

Epidemiology With Video Analysis of Knee Injuries in the Women's National Basketball Association

Kobi Axelrod,* BS, Neal Canastra,*[†] BA, Nicholas J. Lemme,[‡] MD, Edward J. Testa,[‡] MD, and Brett D. Owens,[‡] MD

Investigation performed at the Alpert Medical School of Brown University, Providence, Rhode Island, USA

Background: Knee injuries are the most common type of injury seen in the Women's National Basketball Association (WNBA). However, there are sparse epidemiologic data regarding these injuries over the past 20 years.

Purpose/Hypothesis: The purpose of this study was to determine the prevalence, return to play (RTP) rate/length, and mechanism of knee injuries in the WNBA. We hypothesized that anterior cruciate ligament (ACL) tears would have the highest prevalence and longest RTP times.

Study Design: Descriptive epidemiology study.

Methods: Publicly available WNBA injury reports were used to find WNBA athletes who sustained knee injuries. The RTP length was determined by calculating the number of days between the date of the injury and the date of the first game they played after returning. The RTP rate was determined by calculating the number of players who returned to play from each injury compared with the total number of each injury. Incidence of knee injuries, frequency, and time to RTP were calculated for each injury. Available videos were analyzed to determine the mechanism and body position at the time of injury.

Results: Overall, 99 WNBA players were identified as having sustained a knee injury during the study period resulting in loss of play. ACL tears ($n = 37$; 37%) were the most devastating injury, resulting in the longest time before RTP ($n = 375$ days; 70%). The position with the highest incidence of knee injuries was guard, accounting for 53% of knee injuries. Video analysis conducted on 12 knee injuries revealed that such injuries were most commonly noncontact (83%). The mechanisms of injury were most commonly planting (58%) and landing from a jump (33%) with the knee flexed in the valgus position (100%).

Conclusion: Study findings indicated that ACL tears are the most common clinically significant knee injuries sustained in the WNBA, accounting for 37% of total knee injuries with a mean RTP rate of 375 days. The most common mechanism of injury was planting the foot or landing from a jump with a flexed knee in the valgus position. Knee injuries had a high RTP rate in WNBA players but resulted in them missing a significant amount of playing time.

Keywords: female athletes; knee injuries; WNBA

The differences in injury epidemiology between male and female athletes have been well studied, with substantial focus on the knee.⁵ Anterior cruciate ligament (ACL) tears have been studied widely among athletes in the hope of developing better injury prevention protocols given the significant disability and time lost from sport associated with such injuries. Female athletes are at increased risk for injuries to the knee, particularly injuries to the ACL, as biomechanical and anatomic differences put female athletes at an increased risk for sustaining ACL tears when compared with their male counterparts.^{1,4,8,10} Whereas there have

been many studies evaluating injury incidence and their influence on male professional athletes, the literature is lacking with respect to female professional athletes.

The effect of knee injuries in the National Basketball Association (NBA) has been researched extensively.⁷ One study found that, after an ACL tear, the return-to-play (RTP) rate of NBA players was 89%, with their per game statistics declining in their first season after injury.^{7,13,15} Although their performance increased during their second season postinjury, most of these athletes were never able to return to their preinjury performance.¹³ Another study evaluating the effects of meniscal tears in NBA athletes identified 129 tears over the course of 21 seasons.¹³ The lateral meniscus was torn at a higher rate than the medial meniscus, with an RTP time of roughly 40 days.¹⁵ The

The Orthopaedic Journal of Sports Medicine, 10(9), 23259671221120832

DOI: 10.1177/23259671221120832

© The Author(s) 2022

This open-access article is published and distributed under the Creative Commons Attribution - NonCommercial - No Derivatives License (<https://creativecommons.org/licenses/by-nc-nd/4.0/>), which permits the noncommercial use, distribution, and reproduction of the article in any medium, provided the original author and source are credited. You may not alter, transform, or build upon this article without the permission of the Author(s). For article reuse guidelines, please visit SAGE's website at <http://www.sagepub.com/journals-permissions>.

Women's NBA (WNBA) has grown in popularity over the past 20 years. Nevertheless, there are limited data on the incidence and RTP rate of clinically significant knee injuries in the WNBA.

The purpose of this study was to determine the epidemiology, mechanisms, and RTP rate of WNBA players sustaining injuries to the knee. We hypothesized that ACL tears would have the highest prevalence and longest RTP times in WNBA players.

METHODS

WNBA players who sustained a knee injury between the inception of the WNBA in 1997 and the end of the 2019 season were identified retrospectively. Information on injuries was collected using publicly available injury reports from the individual WNBA teams or from reputable sports websites such as the official WNBA website (www.wnba.com) or ESPN (www.espn.com), as described in previous studies.^{2,7} Out-of-season injuries were not included in our data collection or analysis since the circumstances of these injuries were seldom reported. Because of the use of publicly available data, no ethics committee approval was needed.

Each knee injury was confirmed by 2 independent sources to ensure its legitimacy. The retention rate (RTP rate) was defined as the percentage of athletes who returned to the WNBA for a minimum of 1 game after a specified knee injury. All knee injuries resulting in ≥ 1 missed game were included. Such injuries included meniscal tears, ACL tears, knee contusions, patellar contusions, medial collateral ligament (MCL) sprains, and knee sprains. Epidemiologic data collected included injury type, player's name, position, team, age, height, weight, date of injury, date of return, and days missed from sport. Descriptive information was collected from each team's official website. Any injury that did not result in time/games missed was excluded from our analysis. We determined the mean, standard deviation, frequency, incidence, and RTP rate and time to RTP of each injury. An analysis of variance (ANOVA) test was conducted to measure the statistical significance of injury rates by position.

Video analysis was performed on 12 knee injuries obtained from the WNBA all-access league pass. A quantitative video analysis was conducted individually by 2 authors (K.A. and N.C.). Video analysis software was not implemented, so quantitative analysis metrics were not performed. Each author conducted his individual analysis to determine whether the

TABLE 1
Characteristics of WNBA Players Sustaining Knee Injuries^a

Variable	Value
Age, y	26.9 ± 3.8 (21-23)
Height, cm	182.6 ± 8.9 (167.3-193.5)
Weight, kg	76.0 ± 10.1 (58.9-95.2)
Body mass index	22.7 ± 1.9 (16.7-26.2)

^aValues are presented as mean ± SD (range). WNBA, Women's National Basketball Association.

knee injury was a contact injury, the game activity during injury (ie, landing, planting, jumping, or running), and the knee positions during injury (ie, flexion, extension, varus, valgus). All of the reviewers' answers were compared and analyzed using the Cohen kappa test to determine interrater reliability. The reliability was categorized as substantial ($\kappa = 0.60-0.80$) or excellent ($\kappa = 0.81-1.0$).^{9,11} A third reviewer (N.J.L.) analyzed the video in the event of inconsistency between reported injury mechanisms and body positions by the initial 2 reviewers.

RESULTS

We identified 99 knee injuries sustained by 99 WNBA players over the course of 21 seasons spanning 1998 to 2019. The descriptive data of these players is reported in Table 1. Of these players, 37 (37%) sustained an ACL tear, 20 (20%) sustained a torn meniscus, 6 (6%) sustained an MCL strain, and 36 (36%) sustained a non-specific knee injury (reported as knee contusion, patellar contusion, and knee sprain). Of the 99 injuries recorded, all players averaged ≥ 1 day to recover after an injury. The number of injuries across the various types are shown in Figure 1.

The RTP times and rates of players are reported in Table 2. The average times to RTP for an ACL tear, torn meniscus, and MCL strain injury were 375, 231, and 124 days, respectively, and the average RTP rates for these injuries were 70%, 95%, and 100%, respectively. Depending on when the injury occurred, these RTP lengths may have included parts of the offseason. A breakdown of the players' RTP times and rates can be seen in Figure 2.

Overall, the player positions that sustained the highest injury rate across all knee injuries were point guards (27%) and shooting guards (25%), with a combined average

[†]Address correspondence to Neal Canastra, BA, Alpert Medical School of Brown University, 222 Richmond Street, Providence, RI 02903, USA (email: canastra_neal@wheatoncollege.edu).

^{*}Alpert Medical School of Brown University, Providence, Rhode Island, USA.

[‡]Department of Orthopaedic Surgery, Alpert Medical School of Brown University, Providence, Rhode Island, USA.

Final revision submitted March 19, 2022; accepted June 6, 2022.

One or more of the authors has declared the following potential conflict of interest or source of funding: B.D.O. has received research support from Arthrex and Mitek; consulting fees from ConMed Linvatec, DePuy/Medical Device Business Systems, Miach, Mitek, Musculoskeletal Transplant Foundation, and Vericel; royalties from ConMed Linvatec, Saunders/Mosby-Elsevier, SLACK, and Springer; honoraria from Vericel; and stock options in Vivorte and is a paid associate editor for *The American Journal of Sports Medicine*. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval was not sought for the present study.

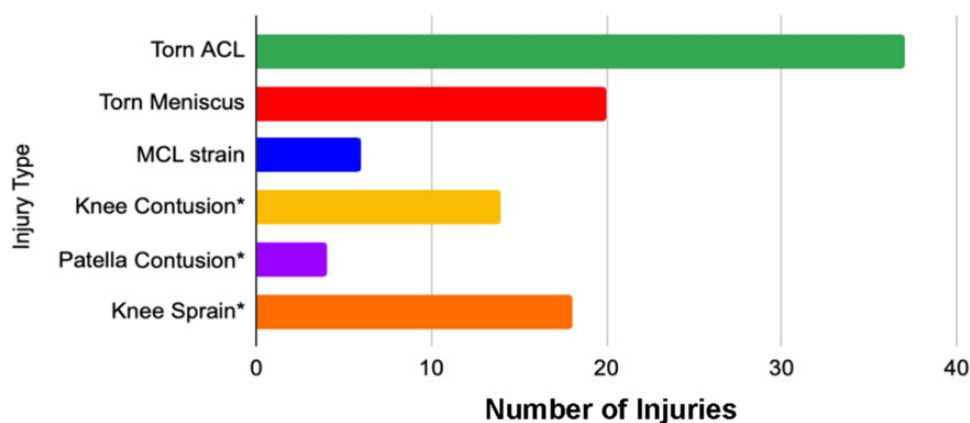


Figure 1. Injury types. *Nonspecific/other injuries. ACL, anterior cruciate ligament; MCL, medial collateral ligament.

TABLE 2
Number of Injuries, RTP Times, and RTP Rates (N = 99 injuries)^a

	Injuries, n (%)	Average RTP Time, d	RTP Rate, %
ACL tear	37 (37)	375	70
Torn meniscus	20 (20)	231	95
MCL strain	6 (6)	124	100
Knee contusion ^b	14 (14)	77	94
Patellar contusion ^b	4 (4)	166	100
Knee sprain ^b	18 (18)	56	77

^aACL, anterior cruciate ligament; MCL, medial collateral ligament; RTP, return to play.

^bNonspecific/other injuries.

of 53%, as indicated in Table 3 and Figure 3. The position with the lowest injury rate was center at 16%, with power forwards averaging 15% and small forwards at 16% for a combined 31% of knee injuries. There were no significant differences in injury rates by position ($P > .05$; ANOVA).

Video analysis was conducted for 12 injuries, consisting of ACL tears and MCL strains. The interrater agreement between the 2 reviewers was excellent for game action ($\kappa = 0.81$), and substantial agreement was determined for both hip position ($\kappa = 0.80$) and knee position ($\kappa = 0.74$). The interrater reliabilities can be seen in Table 4.

Of the 12 injuries analyzed, 2 (17%) were contact injuries, with the remaining 10 (83%) being noncontact injuries. The most common action during injury was planting the foot (58%), followed closely by landing (33%). In terms of hip position at the time of injury, hip flexion was the most commonly observed position (92%), with the remaining injuries showing a neutral hip position (8%). All analyzed injuries occurred with the leg in the flexed position and with the knee flexed in the valgus position. Knee injuries that occurred in the valgus position were accompanied by high levels of flexion recorded across the sagittal plane (100%). Information regarding injury type, contact versus noncontact injuries, player action during injury, and leg/knee position after video analysis is reported in Table 5.

DISCUSSION

Our study revealed that ACL tears are the most common type of knee injury in the WNBA that resulted in loss of play, accounting for 37% of total knee injuries. In addition, ACL tears were found to have the longest RTP length of all knee injuries at 375 days (including time during the off-season). These findings were not surprising given the frequency of high-risk athletic activities such as jumping and landing involved in the sport. We also found that a majority of knee injuries (53%) were sustained by guards.

The second most common knee injury in the WNBA was a meniscal tear, accounting for 20% of all knee injuries. Meniscal tears resulted in the second longest RTP lengths and rates out of play of all knee injuries at 375 days and 231 days, respectively. Overall RTP rates of ACL and meniscal tears were 70% and 95%, respectively. This RTP rate of ACL tears in the WNBA is consistent with a study evaluating performance effects of ACL tears in WNBA athletes that cited an RTP rate of 69.5%.¹⁴ Importantly, this rate appears to be lower than the RTP rate of NBA players who underwent ACL reconstruction surgery, which is 88.9%.¹³ NBA players who sustained a torn meniscus missed on average between 40 and 45 days, which again is also an appreciably shorter length than the RTP length of the WNBA players with similar injuries at 231 days.¹⁵

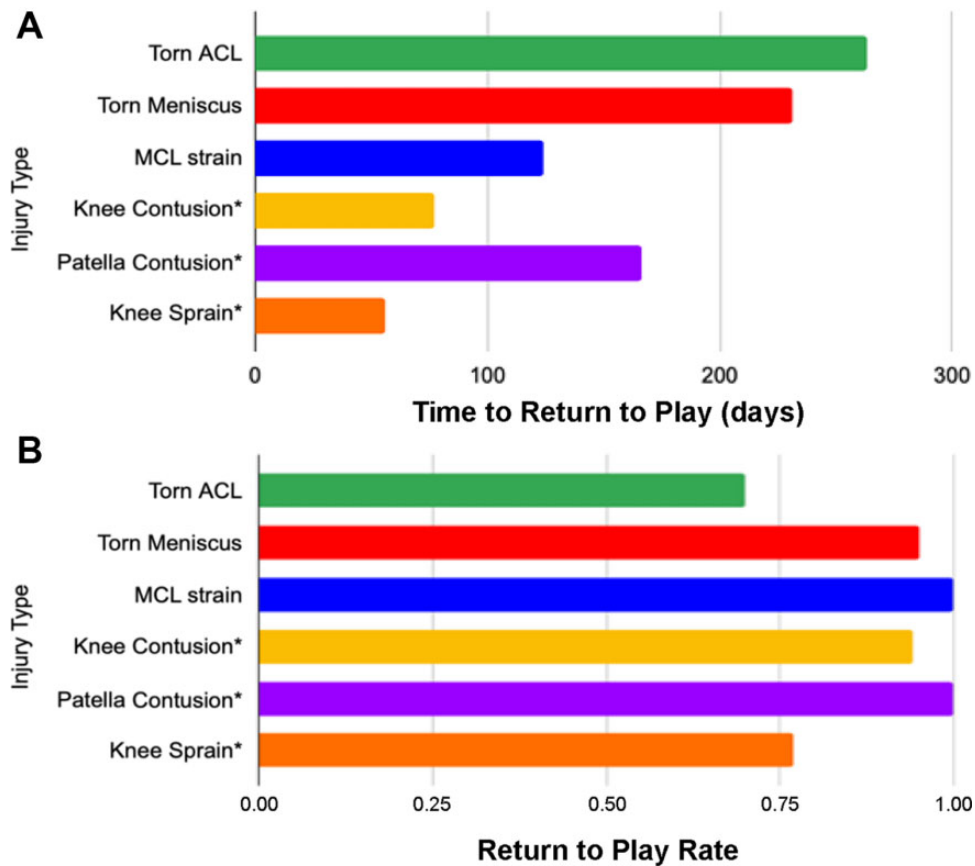


Figure 2. (A) Return to play times and (B) rates by injury type. *Nonspecific/other injuries. ACL, anterior cruciate ligament; MCL, medial collateral ligament.

TABLE 3
Injury Rate by Position^a

	Injury Rate, %					P
	Point Guard	Shooting Guard	Small Forward	Power Forward	Center	
ACL tear, n=37	24	30	27	16	3	.11
Torn meniscus, n=20	25	25	10	10	30	.29
MCL strain, n=6	33	16	16	33	0	.15
Knee contusion ^b , n=14	35	14	7	14	28	.18
Patellar contusion ^b , n=4	0	25	25	0	50	.07
Knee sprain ^b , n=18	33	27	5	16	11	.21

^aACL, anterior cruciate ligament; MCL, medial collateral ligament.

^bNonspecific/other injuries.

Meniscal tears have not been shown to significantly affect the performance of NBA players; however, the longer RTP length seen in the WNBA indicates that this may not be the case for professional female basketball players.¹⁵ The anatomic and physiological differences between men and women, such as hormone levels, limb alignment, and ligamentous laxity, could contribute to a potentially greater performance effect after meniscal tears.⁸ We believe that the likely reason for these observed differences is resource

disparities in rehabilitation between the NBA and WNBA. Moreover, we do not have any specific information regarding postinjury rehabilitation or treatment protocols, which can also play a large role in RTP. Operative intervention versus nonoperative management as well as the specific rehabilitation protocols would be interesting to evaluate and compare between WNBA players and their male professional basketball counterparts to help further elucidate the pronounced differences in RTP times between these 2 cohorts.

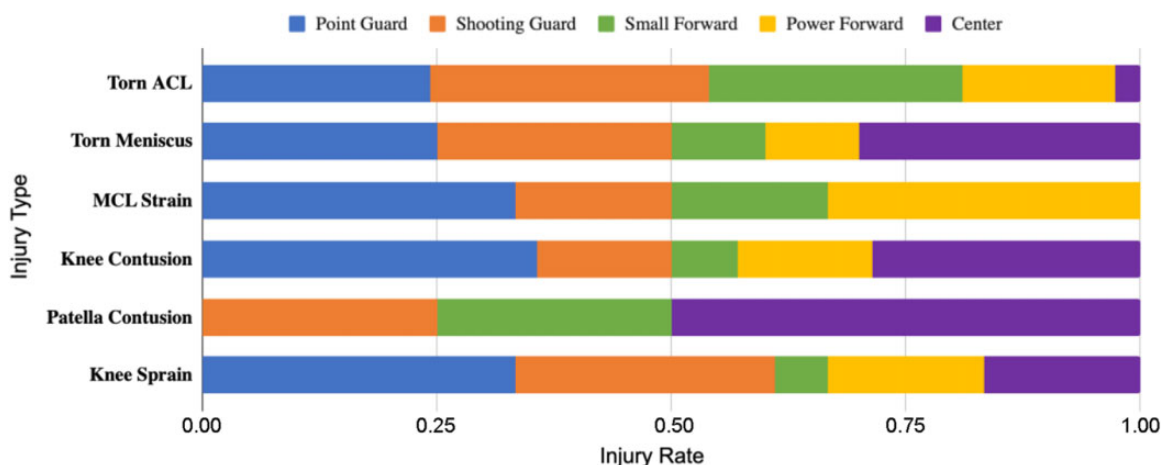


Figure 3. Injury rate by position. ACL, anterior cruciate ligament; MCL, medial collateral ligament.

TABLE 4

Interrater Reliability of Video Analysis of Knee Injuries

Position/Action	κ	SE	P
Game action	0.81	0.16	<.01
Hip position in flexion and extension	0.8	0.14	<.01
Knee position	0.74	0.18	.01

TABLE 5

Injury Mechanism of ACL Tear and MCL Strain According to Video Analysis^a

Injury Mechanism	ACL Tear (n = 10)	MCL Strain (n = 2)
Injury type: contact	1 (10)	1 (50)
Injury type: noncontact	9 (90)	1 (50)
Action: jumping	0 (0)	1 (50)
Action: landing	4 (40)	0 (0)
Action: planting	6 (60)	1 (50)
Leg position: flexion	10 (100)	2 (100)
Knee position: valgus	10 (100)	2 (100)
Knee position in sagittal plane: flexion	10 (100)	2 (100)

^aData are reported as n (%). ACL, anterior cruciate ligament; MCL, medial collateral ligament.

A study was previously performed evaluating knee injuries previously sustained by athletes taking part in the WNBA Combine between 2000 and 2008.¹¹ Before entering the combine, the most common surgery was an ACL reconstruction, which was performed on 14.4% of athletes.¹¹ Meniscal repair surgery was the second most common surgery, performed on 9.9% of athletes. Most of the ACL surgeries were performed in both point and shooting guards (47% of all ACL tears), while most of the meniscal surgeries were performed on small and power forwards (40% of all meniscal tears).¹¹ Our study found that guards as a whole were more likely to sustain both ACL tears and meniscal tears compared with any other position. Future

research evaluating position-specific demands resulting in variable rates of specific injuries to the knee, as observed in the current study, would be useful to examine the factors that may predispose guards to knee injuries and perhaps create a preventative exercise program for specific athletes based on their position.

Video analysis has been a tool used to identify and understand the mechanism of injuries in multiple sports at both the collegiate and the professional levels.^{3,6,7,12} However, there remains a lack of research on the mechanisms of knee injuries in WNBA athletes. The present study is the first study to date using video analysis to determine the movements and mechanisms that caused various knee injuries in WNBA athletes. After evaluating 12 knee injuries, we found that 10 (83%) were noncontact injuries, with the most common actions at the time of injury being planting/pivoting (58%) and landing (33%). The knee position at the time of all analyzed injuries was valgus and flexion (100%). The hip position at the time of injury was flexion (92%) and neutral (8%). These results are consistent with the mechanisms responsible for ACL tears, the most commonly seen clinically significant knee injury in the WNBA.¹⁶ While ACL tears accounted for a majority of the knee injuries we analyzed (83%), a flexed knee in the valgus position accounted for 100% of all injuries analyzed. This suggests that such a mechanism of injury may result in various types of knee injuries, in addition to the classically described ACL tear mechanism. In comparison, a similar study conducted in the National Football League found that the majority of ACL injuries occurred via a noncontact mechanism (72.5%),⁶ which aligned closely with our findings of 90%. In addition, hip abduction/flexion and early knee flexion/abduction were shown to be the predominant position during injury, with similar findings corroborated in multiple orthopaedic studies on noncontact injury mechanisms.^{1,16}

An epidemiological study performed by Baker et al² examining injuries in the WNBA between 2015 and 2019 found that knee injuries contributed to 29% of all injuries sustained in the WNBA. Specifically, players with ACL tears averaged an RTP rate of 376 days, which aligns with

our current findings of 375 days. When comparing the number of data points, the study by Baker et al found 56 knee injuries over a 5-year period (2015-2019), while our study gathered 99 players over a period of 21 years (1998-2019). The 34-injury difference over the span of 17 years likely does not accurately reflect the true number of knee injuries that occurred over that period because of the limitations both studies faced in collecting data from publicly available sources. Despite the similar results, a major difference is that the study of Baker et al evaluated injuries across the entire body, while our study focused solely on knee-related injuries. Furthermore, our study measured days missed after an injury as our RTP length, while the Baker et al study evaluated games missed after an injury as a measure of recovery time. We believed that days missed after an injury would be a more accurate determinant for recovery time since it considers the offseason when no games are played for 3 to 4 months at a time. In addition, the study by Baker et al did not evaluate the prevalence of injuries based on player position. Finally, we performed video analysis to determine commonly seen mechanisms of injury—an important factor in injury prevention and management.

Limitations

There are several limitations to this study to consider critically. Our methodology, by using injury reports and public records rather than a pre-established database or prospective analysis, lends itself to the possibility of missing subacute injuries that may have occurred in practice or were not widely publicized. This also creates the possibility of our finding injuries of only “newsworthy” players. This may have led to reporting errors and unintentional omissions. No clinical data were available, so surgical versus conservative management was unable to be assessed. It is certainly possible that RTP rates and duration may be affected by time to surgery, type of physical therapy or rehabilitation, and surgical or nonsurgical management for specific injuries. The lack of practice footage available limited our analysis to only game footage, resulting in the potential underreporting of total injuries sustained throughout the season. In addition, because of the inability to standardize minutes played across positions, player exposure information was assumed to be distributed evenly across the various positions.

CONCLUSION

Our findings indicated that ACL tears are the most commonly reported injury type and have the longest times before RTP among WNBA players. Guard was shown to be the position with the greatest risk of sustaining a knee injury, with centers sustaining, on average, the lowest injury rate across the majority of all 5 injury types. The

most common mechanism of injury is planting the foot and landing from a jump with a flexed hip and flexed knee in the valgus position. Further research evaluating the clinical management and outcomes of ligamentous injuries of WNBA players would be useful.

REFERENCES

1. Arendt EA, Agel J, Dick R. Anterior cruciate ligament injury patterns among collegiate men and women. *J Athl Train.* 1999;34(2):86-92.
2. Baker H, Rizzi A, Athiviraham A. Injury in the Women's National Basketball Association (WNBA) from 2015 to 2019. *Arthrosc Sports Med Rehabil.* 2020;2(3):e213-e217.
3. Barone M, Senner V, Schaff P. ACL Injury mechanism in alpine skiing: analysis of an accidental ACL rupture. *Am J Sports Med.* 1999;1999:63-81.
4. Bjordal JM, Arnøy F, Hannestad B, Strand T. Epidemiology of anterior cruciate ligament injuries in soccer. *Am J Sports Med.* 1997;25(3):341-345.
5. Ingram JG, Fields SK, Yard EE, Comstock RD. Epidemiology of knee injuries among boys and girls in US high school athletics. *Am J Sports Med.* 2008;36(6):1116-1122.
6. Johnston J, Mandelbaum BR, Schub D, et al. Video analysis of anterior cruciate ligament tears in professional American football athletes. *Am J Sports Med.* 2018;46(14):862-868.
7. Lemme N, Li N, Kleiner J, Tan S, DeFroda S, Owens B. Epidemiology and video analysis of Achilles tendon ruptures in the National Basketball Association. *Am J Sports Med.* 2019;47(10):2360-2366
8. Lewis T. Anterior cruciate ligament injury in female athletes: why are women so vulnerable? *Physiotherapy.* 2000;86(9):464-472.
9. Lowe JT, Testa EJ, Li X, Miller S, DeAngelis JP, Jawa A. Magnetic resonance imaging is comparable to computed tomography for determination of glenoid version but does not accurately distinguish between Walch B2 and C classifications. *J Shoulder Elbow Surg.* 2017;26(4):669-673.
10. Malone TR, Hardaker WT, Garrett WE, Feagin JA, Bassett F. Relationship of gender to anterior cruciate ligament injuries in intercollegiate basketball players. *J South Orthop Assoc.* 1993;2:36-39.
11. McCarthy MM, Voos JE, Nguyen JT, Callahan L, Hannafin JA. Injury profile in elite female basketball athletes at the Women's National Basketball Association combine. *Am J Sports Med.* 2013;41(3):645-651.
12. Montgomery C, Blackburn J, Withers D, Tierney G, Moran C, Simms C. Mechanisms of ACL injury in professional rugby union: a systematic video analysis of 36 cases. *Br J Sports Med.* 2018;52(15):994-1001.
13. Nwachukwu BU, Anthony SG, Lin KM, Wang T, Altchek DW, Allen AA. Return to play and performance after anterior cruciate ligament reconstruction in the National Basketball Association: surgeon case series and literature review. *Phys Sportsmed.* 2017;45(3):303-308.
14. Tramer J, Lafi K, Alexander Z, Nima M, Kelechi O. Return to play and performance in the Women's National Basketball Association after anterior cruciate ligament reconstruction. *Orthop J Sports Med.* 2020;8(9):2325967120947078.
15. Yeh PC, Starkey C, Lombardo S, Vitti G, Kharrazi FD. Epidemiology of isolated meniscal injury and its effect on performance in athletes from the National Basketball Association. *Am J Sports Med.* 2012;40(3):589-594.
16. Yu B, Garrett WE. Mechanisms of non-contact ACL injuries. *Br J Sports Med.* 2007;41(1):41-51.