

Increasing Burden of Youth Baseball Elbow Injuries in US Emergency Departments

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Background: Youth athletes are starting sports earlier and training harder. Intense, year-round demands are encouraging early sports specialization under the perception that it will improve the odds of future elite performance. Unfortunately, there is growing evidence that early specialization is associated with increased risk of injury and burnout. This is especially true of pediatric and adolescent baseball players.

Purpose/Hypothesis: The purpose of this investigation was to analyze national injury trends of youth baseball players. We hypothesized that while the total number of baseball injuries diagnosed over the past decade would decrease, there would be an increase in adolescent elbow injuries seen nationally. A further hypothesis was that this trend would be significantly greater than other injuries to the upper extremity and major joints.

Study Design: Descriptive epidemiology study.

Methods: Injury data from the National Electronic Injury Surveillance System, a United States Consumer Product Safety Commission database, were analyzed between January 1, 2006, and December 31, 2016, for baseball players aged ≤ 18 years. Data were collected on the location of injury, diagnosis, and mechanism of injury.

Results: Between 2006 and 2016, an estimated 665,133 baseball injuries occurred nationally. The mean age of the injured players was 11.5 years. The most common injuries diagnosed included contusions (26.8%), fractures (23.6%), and strains and sprains (18.7%). Among major joints, the ankle (25.6%) was most commonly injured, followed by the knee (21.3%), wrist (19.2%), elbow (17.7%), and shoulder (16.2%). The incidence of the ankle, knee, wrist, and shoulder injuries decreased over time, while only the incidence of elbow injuries increased. A linear regression analysis demonstrated that the increasing incidence of elbow injuries was statistically significant against the decreasing trend for all baseball injury diagnoses, as well as ankle, knee, wrist, hand, and finger injuries ($P < .05$). Additionally, the only elbow injury mechanism that increased substantially over time was throwing.

Conclusion: The current investigation found that while the incidence of baseball injuries sustained by youth players is decreasing, elbow pathology is becoming more prevalent and is more commonly being caused by throwing. Given that the majority of elbow injuries among adolescent baseball players are overuse injuries, these findings underscore the importance of developing strategies to continue to ensure the safety of these youth athletes.

Keywords: baseball; injuries; elbow; sports specialization

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Youth athletes today are being increasingly subjected to extreme performance demands that have resulted in early sports specialization.⁵ However, early specialization has not been shown to improve the odds of future elite-level status; instead, it has been associated with increased rates of overuse injuries, burnout, decreased motivation for play, and increased psychological stress.^{5,13-15} Given that youth injuries can impose significant immediate and long-term consequences, including risk of future injuries, cognitive deficits, and other health burdens, they are imperative to prevent.

Unfortunately, overuse injuries of the upper extremity among baseball players are being increasingly recognized by sports medicine professionals.^{3,9,18} Makhni et al¹⁹ found that anywhere from 30% to 70% of throwers, usually pitchers, develop pain in their throwing arms at some point.

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Even more concerning, the same study found that players reported being encouraged to play through pain, thus increasing the chance of sustaining an overuse injury. This is particularly concerning, as a national survey study of 754 youth pitchers performed by Yang et al²⁴ found that those who threw through their fatigue and pain had >7 times the odds of sustaining a pitching-related injury. One throwing-related injury that has received a great deal of recent media attention involves rupture of the ulnar collateral ligament. Hodgins et al¹¹ investigated the epidemiology of ulnar collateral ligament reconstructions in the state of New York and found that although the mean age for surgery was 21.6 years, there was an increasing trend for surgical treatment among patients aged 17 and 18 years. Such data have spurred national efforts emphasizing public education on the risks of overuse throwing injuries among adolescents and the significance of adhering to preventative guidelines.

Prior investigations have utilized the National Electronic Injury Surveillance System (NEISS) to characterize injury types, rates, and mechanisms in various sports.^{4,12,25} Lawson et al¹⁶ used the NEISS database to evaluate baseball injuries among players younger than 18 years presenting to United States (US) emergency departments between 1994 and 2006. Over this time frame, the authors identified a 24.9% decline in the annual number of injuries sustained during baseball. However, the authors did not look at specific injuries or diagnoses or the trends in the location of injuries over time. The purpose of the current investigation was to expand on the work of Lawson et al¹⁶ with the NEISS database to further characterize youth baseball injuries. We hypothesized that the trend seen by Lawson et al¹⁶—a decrease in the number of total baseball injuries diagnosed over time—will continue. However, given the recent trends seen nationally in the setting of early specialization and overuse injuries, we also hypothesized that certain injuries, specifically of the elbow, will have increased over the past decade. Such a finding would be significant as health care providers, coaches, parents, and youth sports organizers continue to try to mitigate the risk of preventable injuries among young athletes.

METHODS

The NEISS, a publicly available US Consumer Product Safety Commission database, collects information from 100 nationally representative, randomly selected emergency departments.^{4,12,23,25} These departments were selected after all US hospitals were stratified by geographic location, size, and emergency department volume data. Each selected hospital is assigned a statistical sample weight that allows the database to estimate national representative samples. By assigning to each patient a Consumer Product Safety Commission-specific product code, which designates products used and/or activities engaged in at the time of injury, the NEISS is able to generate reliable and reproducible epidemiologic data regarding US emergency department visits.

We analyzed all cases with a baseball product code (5041) from January 1, 2006, to December 31, 2016, for baseball

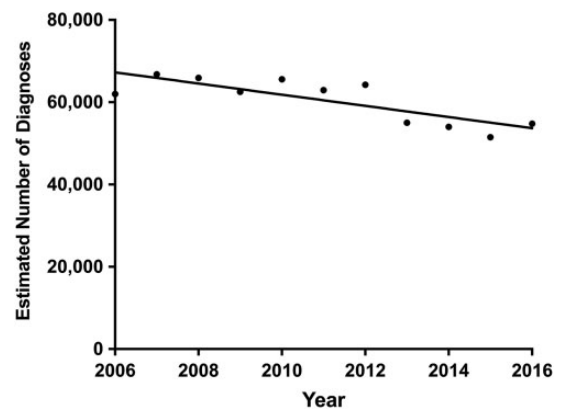


Figure 1. Estimated number of pediatric baseball-related injuries treated in US hospital emergency departments according to year of injury, 2006 to 2016.

players aged ≤ 18 years. A total of 15,925 cases were identified. The narrative provided for each injury was reviewed to ensure that it was sustained while playing baseball. Injuries sustained while not playing baseball were excluded, leaving 15,389 cases. The NEISS provides national estimates of injuries based on the number of cases diagnosed at the 100 emergency departments participating in the database.

Data were collected on the location of injury, emergency department diagnosis, and mechanism of injury. There were 26 possible locations of injury, divided into 5 groups: face, head and neck, upper extremity, lower extremity, and core. Injury diagnoses investigated included concussions, contusions, dislocations, fractures, internal organ injury, laceration, strains, and other. Mechanism of injury was broken down into 5 categories: hit by bat, hit by ball, sliding, throwing, and other (which included nonspecific narratives such as “injured while playing baseball”).

Statistical analyses were performed with GraphPad Prism (v 7.0b; GraphPad Software). Statistical significance for trends was determined with a linear regression analysis, while significance for continuous data was determined with a chi-square test. Statistical significance was set at $P \leq .05$.

RESULTS

Between January 1, 2006, and December 31, 2016, the total number of baseball injuries diagnosed in emergency departments included in the NEISS database was 15,389, resulting in a national estimate of 665,133 related baseball injuries. The mean age of the players sustaining injuries was 11.5 years. Between 2006 and 2016, the estimated number of injuries decreased by 11.7%, from an estimated 61,997 injuries to 54,777 (Figure 1). The most common site of injury was the upper extremity, accounting for 36.3% of all baseball injuries, followed by injuries to the face (26.2%), lower extremity (18.3%), head and neck (13.6%), and core (5.6%) (Figure 2). Regarding diagnoses, contusions (26.8%), fractures (23.6%), strains and sprains (18.7%), and

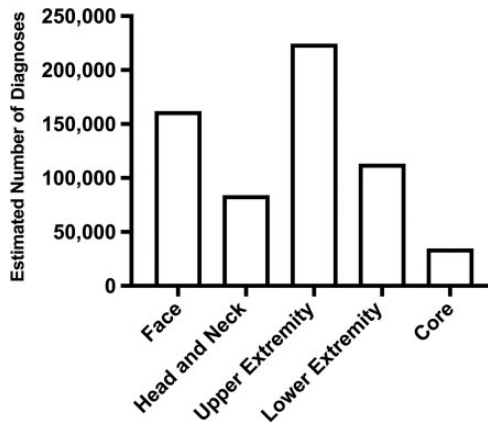


Figure 2. Estimated number of pediatric baseball-related injuries treated in US hospital emergency departments according to location of injury among pediatric baseball players between 2006 and 2016.

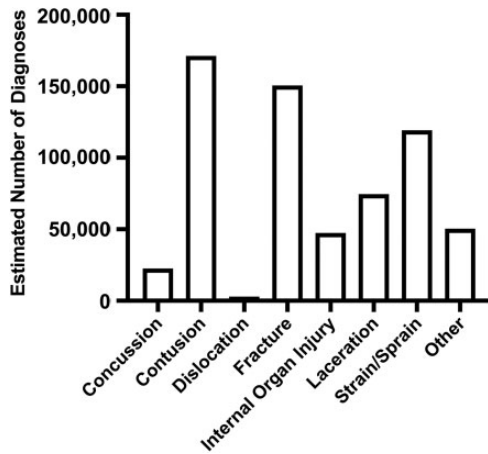


Figure 3. Estimated number of pediatric baseball-related injuries treated in US hospital emergency departments according to diagnosis among pediatric baseball players between 2006 and 2016.

lacerations (11.7%) were most commonly seen in emergency departments (Figure 3).

Injury trends for specific body parts were also investigated. First, injuries to major joints were assessed, including the ankle, knee, shoulder, elbow, and wrist. Among these, the ankle (25.6%) and knee (21.3%) were most commonly injured (Figure 4A). Overall, the elbow was implicated in 17.7% of all injuries to major joints during the study, representing an estimated 31,933 total injuries. Injuries to the shoulder, wrist, knee, and ankle were all found to have a decreasing incidence; however, elbow diagnoses increased (Figure 4B). Furthermore, a linear regression analysis found significant differences between the incidence of elbow injuries and injuries to the ankle ($P = .018$), knee ($P = .030$), and wrist ($P = .006$). There was

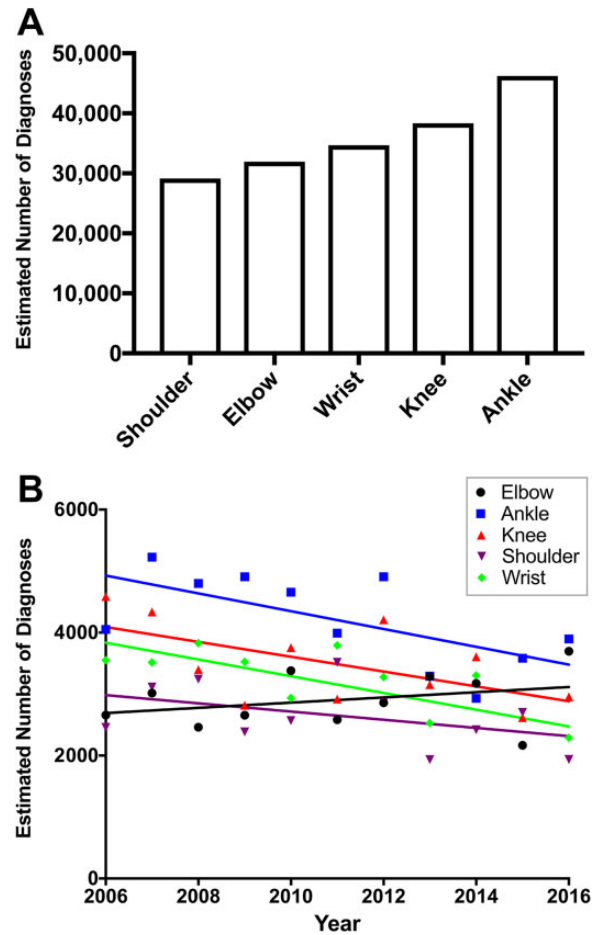


Figure 4. (A) Estimated number of pediatric baseball-related injuries treated in US hospital emergency departments characterized by major joints injured. (B) Trends in major joint injuries among pediatric baseball players between 2006 and 2016.

no significant difference in the trends between shoulder and elbow injuries ($P > .05$).

Injury trends of the upper extremity were further elucidated to compare with elbow injuries. These included injuries to the fingers, hand, wrist, lower arm, elbow, upper arm, and shoulder. Of these, injuries to the fingers were most common, accounting for 32.0% of injuries to the upper extremity, followed by the wrist (15.5%) and elbow (14.2%) (Figure 5A). There were no documented injuries to the upper arm. As with injuries to the major joints, upper extremity injuries except for those to the elbow were all found to decrease over time (Figure 5B). A linear regression analysis showed that the incidence of elbow injuries was significant as compared with the incidence of finger ($P < .001$) and hand ($P = .013$) injuries but not compared with lower arm injuries ($P = .131$).

Specific elbow diagnoses were also examined. The most common diagnoses included contusions (35.8%), strains and sprains (23.0%), fractures (21.2%), and other (17.2%). Trends in these diagnoses between 2006 and 2016 were

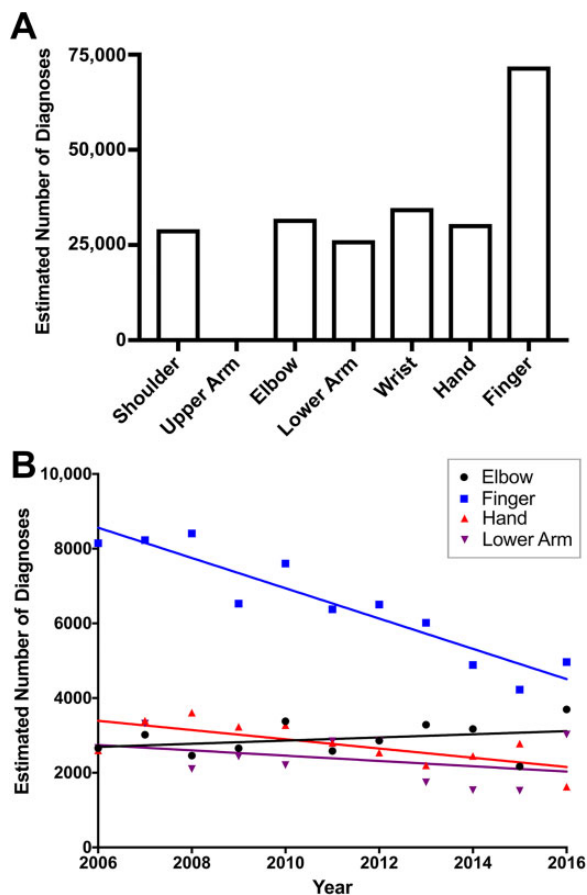


Figure 5. (A) Estimated number of pediatric baseball-related injuries treated in US hospital emergency departments characterized by different upper extremity injuries. (B) Trends in upper extremity injuries among pediatric baseball players between 2006 and 2016 (wrist and shoulder injuries not included).

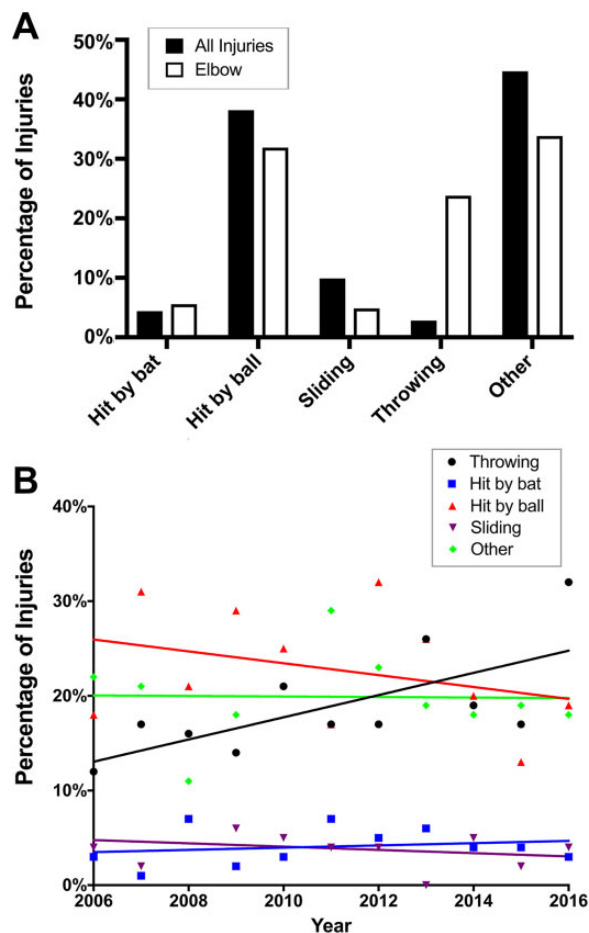


Figure 7. (A) Comparison of the distribution of injury mechanisms between all baseball-related injuries and elbow-related injuries. A chi-square analysis showed that the distribution was significantly different ($P < .001$). (B) Trends in the percentage of elbow injuries caused by various mechanisms between 2006 and 2016.

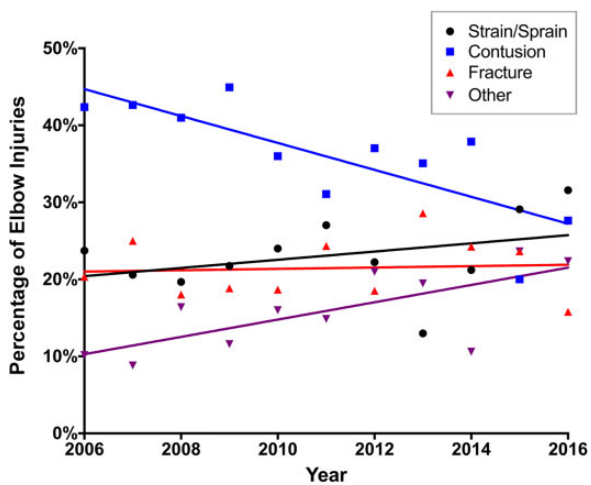


Figure 6. Trends in the percentage of elbow diagnoses between 2006 and 2016.

investigated (Figure 6). The only significant trend identified was a large decrease in contusions presenting to emergency departments. Although strains and sprains, fractures, and other diagnoses all increased over time, these trends were not statistically significant.

Last, baseball injury mechanisms included “hit by bat” (4.4%), “hit by ball” (38.2%), sliding (9.9%), throwing (2.8%), and other (44.7%). Of the investigated mechanisms, throwing caused the least number of baseball-related injuries but was responsible for a higher percentage (23.8%) of elbow injuries than any other type of injury, including injuries to the shoulder (17.1%). The 23.8% of elbow injuries caused by throwing represents an estimated 7600 injuries seen during the study time frame nationally. The distribution of injury mechanisms between elbow and all baseball injuries was significantly different ($P < .001$) (Figure 7A). Finally, the trends in elbow injury mechanisms between 2006 and 2016 were investigated (Figure 7B). The only mechanism of injury that increased substantially over time

was throwing. A linear regression analysis found that the increasing trend in elbow throwing injuries was significant as compared with the incidence of injuries caused by being hit by a bat ($P = .017$), being hit by a ball ($P = .002$), sliding ($P = .003$), and other mechanisms ($P = .039$).

DISCUSSION

The most significant finding of this study is that between 2006 and 2016 the only location of injury that saw an increase in diagnosis was the elbow. Furthermore, the increasing rate of elbow diagnoses made in US emergency departments was significantly greater than the trend seen for all baseball injuries, as well as for injuries to the knee, ankle, wrist, hand, and fingers. Although the exact cause of these trends cannot be fully elucidated by the methods of the current investigation, we hypothesize that the trend toward early sports specialization and associated overuse injuries played a role in the growing number of elbow injuries diagnosed. This hypothesis is supported by the fact that the mechanism of elbow injury that saw the greatest increase over time was throwing. Further support for this conclusion comes from Saper et al,²² who in 2018 performed an epidemiologic study on shoulder and elbow injuries among high school baseball players between 2005 and 2015. With regard to their identified mechanisms of injury, the authors found that overuse and noncontact injuries accounted for the majority of shoulder (71.3%) and elbow (73.9%) injuries. A similar conclusion was drawn by Fleisig and Andrews⁸ in 2012.

It is also interesting to note that Saper et al²² found injury rates of 1.39 and 0.86 per 10,000 athlete-exposures for the shoulder and elbow, respectively, among high school students. This is in contrast to the current investigation, which identified a higher overall number of elbow injuries on a national level. If our hypothesis that the increasing volume of elbow pathology among these pediatric and adolescent baseball players is a result of overuse, then there are certain modifiable risk factors that can be addressed. These include, but are not limited to, high-velocity pitching (>85 miles per hour), participation in showcases, pitching on >1 team, high pitch counts, pitching while fatigued, and poor pitching mechanics.^{2,8,20} Knowledge of these risk factors has led to national efforts aimed at developing strategies to reduce the overall injury burden—namely, pitch count limitations and recommended lengths of rest between pitching sessions.^{7,21} As our data and those of Saper et al²² suggest, these preventative interventions may require further education among coaches, parents, and players as well as stricter adherence within youth leagues to mitigate the risks of overuse injury. Other studies have investigated this subject specifically. For instance, Fazarale et al⁶ performed a survey investigation of 228 coaches who correctly answered only 43% of questions related to pitch count and rest periods. Even more concerning, 19% of these coaches admitted to allowing at least 1 pitcher to continue playing when fatigued.

The results of the current investigation also corroborate findings described by Lawson et al¹⁶ in 2009. For example,

the number of baseball injuries diagnosed in emergency departments across the nation has continued to decrease. The cause of this is likely multifactorial, but a major factor may be convenience, as many patients likely have the option of presenting to primary care physicians, specialists, and/or urgent care clinics as opposed to the emergency department. Another similarity between these 2 studies is that soft tissue injuries remain the most common type of injury sustained.

There are also key differences between these investigations. First, Lawson et al¹⁶ identified the face (33.5%) as the most common location of injury between 1994 and 2006, followed by the upper extremity (32.4%). Between 2006 and 2016, however, the upper extremity was most commonly injured (36.3%), with subsequent analyses showing that nearly one-third of all upper extremity injuries were to the fingers. Interestingly, despite being the most commonly diagnosed location of injury over the study time frame, finger diagnoses decreased by 39.0%. Furthermore, if the current trend continues, the elbow will soon become the most commonly diagnosed upper extremity injury. This is not surprising, as elbow pain is becoming increasingly diagnosed among youth throwers, with studies reporting an incidence of 20% to 30% for 8- to 12-year-olds, 45% for 13- to 14-year-olds, and >50% for high school and college baseball players.^{10,17,18}

Limitations to this study include all the biases inherent to utilizing a large national database. Additionally, our methodology did not permit an analysis on the severity of injuries as measured by time missed from play or need for surgical intervention. Prior investigations were able to demonstrate significant morbidity related to elbow injuries, with 22.1% resulting in an inability to return to play for >3 weeks.²² Another limitation involved the evaluation of injury mechanisms. Specifically, 44.7% of all injuries had a mechanism classified as “other” owing to a combination of infrequently described mechanisms, such as running into a fence, or a lack of descriptive information provided in the narrative.

Additionally, although the main purpose of this investigation was to identify and characterize trends in baseball injuries, we cannot fully elucidate the cause of those trends. While we believe that early specialization and overuse injuries play a significant role, we are unable to prove this hypothesis with the current methodology. The reason is primarily that the majority of injuries presenting to emergency departments are acute traumatic injuries, and we are assuming that certain mechanisms, such as throwing, represent nontraumatic overuse injuries. However, it is important to note that overuse injuries can also present as acute exacerbations requiring medical attention, such as increasing medial elbow pain attributed to worsening apophysitis or, even more severe, a medial epicondyle epiphyseal avulsion. Despite this limitation, there is currently no alternative or superior method of investigating overuse injuries in this vulnerable patient population on a national level. Other possibilities for the increasing trend of elbow diagnoses include the heightened publicity that elbow injuries have received in the media, leading players and parents to be increasingly cognizant or concerned about a potential injury.

Finally, as discussed, while utilization of the NEISS does allow for analysis of trends, we are unable to calculate the true incidence of injuries, as the denominator remains unknown. Despite these limitations, the NEISS data set is an effective tool that has been used in investigations to assess injury patterns in a number of sports and that allowed us to effectively examine a national representative sample of baseball injuries.

CONCLUSION

There is a growing body of evidence demonstrating that young baseball players are increasingly susceptible to elbow injuries. Furthermore, in recent years, an increasing number of these injuries are being caused by throwing. This is despite increased public awareness and recent national efforts aimed at lowering injuries in throwers. As such, new initiatives continue to be developed to limit early sports specialization, prevent overuse injuries, and keep youth players healthy.^{1,15} Further analysis of these efforts through large-scale prospective investigations will be necessary to appropriately evaluate the effect of these protective measures on injury rates.

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