Editorial Commentary: Sex-Specific Differences in Elbow Ulnar Collateral Ligament Injuries: A Retrospective Analysis

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Orthopedic injuries in female athletes continue to rise at a dramatic rate at every level of competition. This has sparked increased research interests into the pathoanatomy, epidemiology, treatment, and outcomes related to sex-specific differences involving ligament injuries, including ulnar collateral ligament (UCL) injuries. However, most published research studies have been limited when evaluating for any sex-specific differences beyond anterior cruciate ligament (ACL) injuries. Most UCL-related research, especially as it pertains to high level athletes, has occurred in the realm of professional baseball, a male-dominated sport. While there are small reports of UCL injuries in females, these injuries are more common in women who participate in track and field (javelin), and gymnastics. It is imperative for our orthopedic surgery community to continue to advance our understanding of sex-related differences in elbow UCL injuries to improve our injury understanding and ultimately help improve treatment and rehabilitation protocols for both male and female athletes with regards to different ligament injuries.

Elbow ulnar collateral ligament (UCL) injuries are one of the most common overhead sports-related injuries, particularly in throwing type athletes. The rise in throwing related injuries, particularly amongst baseball athletes, has led some to suggest that we are experiencing an 'UCL epidemic' among youth and professional throwers.[1,2] While UCL injuries are a well-known issue among baseball players, a sport predominantly played by male athletes, there remains a paucity of literature on the incidence and outcomes following the treatment of UCL injuries in female athletes.[3] As participation in female athletics increases, injuries specific to this population has been increasing. The present article by Beaudry et al[4], "Sex-specific differences in elbow ulnar collateral ligament injuries: a retrospective analysis" recognizes the need to better understand any potential sex-specific differences in anatomic, environmental, hormonal, and biomechanical factors that may affect the treatment and care of this injury. The authors also aim to optimize treatment and recovery protocols based on sex.

Beaudry et al[4] performed a retrospective chart review, including MRI findings, from a single institution between 2015 and 2022 to identify all UCL injuries, both male and female. Their inclusion criteria resulted in the analysis of 169 young athletes between the ages 15-35 years old. Of these athletes, two-thirds of the qualifying cohort was male (113), with female (55) athletes making up the remaining 33% of the cohort. Although the study cohort may not be generalizable to the national population due to the study being limited to one institution, the study involves the largest number of female athletes with UCL injury to date. In this study, the authors were most interested in differences in injury patterns and the presence of concomitant injuries.

The study found notable differences between male and female athletes specific to injury onset, UCL injury grade, and MRI findings. The authors found that female athletes were more likely than male athletes to have chronic injury onset, lower UCL injury severity or grade, and lower rate of UCL tear and abnormalities on MRI studies. Specifically,

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they reported higher rates of bony edema (63% vs. 26%) in male athletes. Male injuries were also much more likely to be acute (94%) compared to female injuries (29%). These distinctions may explain lower rates of surgical ligament repair and UCL reconstructive surgery in female vs. male athletes (14% vs. 42% respectively in their study). From a management perspective, the lower rates of surgical intervention in female athletes also were associated with much longer symptom duration (up to 10x longer than male athletes) and delayed return to play; albeit the study acknowledged no significant sex-specific differences when adjusted for age, weight, onset of injury, and MRI findings.

While these sex differences may be physiological, we must also consider that the differences in the type of sports may account for the study results. As noted in the study, the author acknowledged that the UCL injuries in male athletes were predominantly baseball-related while those in the female cohort were largely softball players. Baseball is notorious for UCL injuries due to the large valgus force created across the elbow during pitching. Morrey and An showed that 64 N·m of valgus stress is generated across the elbow during throwing, with the UCL providing 55% (33 N·m) of the valgus stability while throwing during a cadaveric study. [5] A similar cadaveric study by Fleisig et al showed that mean valgus torque generated by healthy pitching subjects was 67 N·m. [6] Their follow-up study assessing valgus torque generated by various pitches (fastball, change up, curveball, and slider) showed values of 82, 71, 79, and 81 N·m, respectively. [8] This means that the mean torque on a pitch-to-pitch basis exceeds the UCL torque to failure in cadaveric specimens, putting baseball athletes at a high risk of acute tear, as seen in the study by Beaudry. Female athletes may rely less on the valgus restraint of the UCL than those of their male counterparts. Softball, for instance, is reliant on underhand pitching, limiting the exposure risk experienced by overhand baseball pitchers. While position players in softball may be subject to a UCL injury, it is much less common, even in baseball, for these players to experience UCL injury. Additionally, velocity, namely fastball velocity, has been shown to be a major predictor of UCL injury in major league baseball athletes. [8] This is likely another reason for a lower incidence of UCL injuries amongst female overhead throwing athletes, specifically in softball.

Both anecdotally, and as seen in the present study, female UCL injuries are more likely to be attritional, and can be experienced in throwers, as well as in gymnasts and athletes of other sports which require repetitive valgus loads across the elbow. Studies such as the one by Beaudry et al. may set the stage to analyze subgroups of female athletes who injure their UCL during gymnastics, or cattle roping, where similar overhand biomechanics involve large valgus force on the elbow as seen in baseball. The different forces on the elbow associated with different types of sports may contribute to the sex-specific observations in this study regarding UCL injury grade and chronic type of injury onset. Therefore, further investigations would be useful in comparing UCL injury associated with different types of sports. Another reason for a more "delayed" presentation of the female UCL injury may also be clinical suspicion. While baseball has gained significant recognition for UCL injury, the study by Beaudry et al. identifies UCL injuries as a major issue in female athletes as well. Part of the delay in diagnosis seen in this study may also be due to a lack of timely diagnostic testing. I know that in my practice if a collegiate pitcher experiences acute elbow pain and must leave a game, he is going to get an MRI performed within the week to examine his ulnar collateral ligament. However, I cannot say that this is necessarily true for 100% of my female patients. Part of the importance of the present study is that this brings to light the real issue of female UCL injuries, and I believe indirectly calls for us to be more aware and aggressive with the diagnosis and management of these injuries in female athletes.

Beaudry et al. identified that a prior biomechanical analysis of the elbow indicated that females have a greater carrying angle and range of motion of the elbow joint compared to the male population. The author suggests that this can lead to the UCL in females having more laxity than in males, potentially supporting the study findings of higher rates of incompetent UCLs on MRI and a relative lack of acute tears. While anatomical differences in UCL injuries have been studied by Shimizu et al [9], this group focused their work on specific differences in morphological features of the posterior oblique ligament (POL), the secondary restraint mechanism against elbow valgus stress. They describe differences in fiber bundle, width, and bundle thickness based on sex, where females had an independent POL from the joint capsule,

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and males were more likely to have a POL that cannot be separated from the joint capsule. [9] Although this study did not assess the anterior oblique ligament, which is the primary restraint mechanism against valgus stress, the noted sex differences in the POL suggests anatomic differences may play a role in UCL injuries. However, it is not clear whether these biomechanical differences may be due to sex-specific physiological versus anatomic differences; so further supporting investigations to better understand this relationship with elbow UCL injuries is needed.

Although this study is a retrospective observational descriptive analysis with several limitations acknowledged by its authors, it clearly provides evidence for sex-specific difference involving UCL injuries which has not previously been elucidated in the literature. What is particularly curious is the potential difference between the male and female UCL with regards to ligament structure and response to various stimuli such as estrogen, progesterone, and elastin. While the present study did not investigate this, it is a significant area of research in the sex-specific factors for ACL tear. Specifically, decreased collagen and elastin levels and their relationship to sex hormones has been suggested to contribute to ACL injuries. Interestingly, the Beaudry et al. study seems to indicate the possibility that the female UCL may have different characteristics compared to the female ACL, where the UCL may tend to be more resistant to tearing at lower forces. This phenomenon will need to be further studied to build upon this study by Beaudry et al. We need more research grants and financial support to continue research and advancement in this field. With more female athletes participating in sports, better understanding of sex differences in sports-related injuries including elbow UCL injuries will be of great benefit for determining optimal treatment and rehabilitation protocols for our male and female athletes. While UCL injuries in male baseball athletes has been described as an "epidemic," this raises the question of whether we are dealing with a "silent epidemic" of female UCL injuries that have been going unnoticed. Personally, this study by Beaudry et al. has certainly opened my eyes and raised my clinical suspicion for UCL injuries in the female athlete, making this an interesting area of future study.

Conflict of Interest Statement
The authors report no conflict of interest with the contents of this manuscript.

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