

# The Delayed Presentation and Diagnosis of Youth Wrestling Injuries: A 20-Year Analysis of National Injury Data

William H. Huffman, BS 

Steven R. Ayotte, BS 

Lori Jia, BS

Kevin Pirruccio, MD

Xinning Li, MD

John D. Kelly IV, MD

Robert L. Parisien, MD 

From the Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA (Mr. Huffman, Mr. Ayotte, and Ms. Jia); the Department of Orthopaedic Surgery, Yale-New Haven Hospital, New Haven, CT (Dr. Pirruccio); the Department of Orthopaedic Surgery, Boston University Medical Center, Boston, MA (Dr. Li); the Department of Orthopaedic Surgery, Hospital of the University of Pennsylvania, Philadelphia, PA (Dr. Kelly IV); and the Department of Orthopaedic Surgery, Mount Sinai, New York, NY (Dr. Parisien).

Correspondence to Dr. Parisien: Robert.l.parisien@gmail.com

JAAOS Glob Res Rev 2024;8: e23.00150

DOI: 10.5435/JAAOSGlobal-D-23-00150

Copyright 2024 The Authors. Published by Wolters Kluwer Health, Inc. on behalf of the American Academy of Orthopaedic Surgeons. This is an open access article distributed under the Creative Commons Attribution-NoDerivatives License 4.0 (CC BY-ND) which allows for redistribution, commercial and non-commercial, as long as it is passed along unchanged and in whole, with credit to the author.

## ABSTRACT

**Introduction:** The nature of wrestling may lead athletes to mask injuries with the delayed presentations of youth wrestling-related injuries not being well characterized.

**Methods:** This descriptive epidemiological study queried the National Electronic Injury Surveillance System database to characterize delayed presentations of wrestling-related injuries in middle and high-school athletes. Data collection consisted of national estimates, demographics, and injury characteristics of patients with delayed (D) presentations ( $\geq 1$  day) and same-day (S) presentations to US emergency departments after sustaining a wrestling-related injury during the scholastic wrestling season (December to February, 2000 to 2019).

**Results:** Of middle and high-school wrestlers presenting to US emergency departments, 5.6% (95% confidence interval [CI] 4.3% to 7.1%) reported delayed presentations for a total of 1,110 patients (CI, 591 to 1,630) annually. Most commonly ( $P < 0.001$ ), injuries were sustained on Saturdays in both cohorts (D, 28.2%; CI, 22.4% to 34.8%; S, 29.6%; CI, 24.3% to 35.5%). Patients reporting delayed presentations were less likely to sustain fractures (D, 11.5%; CI, 8.3% to 15.6%; S, 18.9%; CI, 15.0% to 23.5%;  $P = 0.019$ ) and injuries of the head/neck (D, 20.0%; CI, 16.5 to 24.1%; S, 26.2%; CI, 21.4% to 31.7%;  $P = 0.011$ ).

**Discussion:** A substantial proportion of adolescent wrestlers report delayed presentations of injuries. This emphasizes the need for vigilance in detecting subtle signs of injury.

Participation in sports provides many social and physical benefits but is not without considerable risk of injury.<sup>1,2</sup> However, wrestlers may dismiss such injuries as subtle and associated with the normal stress of the sport, potentially leading to delayed diagnosis and chronicity. Rupture of the anterior cruciate ligament is a common injury that is not often

diagnosed on initial healthcare consultation most commonly associated with activities of soccer, rugby, and skiing, which may give rise to a higher incidence of medial meniscal tearing and secondary chondral damage.<sup>3</sup> In football, delayed reporting of concussions is associated with a recovery time prolonged by almost 5 days, carrying with it the potential of long-term neurological and cognitive sequelae.<sup>4,5</sup> Thus, prompt diagnosis and treatment of injuries is vital for protecting athletes from long-term harm.

Despite the relatively high frequency of injuries in wrestling, delayed presentation of wrestling injuries has not been well characterized.<sup>6</sup> The inherent culture of the sport and rigor of competition days may contribute to the downplaying of serious injuries with fear of removal from competition. To our knowledge, previous studies have been limited to case reports or have occasionally noted the percentage of wrestling-related injuries that are delayed.<sup>7,8</sup> One study found that 6.2% of patients with wrestling-related concussions did not present to emergency departments (EDs) on the same day the injury occurred.<sup>8</sup>

The purpose of this study was to examine the characteristics of delayed (D) and same-day (S) presentations to US EDs for wrestling-related injuries in middle and high-school athletes between 2000 and 2019. We hypothesized the greatest number of injuries would occur on days of competition and delayed injury presentation would involve subtle injuries less noticeable to coaches or parents (ie, concussions, sprains, and strains) as compared with gross deformities such as fractures or lacerations.

## Methods

We retrospectively identified cases of wrestling-related injuries in the Consumer Product Safety Commission's National Electronic Injury Surveillance System (NEISS).

The NEISS database documents product or activity-related injuries presenting to US EDs. The database is a publicly available, deidentified, weighted survey that serves as a nationally representative probability sample of designated US hospital EDs, from which weighted national estimates and sampling errors for queries may be derived. Since its inception, the database has been used for a multitude of reliable and reproducible epidemiological studies on injury-related ED visits.<sup>9,10</sup> Specific data collection methodologies and quality control precautions are available on the Consumer Product Safety Commission's webpage.<sup>11,12</sup>

## Variables

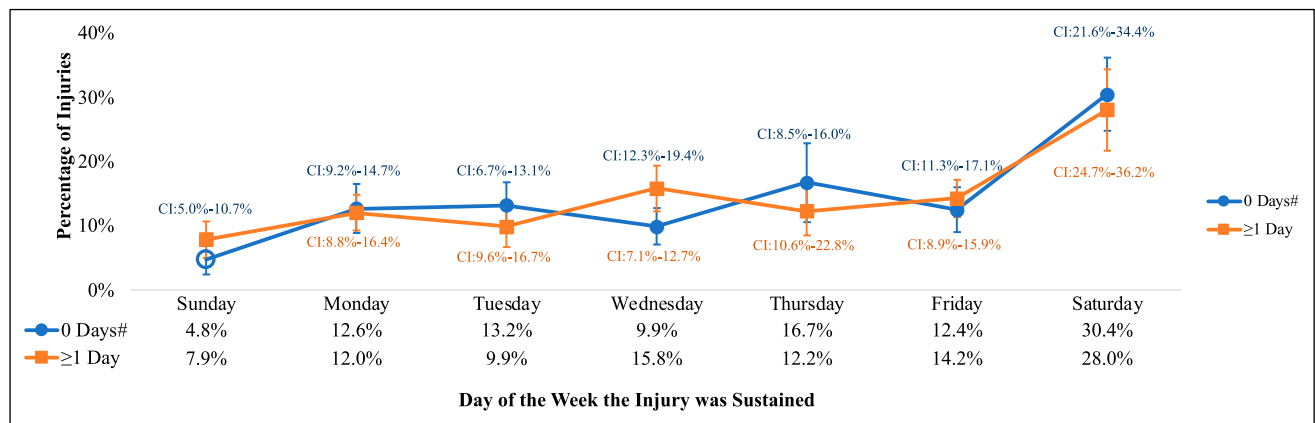
The NEISS database includes the following variables in each annual survey sample: the date of treatment; case record number; age, sex, and race/ethnicity of the patient; injury diagnosis; body part affected by the injury; disposition; product involved in the injury; location where the injury occurred; whether fire or motor vehicles were involved in the injury; whether the injury was work-related; and a short, free-text narrative of the circumstances surrounding recorded injuries and details regarding final diagnoses.

## Selection Criteria

We initially identified all patients presenting to a US ED during the scholastic wrestling season (December to February, or "in-season") between 2000 and 2019 with any wrestling-associated injuries (Product Code: 1270-WRESTLING [ACTIVITY, APPAREL OR EQUIPMENT]), which yielded 11,268 entries. Next, free-text case narratives were searched to identify and exclude cases unrelated to wrestling. These included the following activities: sumo wrestling; mud wrestling; World Wrestling Entertainment, Inc. wrestling; and any description of a patient wrestling with a sibling, friend, or parent in a non-sports setting (eg, on the couch and horsing around at home). We identified 472 cases

Dr. Li or an immediate family member has received royalties from FH Ortho; serves as a paid consultant to DePuy, A Johnson & Johnson Company, and FH Ortho; serves as a board member, owner, officer, or committee member of AAOS, American Shoulder and Elbow Surgeons, Arthroscopy Association of North America, American Journal of Sports Medicine, BMC Musculoskeletal Disorders, Journal of Bone and Joint Surgery–American, Journal of Medical Insight (JOMI), Orthopedic Reviews, and World Journal of Orthopaedics. Dr. Kelly IV or an immediate family member serves as a board member, owner, officer, or committee member of AAOS, American Orthopaedic Society for Sports Medicine, Arthroscopy Association of North America, Eastern Ortho, Arthroscopy, Orthopedics, and Orthopedics Today; has received nonincome support (such as equipment or services), commercially derived honoraria, or other non-research-related funding (such as paid travel) from SLACK Incorporated, and Springer. Dr. Parisien or an immediate family member serves as a board member, owner, officer, or committee member of Journal of Cartilage & Joint Preservation, Arthroscopy, Arthroscopy, Sports Medicine and Rehabilitation, American Orthopaedic Society for Sports Medicine, Arthroscopy Association of North America, Arthroscopy Association of North America, Society of Military Orthopaedic Surgeons, American Journal of Sports Medicine, Orthopaedic Journal of Sports Medicine, Sports Health, The Bone and Joint Journal, Journal of Shoulder and Elbow Surgery, BMC Musculoskeletal Disorders, and The Orthopaedic Journal at Harvard Medical School; has received nonincome support (such as equipment or services), commercially derived honoraria, or other non-research-related funding (such as paid travel) from Arthrex Inc. None of the following authors or any immediate family member has received anything of value from or has stock or stock options held in a commercial company or institution related directly or indirectly to the subject of this article: Mr. Huffman, Mr. Ayotte, Ms. Jia, and Dr. Pirruccio.

Figure 1



Graph showing percentage of wrestling-related injuries sustained on a given day of the week in patients aged 11 to 18 years presenting to US emergency departments from December through February between 2000 and 2019, stratified by days passed since the initial injury presentation. #: Zero days since injury before presentation indicates that the patient was explicitly stated to have sustained the injury on the same day during which the patient chose to present to the emergency department; \*\*\*,  $P < 0.001$ ; CI: 95% confidence interval; unfilled circular marker: The estimate is considered potentially unstable because of the number of unweighted cases from the sample frame totaling  $<20$ , the weighted national estimate totaling  $<1,200$ , or coefficient of variation  $>33\%$ . Therefore, no confidence intervals are provided. Instead, the unstable percentage estimate is provided for reference purposes only.

unrelated wrestling, leaving 10,796 unique cases amounting to 396,854 weighted national estimates of wrestling-associated injuries presenting to US EDs for our final analyses. The narrative section was individually analyzed to identify the day of the week on which the injury occurred and the number of days from injury occurrence to presentation to the ED. Demographics, injury type, and day of injury were compared for delayed and same-day presentations.

### Statistical Analyses

All national weighted estimates, standard errors, simple univariate regression statistics, and 95% confidence intervals (CIs) were calculated by using the svyset function in Stata/IC 15.1 statistical software (StataCorp LLC). Significances of trends and group comparisons were determined using adjusted Wald tests, given the use of weighted survey data.

This study was exempt from institutional review board review because it does not meet the definition of human subject research. This is because our analysis uses deidentified survey data that are freely published and publicly accessible on a government website.

### Results

The mean number of wrestling-related injuries presenting to US EDs per year was 1,110 (95% CI, 591 to 1,630). The annual estimated national number of such injuries between 2000 and 2019 is summarized in

Supplemental Table 1 (<http://links.lww.com/JG9/A340>). No notable change was observed in the number of injuries between the entire study period from the 2000 to 2001 wrestling season ( $n = 2,521$ ; 95% CI, 1,212 to 3,830) through the 2018 to 2019 season ( $n = 1,910$ ; 95% CI, 1,072 to 2,749). Therefore, no specific trend can be declared.

The number of days since injury before presentation to a US ED is presented in Supplemental Table 2 (<http://links.lww.com/JG9/A340>). Most of the case narratives did not specify the date of injury relative to presentation (90.1%; 95% CI, 87.3% to 92.4%). For cases with specified injury dates in narratives, more patients presented more than 1 day after injury ( $n = 659$  [5.6%]; 95% CI, 4.3% to 7.1%) compared with those on the same day of injury ( $n = 420$  [4.3%]; 95% CI, 3.1% to 5.9%), but this difference was not statistically significant.

The day of the week on which wrestling-related injuries occurred is demonstrated in Figure 1, stratified by the number of days between injury occurrence and presentation (zero days versus  $\geq 1$  day). The highest proportion of injuries occurred on Saturday for patients presenting on both the same day as the occurrence of injury (29.6%; 95% CI, 24.3% to 35.5%;  $P < 0.001$ ) and  $\geq 1$  day since the injury (28.2%; 95% CI, 22.4% to 34.8%;  $P < 0.001$ ).

Because most of the narratives did not specify a date of injury, we compared the demographics of the no date-specified and date-specified subpopulations to determine whether they were similar and whether the date-

specified population was representative of the overall population. We compared the composition of the populations for age (zero to 18), sex, race (White, Black, Hispanic, other, or not specified), and disposition (treated and released or treated and admitted). The only statistically significant difference we found in making this comparison was in the proportion of 18-year-old patients included in the population (no date-specified: 8.2%; 95% CI, 7.2% to 9.3%; date-specified: 5.9%; 95% CI, 4.5% to 7.8%;  $P = 0.008$ ). For all other demographic characteristics, we did not find statistically significant differences. Although the date-specified subpopulation represents only 10% of the overall population, it is demographically similar to the rest of the population with no date-specified.

Supplemental Table 3 (<http://links.lww.com/JG9/A340>) compares the demographic characteristics of the subpopulations presenting on the same day of the injury and those presenting on later days. Most of the patients were male (same day: 94.7%; 95% CI, 89.1% to 97.5%; delayed: 95.9%; 95% CI, 93.5% to 97.4%;  $P = 0.552$ ). Race was most often reported to be White (same day: 63.6%; 95% CI, 49.3% to 75.8%; delayed: 58.5%; 95% CI, 49.9% to 66.5%;  $P = 0.267$ ), although the race of roughly one-quarter of patients was not specified (same day: 25.4%; 95% CI, 14.9% to 39.9%; delayed: 22.9%; 95% CI, 14.1% to 34.9%;  $P = 0.498$ ). Only 16-year-old patients differed in the day of presentation relative to injury, with more 16-year-old patients presenting  $\geq 1$  day after injury than those on the same day of injury occurrence (same day: 14.6%; 95% CI, 11.6% to 18.3%; delayed: 20.8%; 95% CI, 17.6% to 24.3%;  $P = 0.011$ ). Regarding patient disposition status, nearly all patients were treated and subsequently discharged directly from the ED on the same day of presentation (same day: 98.8%; 95% CI, 96.5% to 99.6%; delayed: 98.3%; 95% CI, 96.5% to 99.3%;  $P = 0.644$ ).

The types of injuries sustained and anatomic regions most commonly affected are listed in Supplemental Table 4 (<http://links.lww.com/JG9/A340>). The most commonly affected region was the head and neck, with patients more likely to present on the same day as the injury (same day: 26.2%; 95% CI, 21.4% to 31.7%; delayed: 20.0%; 95% CI, 16.5% to 24.1%;  $P = 0.011$ ). The most common diagnoses were strains and sprains, which presented more often  $\geq 1$  day after the injury occurred (same day: 29.6%; 95% CI, 23.6% to 36.3%; delayed: 37.1%; 95% CI, 31.4% to 43.3%;  $P = 0.049$ ), and fractures, which presented more often on the same day as the injury (same day: 18.9%; 95% CI, 15.0% to

23.5%; delayed: 11.5%; 95% CI, 8.3% to 15.6%;  $P = 0.019$ ).

## Discussion

Our study presents the notable number of wrestling-related injuries presenting to US EDs with an estimated incidence of 1,110 injuries annually. This is the first study of its kind to compare same-day versus delayed presentations of wrestling-related injuries. Importantly, athletes with fractures and injuries to the head and neck were more likely to present to an ED on the same day of injury occurrence, whereas athletes with strains/sprains, and those specifically in the 16-year-old age group, were more likely to have a delayed presentation. This is in alignment with our hypothesis that injuries readily observable by parents or coaches, such as fractures or injuries to areas such as the head or neck, would be more likely to present on the same day as the injury.

Our results can be compared with previous studies on wrestling-related injuries. Kroshus et al<sup>13</sup> also identified the head/face as the most commonly injured site in high-school wrestlers. However, their research suggested the differences between injuries in high-school and collegiate wrestlers limited the scope of their findings. Similar to our study, Agel et al<sup>14</sup> and Powell et al<sup>15</sup> observed much higher injury rates on match days compared with practice in a retrospective analysis of collegiate wrestling-related injuries.

To our knowledge, this is the first study to identify a unique injury presentation in the 16-year-old age group specifically. One hypothesis is that this particular age group may have delayed presentations because of their place on the team. In the United States, 16-year-old athletes are often in their second or third year in high school and this is a crucial time to prove oneself to earn a position on the varsity team. Furthermore, literature has suggested that health-related risk taking may be rewarded in athletes, which might explain why this age group may uniquely hide injuries resulting in delayed presentation to EDs.<sup>16-18</sup> Reporting symptoms of injury or removing oneself from play could lead to missing crucial time in practice or competition.

The differences in injury types and locations for same-day and delayed presentations could be related to the ability of coaches and parents to detect the injury. Injuries that would be more apparent to an observer (fractures and injuries to the head and neck) were associated with same-day presentations, whereas strains and sprains were associated with delayed presentations.

Self-reported symptoms are an important component of injury diagnosis, and previous studies have demonstrated that athletes may hide or underreport symptoms to avoid missing play time, especially with concussions.<sup>19-22</sup> Previous literature has demonstrated factors associated with nondisclosure as male sex, participation in a high-risk sport, and pressure from a coach to play after sustaining a hit.<sup>23</sup> Given that common motivations for nondisclosure are not wanting to leave the game or practice and not wanting to let the team down, the greater burden of responsibility to identify wrestling injuries may be borne by coaches, trainers, and parents.<sup>24</sup> This includes injuries that may be thought of as more benign, such as strains or sprains, with misdiagnosis leading to delayed treatment and increased risk of reinjury and long-term sequelae.<sup>25</sup>

We recommend several strategies for reducing the delayed presentations of wrestling injuries. Parents, coaches, and medical personnel should check in regularly with athletes during and after strenuous Saturday competitions, when most injuries occur. Concussion checks may also prove valuable with parents and athletes given adequate information to identify early symptoms. Furthermore, an open culture of injury reporting among athletes and their teammates should be encouraged to prevent delayed presentation leading to long-term chronic sequelae, reinjury, and associated morbidity.

Inherent to the utilization and analysis of national injury data, our study has several limitations. The primary limitation of our analysis is that the date of injury had to be retrieved from the narrative provided for each entry, and this information unfortunately was not included in many of the narratives. In addition, the NEISS database only contains presentations to US EDs. Given that some injuries, such as sprains or abrasions, may be treated outside of ED settings and may be treated by athletic trainers or without formal medical treatment, our data likely under-represent the totality of wrestling-related injuries. In addition, we chose to restrict our study to “in-season” injury presentation, leaving the potential for off-season injuries to be missed and injuries sustained during the wrestling season but presenting later in the off-season.

## Conclusion

A notable proportion of adolescent athletes report delayed presentations to EDs with wrestling-related injuries. We identified that such injuries are typically sustained on Saturdays, which classically comprises a tournament competition day where athletes may wrestle

in multiple matches with limited recovery time. This study further identifies the need for greater awareness and vigilance by parents, coaches, and medical personnel with respect to detecting subtle or atypical signs of injury in at-risk middle and high-school wrestlers, especially during competitions with multiple matches in a single day.

## References

1. Eime RM, Young JA, Harvey JT, Charity MJ, Payne WR: A systematic review of the psychological and social benefits of participation in sport for children and adolescents: Informing development of a conceptual model of health through sport. *Int J Behav Nutr Phys Activity* 2013;10:98.
2. Lemoyne J, Poulin C, Richer N, Bussi eres A: Analyzing injuries among university-level athletes: Prevalence, patterns and risk factors. *J Can Chiropr Assoc* 2017;61:88-95.
3. Arastu MH, Grange S, Twyman R: Prevalence and consequences of delayed diagnosis of anterior cruciate ligament ruptures. *Knee Surg Sports Traumatol Arthrosc* 2015;23:1201-1205.
4. Asken BM, McCrema MA, Clugston JR, Snyder AR, Houck ZM, Bauer RM: “Playing through it”: Delayed reporting and removal from athletic activity after concussion predicts prolonged recovery. *J Athletic Train* 2016;51:329-335.
5. Kanaan NM, Cox K, Alvarez VE, Stein TD, Poncil S, McKee AC: Characterization of early pathological tau conformations and phosphorylation in chronic traumatic encephalopathy. *J Neuropathol Exp Neurol* 2016;75:19-34.
6. *Sports-Related Injuries Among High School Athletes—United States, 2005–06 School Year*. <https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5538a1.htm>. Accessed March 22, 2021.
7. Levine B, Pereira D, Rosen J: Avulsion fractures of the lesser tuberosity of the humerus in adolescents: Review of the literature and case report. *J Orthop Trauma* 2005;19:349-352.
8. Pirruccio K, Parisien RL, Olsen C, Kelly JD: Wrestling-related concussions and closed head injuries predominantly occur in high school age athletes. *J Sports Med Phys Fitness* 2021;61:407-412.
9. Huffman WH, Jia L, Pirruccio K, Li X, Hecht AC, Parisien RL: Acute vertebral fractures in skiing and snowboarding: A 20-year sex-specific analysis of national injury data. *Orthop J Sports Med* 2022;10:23259671221105486.
10. Pirruccio K, Yoon YM, Ahn J: Fractures in elderly Americans associated with walking leashed dogs. *JAMA Surg* 2019;154:458-459.
11. National Electronic Injury Surveillance System (NEISS): U.S. Consumer product safety commission. <u><https://www.cpsc.gov/Research-Statistics/NEISS-Injury-Data></u>. Accessed October 19, 2021.
12. CPSC NEISS On-Line Query System: U.S. Consumer product safety commission. <u><https://www.cpsc.gov/cgi-bin/NEISSQuery/home.aspx></u>. Accessed October 19, 2021.
13. Kroshus E, Utter AC, Pierpoint LA, et al: The first decade of web-based sports injury surveillance: Descriptive epidemiology of injuries in US high school boys’ wrestling (2005-2006 through 2013-2014) and national collegiate athletic association men’s wrestling (2004-2005 through 2013-2014). *J Athletic Train* 2018;53:1143-1155.
14. Agel J, Ransone J, Dick R, Oppliger R, Marshall SW: Descriptive epidemiology of collegiate men’s wrestling injuries: National collegiate athletic association injury surveillance system, 1988-1989 through 2003-2004. *J Athl Train* 2007;42:303-310.

15. Powell JR, Boltz AJ, Robison HJ, Morris SN, Collins CL, Chandran A: Epidemiology of injuries in national collegiate athletic association men's wrestling: 2014-2015 through 2018-2019. *J Athletic Train* 2021;56:727-733.
16. Curry TJ: A little pain never hurt anyone: Athletic career socialization and the normalization of sports injury. *Symbolic Interaction* 1993;16:273-290.
17. Malcom NL: "Shaking it off" and "toughing it out": Socialization to pain and injury in girls' softball. *J Contemp Ethnography* 2006;35:495-525.
18. Roderick M, Waddington I, Parker G: Playing hurt: Managing injuries in English professional football. *Int Rev Sociol Sport* 2000;35:165-180.
19. Baugh CM, Meehan WP, Kroshus E, McGuire TG, Hatfield LA: College football players less likely to report concussions and other injuries with increased injury accumulation. *J Neurotrauma* 2019;36:2065-2072.
20. Beverly EA, Fredricks TR, Leubitz A, et al: What can family medicine providers learn about concussion non-disclosure from former collegiate athletes? *BMC Fam Pract* 2018;19:128.
21. Kroshus E, Baugh CM, Daneshvar DH, Viswanath K: Understanding concussion reporting using a model based on the theory of planned behavior. *J Adolesc Health* 2014;54:269-274.e2.
22. O'Connor S, Geaney D, Beidler E: Non-disclosure in Irish collegiate student-athletes: Do concussion history, knowledge, pressure to play and gender impact concussion reporting? *Phys Sportsmed* 2020;48:186-193.
23. Anderson M, Petit KM, Wallace J, Covassin T, Beidler E: Factors associated with concussion nondisclosure in collegiate student-athletes. *J Athl Train* 2021;56:157-163.
24. Kerr ZY, Register-Mihalik JK, Kroshus E, Baugh CM, Marshall SW: Motivations associated with non-disclosure of self-reported concussions in former collegiate athletes. *Am J Sports Med* 2016;44:220-225.
25. Strauss JE, Forsberg JA, Lippert FG: Chronic lateral ankle instability and associated conditions: A rationale for treatment. *Foot Ankle Int* 2007;28:1041-1044.