (MTP) tibial plateau length.

A sagittal plane was used to measure the LM and MM of each subject. To measure the height of the posterior horn of the medial or lateral meniscus, a line drawn perpendicular to its vertical axis was first drawn. By cutting a transverse line along the posterior horn's horizontal axis, the length of the horn may be determined using the coronal view's matching first third as a guide (Figure 1). Using the matching midpoint of the section in the sagittal view as a reference, a transverse line was drawn along the horizontal axis of the posterior horn of the medial or lateral meniscus in the coronal plane to measure the depth of the LM and MM (Figure 2). The height, length, and depth were multiplied by 0.5 to determine the meniscal volume.



Figure 1: The measurement of medial meniscus posterior horn height, length, on a proton density sagittal magnetic resonance image.



Figure 2: The measurement of medial meniscus posterior horn depth on a proton density coronal magnetic resonance image.

Using the equivalent first third of the section in the coronal view as a guide, a transverse line was drawn through the posterior horn's horizontal axis to measure each patient's length and determine their LM and MM in the sagittal plane. The patient's height was then measured by drawing a perpendicular line down the posterior horn's vertical axis (Figure 1). To measure the depth of the LM and MM, a transverse line was drawn across the posterior horn of the medial or lateral meniscus in the coronal plane using the

corresponding center of the slice in the sagittal view as a reference (Figure 2).



Figure 3: Using a T1 sagittal magnetic resonance imaging to determine the diameter of the medial femoral condyle sphere.

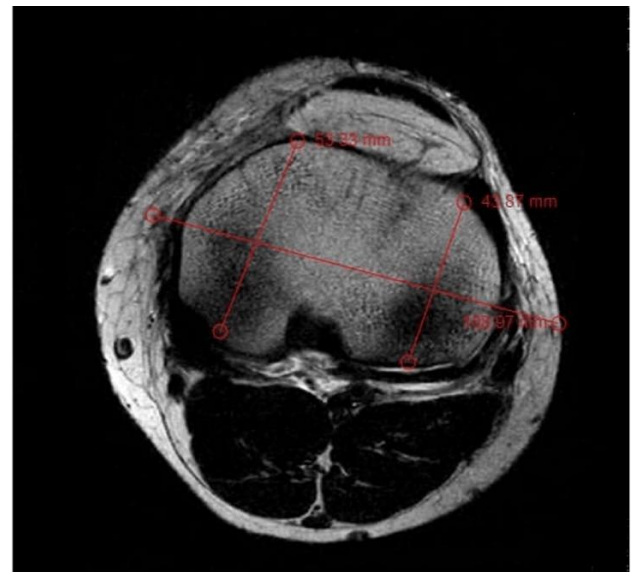


Figure 4: Using a T2 axial view magnetic resonance imaging to determine the length of the medial tibial plateau.

A transverse line was made through the growth plate of the LFC or MFC using a sagittal plane. A perpendicular line was then drawn down to the longest point on the horizontal axis of the medial or lateral meniscus. This made it possible to estimate the sphere's diameter, which was determined using the coronal view's equivalent middle of section (Figure 3).

The LTP and MTP in an axial plane were examined using a transverse line drawn across the proximal transtibial axis and extending from the medial edge of the medial plateau to the lateral border of the lateral plateau (Figure 4).

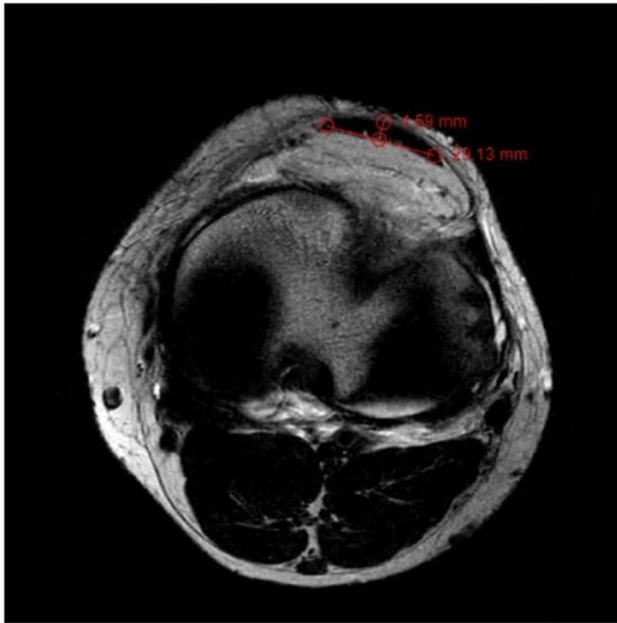


Figure 5: Using a T2 axial view magnetic resonance imaging to estimate the length of the patellar tendon in both the horizontal and vertical directions.

An axial, horizontal, and vertical line was drawn across the patellar tendon to measure its length and height, respectively, using the corresponding thickest point on the sagittal picture as a reference. This made it possible to quantify the tendon's vertical and horizontal diameters (Figure 5).

Analytical statistics

Statistical package for the social sciences (SPSS) version 28.0 (Chicago, USA) was utilized in our investigation.

Using mean±standard deviation, age and other continuous variables were reported. Count (frequency) can be used to characterize other nominal variables, such as gender. The results were expressed as mean (standard deviation) after a t-test for independent samples was utilized to ascertain the mean difference between measurements and both cases and controls. Using Cohen's d, the effect size was calculated. By employing binary logistic regression, the independent risk factors associated with ACL damage were identified.

RESULTS

The 98 patients who made up this study's total had ages ranging from 18 to 52, with an average age of 33.64±9.81 years. Of them, 72 (73.4%) were men and 26 (26.5%) were women.

Our findings demonstrated a significant difference in LM posterior horn depth ($p=0.001$), with an average variation in the affected group of 2.14 or higher (95% CI 0.84-3.45), and MM posterior horn length ($p=0.001$), with a mean difference in the controls of 2.16 or higher (95% CI -3.3 to -0.88) among ACL injury patients as well as controls. The average variations of LTP ($p=0.032$) was 1.61 higher in cases (95% CI 0.143-3.090), the mean difference of MFC sphere diameter ($p=0.025$) was 1.76 higher in cases (95% CI 0.230-3.303), and the mean difference of patellar tendon horizontal diameter ($p=0.002$) was 1.96 higher in cases (95% CI 0.765-3.163). The case facts and control MRI knee measures are displayed in Table 1.

In the univariate analysis, variables exhibiting potentially intriguing correlations at a significant level ($p<0.05$) were incorporated into the multivariate logistic regression. Table 2 showed that independent risk factors for ACL rupture included LM posterior horn depth (OR=1.781; 95% CI=1.373-2.309; $p=0.000$), MM posterior horn length (OR=0.459; 95% CI=0.333-0.630; $p=0.000$), and MFC sphere diameter (OR=1.278 95% CI=1.019-1.603; $p=0.034$).

Table 1: Knee MRI measurements were compared between the patients and the controls.

Parameters	Cases		Control		P value	Cohen's d effect size	95% CI
	Mean	Standard deviation	Mean	Standard deviation			
LM posterior horn height	7.59	1.35	7.22	1.43	0.197	-	-
LM posterior horn length	11.41	2	11.72	2.03	0.441	-	-
LM posterior horn depth	25.59	3.12	23.44	3.36	0.001*	0.663	(0.847-3.453)
LM volume	1171.68	514.11	1093.07	509.7	0.449	-	-
MM posterior horn height	7.82	2.29	7.69	1.6	0.741	-	-
MM posterior horn length	15.89	3.16	18.03	3.08	0.001*	0.685	(-3.390-0.883)
MM posterior horn depth	24.11	3.91	23.47	3.28	0.381	-	-
MM volume	1645.04	902.01	1699.38	695.3	0.738	-	-
LFC sphere diameter	36.27	3.62	35.41	3.33	0.22	-	-

Continued.

Parameters	Cases		Control		P value	Cohen's d effect size	95% CI
	Mean	Standard deviation	Mean	Standard deviation			
MFC sphere diameter	38.52	4.25	36.76	3.37	0.025*	0.458	(0.230-3.303)
LTP length	42.09	3.52	40.48	3.8	0.032*	0.439	(0.143-3.090)
MTP length	51.36	4.12	51.17	6	0.852	-	-
Patella tendon horizontal diameter	27.65	2.84	25.69	3.11	0.002*	0.658	(0.765-3.163)
Patellar tendon vertical diameter	4.68	0.62	4.6	0.62	0.544		

*Statistically significant.

Table 2: MRI knee measures and the likelihood of an ACL damage are associated using logistic regression.

Variables	AOR	95% confidence interval	P value
LM posterior horn depth	1.781	(1.373-2.309)	0
MM posterior horn length	0.459	(0.333-0.630)	0
MFC sphere diameter	1.278	(1.019-1.603)	0.034
Patella tendon horizontal diameter	1.216	(0.946-1.563)	0.126
LTP length	1.143	(0.921-1.418)	0.226

The ROC curve was used to determine the diagnostic effectiveness and correctness of the MRI knee data that was notable in the binary logistic regression analysis. The LM-D ROC curve has the highest reported AUC (0.674; 95% CI, 0.567-0.781; $p=0.003$). The area under the curve (AUC) of MFC (0.618; 95% CI, 0.505-0.731; $p=0.002$) and the area under the curve (AUC) of MM-L (0.318; 95% CI, 0.213-0.422; $p=0.002$) are the two remaining significant measures (Figure 6).

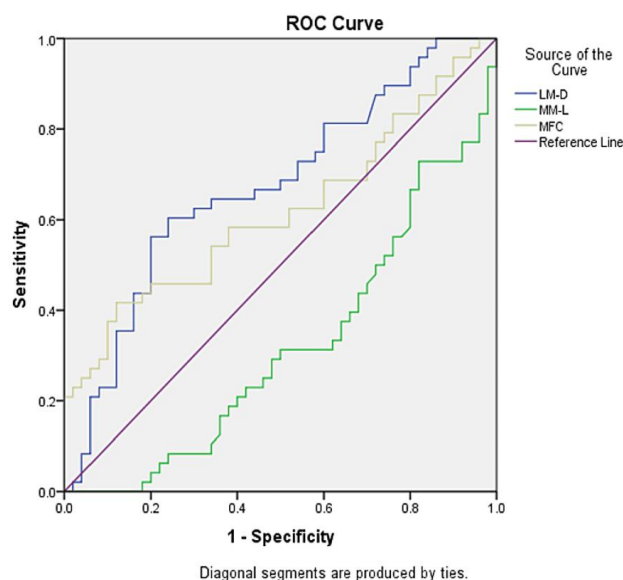


Figure 6: The impacts of the patellar tendon horizontal length, LM posterior horn depth, and MFC sphere diameter on ACL damage were shown by the fifth receiver operating characteristic curve.

LM: Lateral meniscus; MFC: medial femoral condyles

DISCUSSION

ACL injuries are the most common knee injury, therefore, determining the causes and mechanisms is an important step in establishing a basis for prevention.^{4,22} This is very important because, regardless of the treatment methods used, these injuries can have a significant impact on an athlete's career, leading to a continued risk of early osteoarthritis and further impact on their life.⁹ Our data suggest that the length of some knee structures is associated with the development of ACL injuries. Our study found that increased LM posterior horn depth, decreased MFC sphere diameter, and decreased meniscus posterior horn depth were associated with ACL injury. In contrast, several variables, including LM posterior horn height, length, and volume, were significantly different in the group. In addition, our regression model showed that LM horn depth had the most significant predictive value for ACL rupture, followed by MFC sphere diameter and MM horn length. And its relationship with knee joint ACL injury. In a literature review using MRI to identify risk factors, a narrow intercondylar notch was found to be associated with an increased risk of ACL rupture in young adults.²³ Parker et al found that the width and width of the mid condyle were significant factors in ACL injury in males, while the width and width of the mid condyle and the index width were significant factors in ACL injury in females.¹⁶ In another case-control study, significant differences were observed in bicondylar width, medial condylar width, and lateral condylar width between ACL and non-ACL groups.¹⁷ Several associations with ACL injury have been described, including decreased intercondylar femoral fossa size, decreased medial tibial plateau concavity, increased tibial plateau slope, and increased anteroposterior knee laxity.¹² However, the

association between the other knee measurements reviewed in this article and the risk of ACL injury has not yet been investigated. In 2010, Zemirline et al confirmed these findings and found that this connection was present in 13 of 14 dissected non-arthritic knees, which they termed the lateral meniscal ligament.²⁵ Histological studies have also shown that mechanoreceptors in these structures play a role in knee stability.²⁶ However, how this structure normally varies among individuals and how differences in knee dimensions affect its function have not been discussed in the literature. According to our results, there was a significant difference in LM depth between ACL patients and the control group. Therefore, considering that the deep posterior aspect of the lateral meniscus affects the position of the lateral meniscus ligament band, it can be considered that this situation may lead to a decrease in knee stability. It has been stated that the size of the condyle affects the kinematics of the force and that differences in the size of the femoral condyle may have a significant effect on knee rotation.²⁷ Our findings showed that the mean femoral condyle diameter of ACL patients was significantly different from that of non-ACL patients. However, our results showed no difference between the control group and the case group in terms of lateral femoral condyle. On the other hand, several studies have shown that smaller lateral femoral condyle leads to greater knee laxity and these individuals are at greater risk for ACL injury.^{18,19,28} This difference may be due to the difference in male-female comparison between our study and the above studies, as men are known to have larger femoral condyles.²⁷ A larger patellar tendon-tibial shaft angle was found to be a risk factor for non-contact ACL injury and thus could act as an independent predictor based on the binary regression model.²⁰ This is assumed to be due to the increase in anterior tibial shear forces as the patellar tendon-tibial shaft angle increases when the ACL is lengthened.²⁹ In our study, different measurements of the patella, namely the patellar tendon level diameter, were made and the measured values were found to be different between the cases and the control group. Our results also showed that there was no difference in the medial and lateral tibial plateau lengths between the ACL and ACL-free groups. A case-control study found similar results, with neither tibial plateau index being a risk factor for ACL injury.³⁰ However, even among studies linking the tibial plateau to ACL injury, there is no consensus on whether the higher plateau or the lower plateau is responsible for ACL injury. A shallow tibial plateau has been shown to be a risk factor for ACL injury. However, Rahnamai-Azar et al and Grassi et al found that increased tibial plateau slope predisposes to ACL injury.³¹⁻³³ Further research is needed on the slope and length of the tibial plateau and their relationship to ACL injury. First, it is limited by small sample sizes. Additionally, all patients included in the study came from a single center, which may have been affected by regional racial bias. Another limitation is that conditions and controls were not controlled for age or sex. However, our study has several strengths. This is the first study to examine knee MRI measurements in individuals with and without ACL

injuries. In this study, clear definitions and clear procedures were used for all measurements and can be changed very easily. Thus in our study we have made a clear comparison of all the significant parameters with previous studies and found a similar clinical correlation of significance of a decreased MM posterior horn length, an increased LM posterior horn depth and MFC sphere diameter. In predicting the risk of ACL tear injuries. As a result, we think that our findings highlight a crucial discovery that justifies further clinical research. Propensity score matching should be used in future research to reduce potential bias between case and control groups.

CONCLUSION

It can be inferred from this study that there may be variations in the dimensions of some knee components between people who have ACL injuries and those who do not. These differences will likely interact with a variety of other risk factors to influence the probability of ACL injury. Research should be done on a thorough multivariate risk model that takes into account all internal and external risk factors together in order to develop prevention strategies that work as well as appropriate health care and counselling for people who may be more likely to sustain multiple injuries. Further studies should be carried out to accurately classify individuals and determine a threshold value that would allow the determination of the probability of an ACL rupture on magnetic resonance imaging. This can support the physician in patient counselling, preventative measures, and protocol modifications for postoperative rehabilitation protocol.

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Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Petersen W, Zantop T. Anatomy of the anterior cruciate ligament with regard to its two bundles. *Clin Orthop Relat Res.* 2007;454:35-47.
2. Lee K, Siegel MJ, Lau DM, Hildebolt CF, Matava MJ. Anterior cruciate ligament tears: MR imaging-based diagnosis in a pediatric population. *Radiology.* 1999;213:697-704.
3. Purnell ML, Larson AI, Clancy W. Anterior cruciate ligament insertions on the tibia and femur and their relationships to critical bony landmarks using high-resolution volume-rendering computed tomography. *Am J Sports Med.* 2008;36:2083-90.
4. Evans J, Nielson JL. Anterior cruciate ligament knee injuries. StatPearls Publishing. 2021.
5. Hernández LM, Micheo WF, Amy E. Rehabilitation update for the anterior cruciate ligament injured patient: current concepts. *Bol Asoc Med P R.* 2006;98(1):62-72.

6. Gornitzky AL, Lott A, Yellin JL, Fabricant PD, Lawrence JT, Ganley TJ. Sport- specific yearly risk and incidence of anterior cruciate ligament tears in high school athletes: a systematic review and meta-analysis. *Am J Sports Med.* 2016;44:2716-23.
7. Trentacosta NE, Vitale MA, Ahmad CS. The effects of timing of pediatric knee ligament surgery on short-term academic performance in school- aged athletes. *Am J Sports Med.* 2009;37:1684-91.
8. Arundale AJH, Silvers-Granelli HJ, Snyder-Mackler L. Career Length and Injury Incidence After Anterior Cruciate Ligament Reconstruction in Major League Soccer Players. *Orthop J Sports Med.* 2018;6(1):2325967117750825.
9. Lohmander LS, Östenberg A, Englund M, Roos H. High prevalence of knee osteoarthritis, pain, and functional limitations in female soccer players twelve years after anterior cruciate ligament injury. *Arthritis Rheum.* 2004;50:3145-52.
10. Boden BP, Dean CS, Feagin JA, Garrett WE. Mechanisms of anterior cruciate ligament injury. *Orthopedics.* 2000;23:573-8.
11. Smith HC, Vacek P, Johnson RJ, Slauterbeck JR, Hashemi J, Shultz S, et al. Risk factors for anterior cruciate ligament injury: a review of the literature- part 2: hormonal, genetic, cognitive function, previous injury, and extrinsic risk factors. *Sports Health.* 2012;4(2):155-61.
12. Smith HC, Vacek P, Johnson RJ, Slauterbeck JR, Hashemi J, Shultz S, et al. Risk factors for anterior cruciate ligament injury: a review of the literature - part 1: neuromuscular and anatomic risk. *Sports Health.* 2012;4(1):69-78.
13. Di Stasi S, Myer GD, Hewett TE. Neuromuscular training to target deficits associated with second anterior cruciate ligament injury. *J Orthop Sports Phys Ther.* 2013;43:777-92.
14. Gilchrist J, Mandelbaum BR, Melancon H, Ryan GW, Silvers HJ, Griffin LY, et al. A randomized controlled trial to prevent noncontact anterior cruciate ligament injury in female collegiate soccer players. *Am J Sports Med.* 2008;36(8):1476-83.
15. Swart E, Redler L, Fabricant PD, Mandelbaum BR, Ahmad CS, Wang YC. Prevention and screening programs for anterior cruciate ligament injuries in young athletes: a cost-effectiveness analysis. *J Bone Joint Surg Am.* 2014;96:705.
16. Park JS, Nam DC, Kim DH, Kim HK, Hwang SC. Measurement of knee morphometrics using MRI: a comparative study between ACL-injured and non-injured knees. *Knee Surg Relat Res.* 2012;24:180-5.
17. Vrooijink SHA, Wolters F, Van Eck CF, Fu FH. Measurements of knee morphometrics using MRI and arthroscopy: a comparative study between ACL-injured and non-injured subjects. *Knee Surg Sports Traumatol Arthrosc.* 2011;19:12-6.
18. Pfeiffer TR, Burnham JM, Kanakamedala AC, Hughes JD, Zlotnicki J, Popchak A, et al. Distal femur morphology affects rotatory knee instability in patients with anterior cruciate ligament ruptures. *Knee Surg Sports Traumatol Arthrosc.* 2019;27(5):1514-9.
19. Vasta S, Andrade R, Pereira R, Bastos R, Battaglia AG, Papalia R, et al. Bone morphology and morphometry of the lateral femoral condyle is a risk factor for ACL injury. *Knee Surg Sports Traumatol Arthrosc.* 2018;26(9):2817-25.
20. Suprasanna K, Chamala T, Kumar A. Comparison of anatomical risk factors for noncontact anterior cruciate ligament injury using magnetic resonance imaging. *J Clin Orthop Trauma.* 2019;10:143-8.
21. Araujo P, van Eck CF, Torabi M, Fu FH. How to optimize the use of MRI in anatomic ACL reconstruction. *Knee Surg Sports Traumatol Arthrosc.* 2013;21:1495.
22. Bahr R, Krosshaug T. Understanding injury mechanisms: a key component of preventing injuries in sport. *Br J Sports Med.* 2005;39:324-9.
23. Domzalski M, Grzelak P, Gabos P. Risk factors for anterior cruciate ligament injury in skeletally immature patients: analysis of intercondylar notch width using magnetic resonance imaging. *Int Orthop.* 2010;34:703-7.
24. Lahlaïdi A. Morphological value of posterior insertion of the external meniscus in the human knee. *Revue de chirurgie orthopedique et reparatrice de l'appareil moteur.* 1971;57:593-600.
25. Zemirline A, Gérard R, Uguen A, Stindel E, Dubrana F. Meniscoligamentous band between the posterior horn of the lateral meniscus and the anterior cruciate ligament: arthroscopic, anatomical and histological observations. *Surg Radiol Anat.* 2010;32:129-33.
26. Koc BB, Jansen EJP, van Dijk P, Emans PJ, Lataster A. Mechanoreceptors observed in a ligamentous structure between the posterior horn of the lateral meniscus and the anterior cruciate ligament. *Knee Surg Sports Traumatol Arthrosc.* 2021;29:1701-8.
27. Hamdan M, Haddad B, Alshrouf MA, Azzam MI, Isleem U, Hamasha R, et al. Can MRI knee joint measurements predict the population at risk of ACL injury? *BMC Sports Sci Med Rehabil.* 2022;14:98.
28. Blanke F, Kiapour AM, Haenle M, Fischer J, Majewski M, Vogt S, et al. Risk of noncontact anterior cruciate ligament injuries is not associated with slope and concavity of the tibial plateau in recreational alpine skiers: a magnetic resonance imaging-based case-control study of 121 patients. *Am J Sports Med.* 2016;44:1508-14.
29. Englander ZA, Cutcliffe HC, Utturkar GM, Taylor KA, Spritzer CE, Garrett WE, et al. In vivo assessment of the interaction of patellar tendon tibial shaft angle and anterior cruciate ligament elongation during flexion. *J Biomech.* 2019;90:123-7.
30. Blanke F, Kiapour AM, Haenle M, Fischer J, Majewski M, Vogt S, et al. Risk of noncontact anterior cruciate ligament injuries is not associated with slope and concavity of the tibial plateau in recreational alpine skiers: a magnetic resonance imaging-based case-control study of 121 patients. *Am J Sports Med.* 2016;44:1508-14.

31. Rahnemai-Azar AA, Yaseen Z, van Eck CF, Irrgang JJ, Fu FH, Musahl V. Increased lateral tibial plateau slope predisposes male college football players to anterior cruciate ligament injury. *J Bone Joint Surg Am*. 2016;98:1001-6.
32. Grassi A, Macchiarola L, Urrizola Barrientos F, Zicaro JP, Costa Paz M, Adravanti P, et al. Steep posterior tibial slope, anterior tibial subluxation, deep posterior lateral femoral condyle, and meniscal deficiency are common findings in multiple anterior cruciate ligament failures: an MRI case-control study. *Am J Sports Med*. 2019;47:285-95.
33. Hashemi J, Chandrashekar N, Mansouri H, Gill B, Slauterbeck JR, Schutt RCJ, et al. Shallow medial

tibial plateau and steep medial and lateral tibial slopes: new risk factors for anterior cruciate ligament injuries. *Am J Sports Med*. 2010;38:54-62.

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