

Lower Back Injuries in NCAA Female Volleyball Athletes

A 5-Year Epidemiologic Characterization

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Background: Although lower back injuries (LBIs) are common among National Collegiate Athletic Association (NCAA) female volleyball athletes, their incidence and etiology has not been well-defined.

Purpose: To describe the epidemiology of LBIs in collegiate female volleyball athletes over a 5-year period from the academic years 2009 to 2010 and 2013 to 2014.

Study Design: Descriptive epidemiology study.

Methods: The incidence and characteristics of spine injuries were identified utilizing the NCAA Injury Surveillance Program database. Rates of injury were calculated as the number of injuries by the total number of athlete-exposures (AEs). AEs were defined as any student participation in any single NCAA-sanctioned practice or competition. The injury rate was computed as the number of injuries per the total number of AEs and reported as a ration of injuries per 10,000 exposures. The ratio was then reported as overall number as well as stratified for event, time of season, and athletic NCAA division. Incidence rate ratios were then calculated to compare rates between event type. Results with 95% CIs that did not include 1.0 were considered statistically significant.

Results: An estimated 3384 LBIs occurred in NCAA female volleyball players during this 5-year time frame. These LBIs occurred at a rate of 4.89 injuries per 10,000 AEs. LBIs were 2.76 times more likely in preseason when compared with regular season. More injuries occurred in practice (85%) when compared with competition (15%). The outside hitter and middle blocker were the most commonly position to sustain an LBI. Almost 70% of injuries were new injuries, and another 29% were recurrent injuries. The most common mechanism of injury was equally split between contact (50.4%) and overuse (45.5%) injuries, whereas the remaining mechanisms of injury were secondary for unknown reasons (4.14%). Most players returned to play within 24 hours (72.3%) followed by 1 to 6 days (16.4%), and finally 7 to 12 days (11.3%). No patient required surgical intervention.

Conclusion: The rate of LBIs was high (4.89/10,000 AEs) and injuries commonly recurred (29.2%). Most injuries were new, with most athletes returning to play with 24 hours.

Keywords: athletes; collegiate athlete; database; epidemiology; female athletics; lumbar spine; lumbar strain; National Collegiate Athletic Association; spine; volleyball injury; women

In the past few decades, women's volleyball has increased in popularity, and it is now one of the most common sports played among female athletes.²³ In 1981, there were 603 National Collegiate Athletic Association (NCAA) college and university women's volleyball teams with 8418 players. As of 2018, there were 1071 women's NCAA volleyball teams with 17,471 players, highlighting the recent surge

in popularity.¹⁶ From 2013 to 2015, injuries in women's volleyball occurred at a rate of 7.07 per 1000 athlete-exposures (AEs), the majority being to the lower extremity,⁶ mirroring this increase in popularity.

Although not the most common injury, lower back injuries (LBIs) still account for a significant number of injuries in volleyball,¹⁸ occurring at a rate of 4.89 per 10,000 AEs between 2009 and 2015.¹⁵ Furthermore, LBIs are responsible for a similar amount of time lost from participation when compared with lower-extremity injuries.^{11,24} The various repetitive flexion, extension, and rotational type

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movements athletes place on their spine leave the lumbar spine particularly vulnerable to injury. These injuries, if not properly identified and treated, can persist, leading to significant cost to organizations and morbidity among players.^{8,9} Despite the superior body mechanics in athletes, low back pain is estimated to be more prevalent in athletes when compared with the general public.^{14,28,32} The lifetime prevalence of lower back pain in volleyball players alone has been shown to be upward of 63%.²⁸ Whether untreated or poorly managed LBIs can be implicated in this high prevalence is still unknown. Injury research can help guide coaches, trainers, and support staff with proper insight into how to mitigate the risk of injuries.

Limited research has been conducted on volleyball-related injuries, leaving gaps in our current understanding. A study by Hassebrock et al¹⁵ reported rates of lower spinal injuries among all major NCAA athletics. Remarkably, women's volleyball players were among the most likely to sustain an LBI.¹⁵ Recent studies even suggest that LBIs may be the most common injury in volleyball; however, these injuries go unnoticed due to underreporting.^{2,27} In addition, previous research suggests NCAA volleyball players have a higher risk of injury during practice as opposed to games.⁶ Furthermore, while LBIs among women's volleyball have been identified at a significant number, no study has characterized LBIs among women's volleyball players.

The purpose of this study was to analyze the NCAA Injury Surveillance Program (NCAA-ISP) database from the academic years 2009 to 2010 and 2013 to 2014 to characterize and describe the epidemiology of LBIs in women's volleyball. It was hypothesized that NCAA women's volleyball players will sustain a high rate of LBIs, occurring primarily during practice.

METHODS

The protocol for this study was found to be exempt from institutional review board approval and approved by the research review board of the NCAA. The NCAA-ISP is a prospectively gathered injury surveillance program managed by the Datalys Center for Sports Injury Research and Prevention. It has been used previously to characterize LBIs among various sports; however, it has not previously been used to evaluate volleyball athletes.^{15,24,25,34} We used data from the academic years 2009 to 2010 and 2013 to 2014, giving a 5-year insight into women's volleyball injuries. The use of NCAA-ISP for data has been described

previously^{17,24}; a brief overview is presented in the following.

Data Collection

The NCAA-ISP utilizes a voluntary convenience sample of NCAA programs. Accordingly, there is a variability in the number of programs participating in the data set each year. This creates a deterministic sample of data, as opposed to a random sample, allowing proper monitorization of injury trends and patterns.^{10,24} The NCAA-ISP relies on medical staff and athletic trainers (ATs) at each participating program to record injury and exposure data through their electronic health record application throughout the academic year. Data are collected during organized practices and competitions throughout the preseason, regular season, and postseason. For each event, physicians and/or ATs complete a report on common data points such as the type of injury, the position of the player injured, the duration of injury, the anatomic site, and the circumstances surrounding the injury. Hence, data analysis is limited to information entered by ATs, and information such as age, weight, height, pre-existing spine morphology, or comorbid conditions are not given.

If a player sustains an injury such as an LBI, and is subsequently diagnosed by medical personnel, the college institution relies on ATs and/or physicians to update this information within the NCAA-ISP database. It is also the role of ATs to notify coaches of these injuries and follow along with any diagnoses from physician visits. Medical staff and ATs can view and update previously submitted work, allowing them to typify the injury's chronicity, recurrence, and associated return to play. Finally, the ATs provide the number of student-athletes participating in practice and competition to determine exposure.

For quality control, data pooled from certified electronic health records are deidentified and encrypted before being uploaded. The data are then passed through an automated verification process to ensure proper validity and consistency. ATs are notified whether any data were missing, and quality control staff help with any inconsistencies. Finally, exported data are checked for outliers, and data that pass all steps are aggregated into the research database.

The ISP database was queried for women's volleyball players in any division who sustained a "lower back" or "lumbar" injury and "sacrum/pelvis" injury. Data included in the data set that was not pertinent to LBIs were excluded. This study relied on the training and expertise

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of the ATs collecting data as well as the other members of the medical staff in assisting with documentation to accurately diagnose and report all LBIs.

Definitions

An LBI was defined as any injury confined to the lower back, such as contusions, fractures, strains, sprains, pain, or nervous system injuries. An AE was defined as any single student-athlete competing in 1 NCAA-sanctioned practice or competition in which there was a potential they could experience an injury, regardless of whether an injury happened. This allowed data to be controlled by the amount of exposure per practice or per game.

Computing National Estimates

Calculating estimates from the NCAA-ISP database has been described and validated previously.^{6,13} To calculate national estimates of the number of LBIs, poststratification sample weights based on sport, division, and academic year were applied to each reported injury and AE. Poststratification sample weights were calculated with the following formula:

$$\text{Sample weight}_{abc} = \left(\frac{\text{Number of teams participating in ISP}_{abc}}{\text{Number of teams in NCAA}_{abc}} \right)^{-1}$$

where weight_{abc} is the weight for the a th sport of the b th division in the c th year. Weights for all data were further adjusted to correct for underreporting, according to findings from Kucera et al,²⁰ who estimated an 88.3% capture rate of all time-loss medical care injury events with the NCAA-ISP reported previously in the literature.^{8,12} Therefore, weighted counts were scaled to a factor of 0.883^{-1} to account for underreporting.

Data Analysis

Data were analyzed for the rate and characterization of all spine injuries in NCAA female volleyball players using a previously standardized weighted estimate.^{6,13} LBIs were analyzed for type, time loss, time of season, event type, recurrence injury mechanism, and participation restriction. The injury rate was computed as the number of injuries per the total number of AEs and reported as a ratio of injuries per 10,000 exposures. The ratio was then reported as overall number as well as stratified for event (practice vs competition), time of season (preseason, regular season, postseason), and by the NCAA division of the athlete's school (largest to smallest division: Division I, Division II, and Division III). Incidence rate ratios (IRRs) were then calculated to compare rates between event type. The following formula demonstrates a sample IRR calculation using rated between competition and practice as an example, used by various other studies^{15,24,25}:

TABLE 1

National Estimates of Lower Back Injuries by Injury Type^a

Injury Type	n (%)	Injury Rate per 10,000 AEs
Contusion (hematoma)	40 (1)	0.06
Fracture	110 (3)	0.16
Nervous system	158 (5)	0.23
Spasm	654 (19)	0.94
Strain	628 (19)	0.90
Unspecified lower back pain	1795 (53)	2.58
Total	3385	4.89

^aAE, athlete-exposure.

$$\text{IRR} = \frac{\left(\frac{\sum \text{Number of competition injuries}}{\sum \text{Competition AEs}} \right)}{\left(\frac{\sum \text{Number of practice injuries}}{\sum \text{Practice AEs}} \right)}$$

Results with 95% CIs that did not include 1.0 were considered statistically significant. Descriptive data were reported as percentages, and participation restriction time was reported using intervals of <24 hours, 1 to 6 days, 7 to 21 days, and more than 21 days.¹⁵ All data were analyzed using IBM SPSS and Microsoft Excel.

RESULTS

A total of 76 LBIs in female volleyball were identified in the NCAA-ISP database during the academic years 2009 to 2010 and 2013 to 2014. The injuries in these data correlated with a national estimated 3384 LBIs occurring in female volleyball players during this 5-year time frame. The overall injury rate for lower spinal injuries was 4.89 injuries per 10,000 AEs. Close to 53% of injuries were classified as "unspecified lower back pain." After unspecified lower back pain injuries, the most common were strains (19%), spasms (19%), nervous system injuries (5%), fractures (3%), and hematomas (1%) (Table 1).

Injuries by NCAA Division

Athletes in Division III volleyball were the most likely to experience an LBI (6.90 per 10,000 AEs), followed by Division I (5.20 per 10,000 AEs) and Division II (1.40 per 10,000 AEs). (Figure 1). Athletes were 3.73 times more likely to experience an injury in Division I compared with Division II (IRR, 3.72 [95% CI, 3.25-4.27]) and 0.76 times more likely to experience an injury in Division I compared with Division III (IRR, 0.76 [95% CI, 0.70-0.81]). Finally, athletes were 4.93 times more likely to be injured in Division III compared with Division II (IRR, 4.93 [95% CI, 4.32-5.62]).

Event Type

The LBI rates for practice and competition were 5.80 and 2.50 per 10,000 AEs, respectively (Table 2). Players were 0.43 times more likely to be injured in practice when compared with competition (IRR, 0.43 [95% CI, 0.23-0.80]).

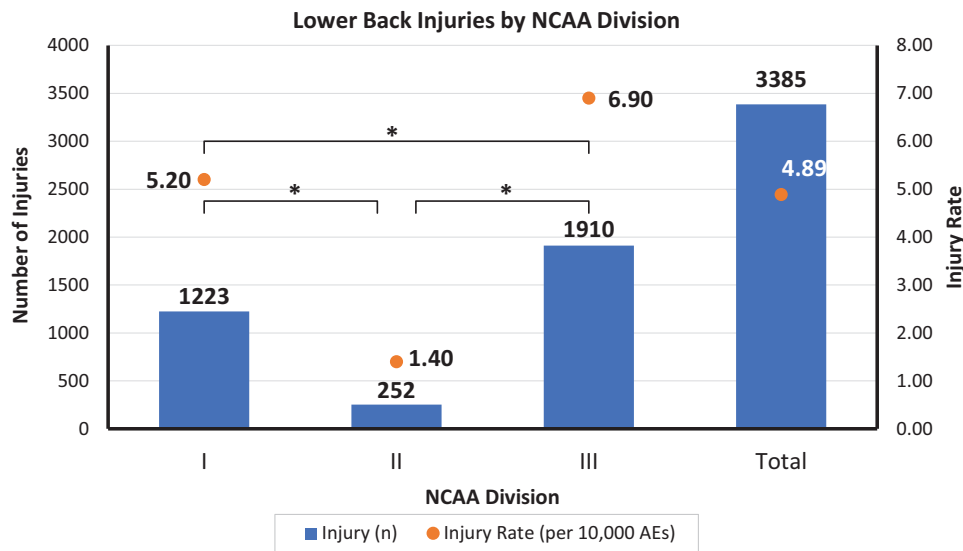


Figure 1. Women’s volleyball lower back injuries by National Collegiate Athletic Association (NCAA) division. AE, athlete-exposure. *Statistically significant difference between divisions.

TABLE 2
Injuries in Relation to Practices and Competitions^a

Variable	Value
Injury, n (%)	
Practice	2879 (85)
Competition	505 (15)
Injury rate (per 10,000 AEs)	
Practice	5.80
Competition	2.50
Rate ratio (95% CI)	
Competition/practice	0.43 (0.23-0.80) ^b

^aAE, athlete-exposure.

^bStatistically significant.

TABLE 3
Injuries by Season Type^a

Variable	Value
Injuries, n (%)	
Preseason	1573 (46)
Regular season	1763 (52)
Postseason	49 (1)
Injury rate (per 10,000 AEs)	
Preseason	9.61
Regular season	3.50
Postseason	1.80
Rate ratio (95% CI)	
Preseason/regular season	2.76 (1.75-4.35) ^b
Postseason/regular season	0.51 (0.07-3.73)
Postseason/preseason	0.19 (.03-1.36)

^aAE, athlete-exposure.

^bStatistically significant.

Season of Play

The injury rate was the highest during the preseason (9.61 per 10,000 AEs) followed by regular season (3.50 per 10,000 AEs) and postseason (1.80 per 10,000 AEs) (Table 3). Players were 2.76 times more likely to be injured during the preseason when compared with the regular season (IRR, 2.76 [95% CI, 1.75-4.35]). Of note, players did not have any significant risk of injury in postseason when compared with preseason (IRR, 0.19 [95% CI, 0.03-1.36]), and no significant risk of injury in postseason when compared with regular season (IRR, 0.51 [95% CI, 0.07-3.73]).

Injury by Position

The outside hitter and middle blocker had the highest weighted injury totals at 1071 (31.7%) and 1030 (30.5%), respectively (Figure 2). These were followed by the libero (n = 523; 15.5%), unknown (n = 488; 14.4%), setter (n = 228; 6.7%), and finally, the right-side/opposite hitter (n = 41; 1.2%).

Mechanism of Injury

Contact and overuse/gradual comprised 1705 (50.4%) and 1540 (45.5%) of the cohort, respectively (Table 4). Another 140 (4.14%) weighted totals were of unknown mechanism, and no injuries were secondary to infection.

Injury Chronicity

Overall, 69.6% (n = 2356) of injuries were new, whereas 29.2% (n = 988) were recurrent injuries from the previous academic year, and the remaining 1.2% (n = 40) of injuries were missing/unknown (Figure 3). Unspecified lower back pain was still the most common culprit of LBIs in both new (49.2%; n = 1159) and recurrent (60.2%; n = 595) injuries.

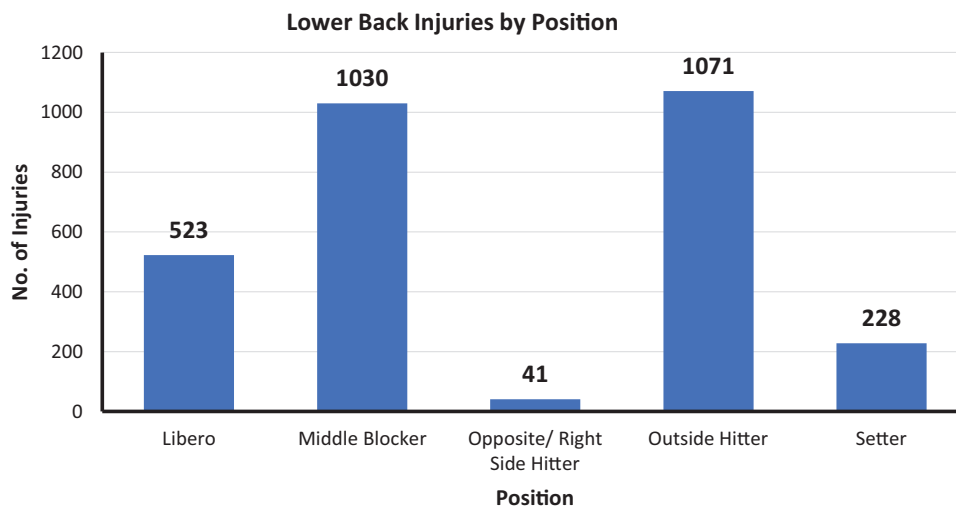


Figure 2. National Collegiate Athletic Association female volleyball lower back injuries by position. This does not include the 488 injuries for which position was unknown.

TABLE 4
Mechanism of Injury by Injury Type^a

Injury Type	Contact	Overuse/Gradual	Unknown	Total
Contusion (hematoma)	40	0	0	40
Fracture	68	41	0	109
Nervous system	68	90	0	158
Spasm	491	102	61	654
Strain	296	332	0	628
Unspecified lower back pain	742	975	79	1796
Total	1705	1540	140	3385

^aData are reported as number of athletes.

Time Lost From Play and Need for Surgery

Athletes with LBIs returned to play most commonly within 24 hours (72.3%), followed by 1 to 6 days (16.4%), and finally 7 to 21 days (11.3%) (Table 5). No athlete needed more than 21 days to return to play. Among the players with unspecified lower back pain injuries (53.8%), 67.5% returned to play within 24 hours, 15.3% needed 1 to 6 days, and 17.1% needed 7 to 21 days. The only other LBI listed that warranted 7 to 21 days off of play was spasms (9.9%). No athlete with an LBI needed surgical intervention.

DISCUSSION

This analysis of LBIs in collegiate female volleyball players during the academic years 2009 to 2010 and 2013 to 2014 yielded several important findings: (1) athletes were less than half as likely to sustain an LBI during competition as opposed to practice (IRR, 0.43 [95% CI, 0.23-0.80]); (2) players were 2.76 more times likely to sustain an injury in preseason compared with regular season (IRR 2.76 [95% CI,

1.75-4.35]); (3) LBIs occurred via only 2 mechanisms, contact and overuse, at similar rates; (4) 29.2% were recurrent injuries or reinjured; (5) the majority of volleyball athletes with LBIs returned within 24 hours (72%), and none needed more than 21 days to recover; and (6) athletes in Division III were the most likely to sustain an injury, almost 5 times more likely when compared with Division II (IRR, 4.93 [95% CI, 4.32-5.62]). In this study, LBIs occurred at a rate of 4.89 injuries per 10,000 AEs.

Previous studies have shown significant LBIs in a multitude of sports.^{1,6,24,15,34} Studies have also indicated that lumbar injuries are common among volleyball players, with female volleyball athletes more likely to experience lower back pain compared with male volleyball players.^{6,15,18,32} Characterizing lumbar injuries in NCAA volleyball players will allow for more informed decision-making and better management of these injuries. With an estimated 63% prevalence of lower back pain among volleyball players, implementation of data-driven protocols can help mitigate this issue.²⁸

NCAA female volleyball players sustained a higher rate of LBIs during practice when compared with competition (5.80 and 2.50 per 10,000 AEs, respectively). Furthermore, the overall number of injuries in practice was greater than in competition. Previous studies involving female athletes, such as gymnasts, show that injuries are more likely in competition, and one would expect the same results here. Interestingly, female volleyball athletes showed the opposite trend. This phenomenon is consistent with recent publications involving female volleyball at both the high school and collegiate levels.^{15,26,29,31} There are many factors suggested to attribute to this trend, including variation in the intensity and type of drills occurring during practices when compared with other sports, routine practice of high-risk maneuvers, such as diving, rarely used in games, and more frequent practice.^{6,19,31} Coaches and support staff should remain cognizant of this phenomenon among female volleyball athletes, with a special emphasis placed on injury

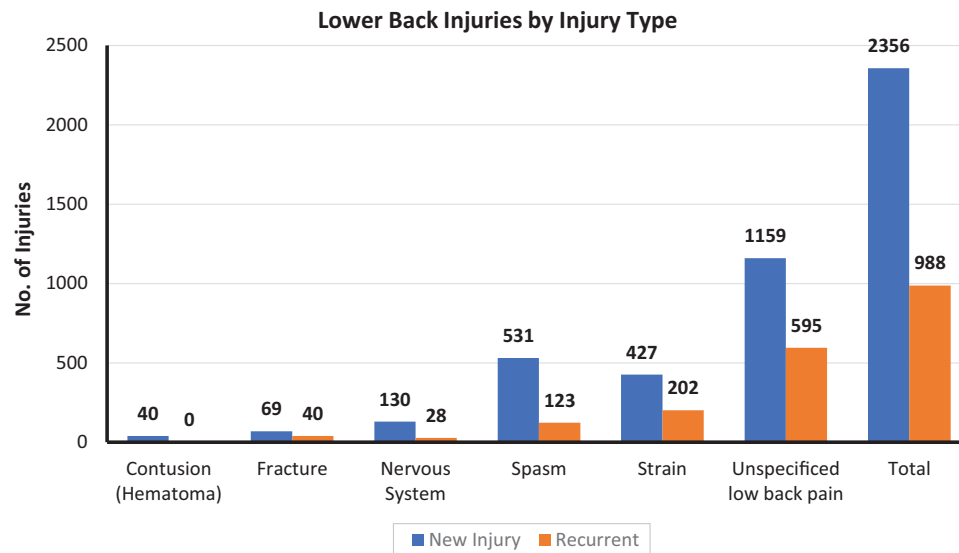


Figure 3. National Collegiate Athletic Association female volleyball lower back injuries by injury type.

TABLE 5
Time Loss by Injury Type^a

Injury Type	Return to Play				Total
	<24 h	1-6 days	7-21 days	>21 days	
Contusion (hematoma)	40	0	0	0	40
Fracture	41	0	0	0	41
Nervous system	130	0	0	0	130
Spasm	504	49	61	0	614
Strain	354	194	0	0	548
Unspecified lower back pain	1081	246	274	0	1601
Total	2150	489	335	0	2974

^aData are reported as number of athletes.

prevention during practice. Future studies are warranted to examine the association of this event-type injury shown only in female volleyball.

In addition, LBIs occurred at a higher rate in the preseason (9.61 per 10,000 AEs) than the regular season (3.50 per 10,000 AEs). This increased risk of injury in the preseason has been explained previously in collegiate athletics, with factors such as poor conditioning, high-intensity preseason training, athletes competing for spots on rosters, and longer practices.^{24,25} In addition, the reasons implicated previously in relation to practice injuries may also contribute to the increase in preseason injuries, as preseason consists predominantly of practice. Together, these findings underscore the need for proper injury prevention in the preseason as well as regular season practice settings. Long-standing data have proven that well-designed, off-season strength training among all athletes, both male and female, decreases injury rates.⁵ Although historically taboo among women,²¹ strength training such as weightlifting and

efforts to gain muscle mass can be particularly beneficial in injury prevention.^{5,30}

Previous studies have reported lower-back pain as the most common overuse injury reported by professional beach volleyball players.³ Our study also reports a significant number of LBIs were due to overuse (45.5%), with the vast majority of overuse injuries secondary to low back pain (63%). Although contact injuries were more common (50.4%), the percentage of overuse LBIs among female volleyball players far exceeded that of other female sports. For example, lumbar injuries secondary to overuse in all aggregated women's sports was 26.1%, a percentage far lower than the 45.5% rate in our study.¹⁵ In addition, almost 30% of LBIs in female volleyball players in our study sustain recurrent injuries, again a higher percentage than other sports.^{15,18,23-25} Taken together, female volleyball players are not only more prone to overuse LBIs, but they are also more likely than other collegiate athletes with similar back injuries to develop recurrent LBIs.^{1,31} It is notable, however, that over 72% of LBIs among female volleyball players returned to play within 24 hours, and all women returned within 21 days. A speculative explanation for these findings would be that female volleyball players take inadequate time off from their injuries and subsequently experience injury recurrence. As a result, athletic medical staff should remain vigilant on the nature of LBIs among female volleyball players and enact proper protocols such as adequate time off and proper preconditioning. Furthermore, recent research has suggested daily monitoring by ATs of overuse complaints decreases the prevalence of substantial issues. Individualized daily monitoring also allows athlete-specific strength and weakness profiles to help minimize future injuries.²²

As expected, LBIs were far more common among front-line players such as the outside hitter (31.7%) and middle blocker (30.5%). This is in line with previous reports and is most likely due to the increased stress and axial load on the

spine from jumping and landing that front-line players experience more often.^{4,7,18} Particular attention should be targeted at front-line players to ensure proper jumping and landing form.

Previous literature has shown Division I athletes are more vulnerable to injury when compared with Division II or III secondary to the increased competitiveness and intensity of Division I.^{8,9} Interestingly, this study showed Division III sustained the highest injury rate. Makovicka et al²⁴ reported similar results in basketball; uniquely, while female athletes were more likely to sustain injuries in Division III, their male counterparts were more likely to sustain injuries in Division I. There is currently a paucity of literature on this unique trend among women's NCAA sports. However, it has been shown that younger volleyball players, with less experience and understanding of game fundamentals, are more prone to injury.³³ It could therefore be deduced that athletes in Division III, where fewer resources are available, spend less time learning game fundamentals and proper conditioning, thereby increasing the likelihood of injury. Future studies are warranted to understand this trend in women's NCAA athletics.

The management of LBIs is of particular importance, as this study shows LBIs have a high tendency to recur. To minimize this, clinicians should help emphasize the need for proper preseason conditioning and continuity with team ATs.^{22,30} It is also important that clinicians keep in mind that female volleyball student-athletes have a higher likelihood of sustaining injuries in the preseason and during practice. Most of these LBIs require less than 24 hours to recover. Although it is speculative, this study suggests student-athletes may need more than 24 hours, as this could help limit the high rate of recurrence. In addition, clinicians should keep in mind that, although volleyball is a noncontact sport, LBIs are not uncommon, and the majority of LBIs in women's volleyball may go unreported.²⁷ Last, strength-training exercises have been notoriously overlooked in women's sports despite research proving its utility. Student-athletes, coaches, and parents should be periodically reminded of the importance of strength training in regard to injury prevention.^{5,21}

Limitations

Although the NCAA-ISP has been a long-standing reputable database, it has its limitations. First, the data set is dependent on medical staff/ATs for proper and correct data entry. Errors in data entry are possible, and updates to existing data could be missed. The database also relies on each university's voluntary participation, giving only a limited view of current NCAA athletes. Although this voluntary participation could allow selection bias, it is believed the NCAA-ISP accurately represent trends across all NCAA athletics. In addition, there is potential for under- or overreporting of LBIs, as the ATs could miss injuries or forget to follow up on diagnoses. It may also be possible an athlete may not report an injury, especially if it is chronic or pre-existing. However, previous studies have suggested a capture rate of roughly 88%.²⁰ Moreover, the NCAA-ISP database is limited and not granular. This study's single

largest injury was "low back pain", encompassing over 50% of injuries in the cohort; however, the database does not specify more into the nature of low back pain. Therefore, it is possible that players with spondylosis or other injuries not listed may have been categorized under diagnosis such as "low back pain" or "fracture." As described previously, the majority of LBIs may go unreported, possibly misdiagnosed as low back pain. Last, the database does not provide any information on preinjury/postinjury rehabilitation or any comorbid conditions. Hence, factors that may have negated or facilitated the listed LBIs are unknown. Despite these limitations, we believe the data presented in the study accurately represent LBIs in NCAA women's volleyball.

Future Direction

Characterizing injuries in collegiate athletes is important and gives insight into appropriate future research. Currently, research needs to be conducted on injury prevention, particularly during practice, as this should be a well-controlled environment, immune to high injury rates. The intensity and amount of practice in women's volleyball should undergo scrupulous analysis. As suggested, preseason conditioning, core strengthening, increased weight training, and athlete load management could be instituted to negate injuries, especially overuse injuries. Future studies should focus on the outcomes of these prevention tactics in NCAA athletes. Ideally, the national injury database will expand to more universities in the future, becoming more granular and allowing further in-depth characterization. It is our hope this research, combined with future research, can be utilized to minimize collegiate athletic injuries.

CONCLUSION

This is the largest study of LBIs in NCAA women's volleyball thus far, and it provides insight into the prevalence, nature, and timing of these common injuries. The rate of LBIs was high (4.89/10,000 AEs) and injuries commonly recurred (29.2%). Most injuries were new, with most athletes returning to play with 24 hours. Efforts to improve injury prevention and management should be informed by these findings. Future studies are warranted to explore proper recovery timelines in addition to injury-prevention programs in collegiate women's volleyball.

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