

# National Estimates of Softball Related Concussions Presenting to Emergency Departments from 2004-2012

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## Abstract

**Objectives:** Softball can be enjoyed at any age. Softballs are being hit at higher velocities off metal or composite bats onto a small field, often with minimal personal safety equipment. These high velocity softballs can lead to serious injuries such as concussions which may have short and long-term ramifications. This study explores trends in concussions and their mechanisms in the US for all types of softball from 2004 to 2012.

**Methods:** The National Electronic Injury Surveillance System was used to determine estimated numbers of concussions in all types of softball from 2004 to 2012. The Outdoor Foundation data were used to determine participation. Incidence rates for concussions were calculated.

**Results:** There were 24,350 estimated concussions over this study period. Most, 14,950 (61.4%), occurred during fast-pitch games. 61.2 percent were caused by being struck by the ball, while 18.7 percent were caused by collision with other players. There is a statistically significant increase in the number of concussions each year ( $r = 0.859$ ,  $p = .003$ ). There is a statistically significant increasing incidence of concussion from 2006 to 2012 ( $r = 0.783$ ,  $p = .037$ ) in fast pitch softball.

**Conclusion:** This study provides an epidemiological update on softball concussions from 2004 through 2012. The greater risk of concussion in fast-pitch softball indicates the need for stricter enforcement of player safety rules. Most concussions in both fast and slow-pitch softball occurred by players being struck by the ball, raising concern that protective equipment should be required attire for batters and fielders alike.

**Keywords:** Softball; Concussions; Sports Medicine; Epidemiology

## Introduction

Over 300,000 sports related concussions occur annually in the U.S. with long-term and immediate traumatic effects currently taking center stage in the public eye [1]. Current literature on concussions that occur while playing softball is limited, but the physics of the game make concussions a serious concern for children and adults who play the sport. Thousands of pounds of force are expended reversing the direction of a pitched softball; with 75% of the energy needed to reverse the ball's direction and 25% of the expended energy devoted to sending the ball screaming back at players standing as little as 40 feet away [2].

Athletes participating in slow pitched softball are not immune to these dangers. In an effort to reduce injuries, the Amateur Softball Association limits the Batted Ball Speed (BBS) to less than 85 MPH, but the Association assumes that batters are swinging 60 MPH or slower with pitches being thrown at 10 MPH [3]. Unfortunately, studies have shown that the average slow-pitch softball pitcher tosses the ball between 20 and 25 MPH and the average batter swings between 81 and 89 MPH, frequently leading to bbs of 110 MPH or higher [3]. Depending on the type and composition of the bat used, slow-pitch softball pitchers have anywhere from 0.361 to 0.409 seconds to react and protect themselves when the BBS reaches 100 MPH or higher [4]. Speeds this great can put even seasoned softball players in harm's way.

Although some fast-pitch leagues mandate that pitchers and infielders wear masks that cover their face, the vast majority do not. Participants in slow-pitch leagues often wear less head protection, as even a batters helmet is not required. This difference in utilization of head and face safety gear across leagues and school districts may have led to thousands of injuries and at least one death, that of a 12-year-old Michigan girl in 2007 [5]. Furthermore, many athletes find facial protection to be cumbersome, obstructive, or aesthetically displeasing, causing many players to refuse wearing the equipment against the wishes of coaches or parents. In 2006, the National Federation of State High School Associations (NFHS) mandated that all batters wear a face mask on their helmet, and gave permission for, but did

not require, the use of head protection among infielders. Despite many cases of athletes getting knocked unconscious on the field of play, nothing has changed to protect softball infielders.

The epidemiology of concussions in softball has not been examined in the literature. The purpose of this study is to elucidate the primary causes of concussions in softball players and comment on trends that have occurred from 2004 to 2012, providing evidence for increased regulation on player safety equipment. We hypothesize that a greater incidence of concussions occurs in the younger, fast-pitch population. Fast-pitch softball, which is typically played by young athletes, provides a steep learning curve for coordination and reaction times. A lack of coordination and athletic skills at the younger levels could place athletes at these levels at an increased risk of missing the ball, colliding with a teammate, or running into an inanimate object. Furthermore, the speed of play is faster than slow-pitch making it more competitive and higher risk for collisions.

## Methods

The National Electronic Injury Surveillance System (NEISS) was utilized for data collection on softball concussions occurring from January 2004 through December 2012. Patient information is collected from each NEISS hospital for every emergency visit involving an injury associated with consumer products, such as sporting equipment. From this sample, the total number of injuries treated in hospital emergency rooms nationwide can be estimated. The NEISS sampling procedure and the statistical basis for calculation of national estimates is a validated approach and described on the CPSC website. The derivation of sampling weights used by the NEISS is well established and used by researchers and government agencies [6]. Sampling weights were applied to the NEISS data to account for selection, number of annual emergency departments visits for each hospital and for hospitals that do not respond. After being weighted, the NEISS data provides estimates for the total number of specific sports related injuries in the United States. Variables included in the standard NEISS case report are treatment date, sex, race, diagnostic category, body part injured, patient disposition, and location of injury. As a part of the Consumer Product Safety Mission, the NEISS database serves as a reliable and reproducible source for a wide range of epidemiological subjects.

Injuries associated with softball were identified and examined using the NEISS consumer product codes in this study. All four types of head injuries including concussion, contusions/abrasions, fractures and lacerations were recorded for head injuries. Database specific codes for softball (NEISS code 5034), head injuries, and concussions were utilized in the search query. Using the validated weighting system a yearly national estimate was calculated. By the suggestions of Thompson et al, every case provided by NEISS had the narrative physician comments examined thoroughly to maintain that the injury was both a confirmed diagnosis of concussion and occurred while participating in the softball [6] Many cases returned by our query involved bystanders and spectators being struck by thrown bats and batted balls, which were excluded in this study.

Variables such as age and gender were sorted using codes provided by the NEISS database. The cause of concussion required an in-depth chart review and was stratified into four categories: unspecified cause, struck by the ball, collision with another player, and sliding or diving. Incidence rates were calculated using participation rates provided by the Outdoor Foundation's annual report [7]. These rates included fast-pitch and slow-pitch softball as separate entities. Unfortunately, the 2004 and 2005 reports were inaccessible, so incidence rates were not calculated for these years. For this study cases involving subjects 21-years or younger were considered fast-pitch cases, while patients 22 and older were considered slow-pitch cases. The nonparametric variable, causes of concussion, was compared between the slow pitch and fast pitch groups using a chi squared test. Linear regression was used to test for change in incidence rates over time. SPSS v. 21 (IBM Corp, Armonk NY) and Microsoft Excel were utilized for all analyses.

## Results

Overall, a query of NEISS provided 705 concussion cases with a weighted estimate of 24,350 concussions over a 9 year time frame. Of all concussions, 14,950 (61.4%) occurred during fast-pitch games and 9,400 (38.6%) occurred during slow-pitch games. Sixty-one percent of concussions were due to a player being struck in the head by the ball, 19% from collisions, 10.5% from sliding or diving, and 10.5% were unspecified. The average age for males suffering softball related concussions was 30.24 years (SD 10.66), while the average age for females was 17.65 (SD 8.69). On average, 2,705 concussions occurred per year. From 2004 to 2012, there is a statistically significant trend showing an increasing number of concussions each year ( $r = 0.859, p = .003$ ). The average incidence rate of concussions from 2006 to 2012 was 7.67 in fast pitch softball and 1.14 in slow pitch softball. There is a statistically significant trend showing an increasing incidence of concussion from 2006 to 2012 ( $r = 0.783, p = .037$ ) in fast-pitch softball; there was no identifiable trend for slow pitch softball.

The demographic data for concussion injuries occurring in fast-pitch and slow-pitch softball are summarized in Table 1. A higher number of females experienced concussions (91%) playing fast-pitch compared to their male counterparts (9%). Concussions during slow-pitch softball showed a slight male predominance, 65% males versus 35% in females. The causes of concussion were significantly different between the fast pitch and slow pitch groups ( $p < 0.005$ ) (Table 2). Of note, fast-pitch softball had a higher proportion of concussions caused by collisions with other players (20.10% in fast pitch vs. 17% in slow pitch) and a lower proportion from being struck by the ball (57.80% in fast pitch vs. 64% in slow pitch), as compared with slow-pitch softball. However for both sports being struck by ball was the most common mechanism of injury, followed by collision with another player.

The average number of all participants each year for fast pitch softball from 2006 to 2012 was 2,384,857.14, while the participation in slow pitch softball during this time was 8,659,142.857. The average incidence rates of concussion were 7.68 and 1.14 concussions per 10,000 participant-years in fast

**Table 1:** Patient demographics. “%” is interpreted as percent of total for the variable in the respective style of softball examined.

Demographics		Pitch Speed		
		Fast-Pitch	Slow-Pitch	
Gender	Male	1,402.54	6,110.02	
	%	9.00	65.00	
	Female	13,555.95	3,267.99	
	%	91.00	35.00	
	Total	14,958.50	9,378.01	
Average Age		14.69 ± 2.55	34.0 ± 3.65	
Incidence		Average Per 10,000	7.67 ± 1.79	1.14 ± 0.43
Cause	Unspecified	1,861.48	722.30	
	%	12.40	8.00	
	Struck by ball	8,644.85	5,969.16	
	%	57.80	64.00	
	Collision	3,000.71	1,599.31	
	%	20.10	17.00	
	Sliding/Diving	1,451.46	1,087.24	
%	9.70	12.00		

more even injury rates in slow pitched softball probably reflects the recreational nature of participation and the more evenly distributed gender participation rates.

Although absolute numbers of estimated concussions were similar for the slow-pitch and fast-pitch groups; it was apparent that there was a greater risk associated with fast-pitch softball when adjusting for participation numbers. Larger proportions of concussions occurred from colliding with other players in fast-pitch softball compared to slow-pitch softball. This may be due to younger athletes’ incomplete development of coordination skills, a more competitive nature to fast pitch game, and a faster game pace. The overall nature of slow-pitch softball tends to be less competitive and is played at a slower pace; therefore, it is understandable that the data would show a lower incidence rate of concussions.

Despite these differences, the majority of concussions in both fast pitch and slow pitch softball are caused by being struck by the ball (57% and 64% respectively). This proportion is similar to previous reported data on concussions in high-school and collegiate level softball [8]. This study also demonstrated that only 7% of concussions in softball occurred due to being hit by

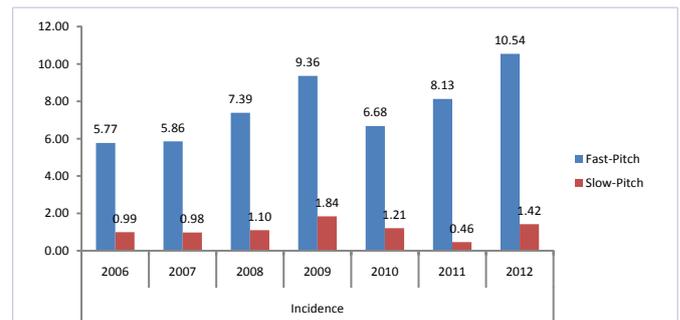
**Table 2:** Mechanism of Concussion in Slow Pitch and Fast Pitch Softball.

		Mechanism				Total
		Unspeci-fied	Struck by Ball	Colli-sion	Sliding/Div-ing	
Game	Fast pitch	1861	8645	3001	1451	14958
	Slow pitch	722	5969	1599	1087	9377
Total		2583	14614	4600	2538	24335

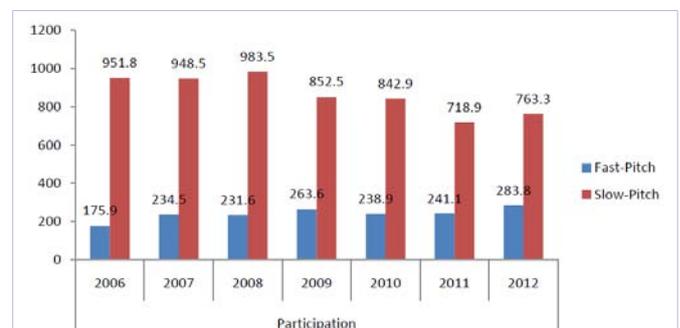
pitch and slow pitch softball respectively. This demonstrates a 6.7 times increased relative risk for concussion in fast pitch compared to slow pitch softball. There was also was a significant increase in the incidence rates of concussions in fast pitch softball over the studied time period (R=0.781 p=0.038). On the other hand, the incidence of concussion in slow pitch softball did not show any significant change over the study time period (p=0.889) (Figure 1). Participation rates declined over the same period of time for fast-pitch softball, from an average of 9.6 million participants from 2006-2008, to an average of 7.4 million over the final two years of the study (Figure 2).

### Conclusion

This study provides the first look into the epidemiology of softball concussions in the U.S. Overall the concussion rate for all softball players was 24,350 for the 9 year period with an average annual concussion rate of 2,705. There appeared to be overall increase in incidence rates for concussions in fast pitched softball with a clear predominance of occurrence in women over men. The fact that females were the most injured demographic (91%) in our fast pitch group is not surprising given the predominance of female participants in competitive fast-pitch softball. The



**Figure 1:** Incidence rates of concussions, by year, for both styles of softball. Incidence rates are reported as concussions per 10,000 participants-year. A steady increase in incidence can be seen from 2006 to 2012, while the slow-pitch incidence rate has remained relatively stable over the same timeframe.



**Figure 2:** Participation rates for fast-pitch and slow-pitch softball from 2006 to 2012. Number of participants is reported by the 10,000s. Data provided by the Outdoor Foundation Annual Report. Slow-pitch softball saw an incline in participation of about 153 thousand per year, while fast-pitch saw an average decline of 269 thousands participants per year, between the years 2004 and 2012.

a pitch, emphasizing the importance of protective equipment for defensive players as well as batters. This represents a much larger proportion of concussions occurring by means other than being hit by a pitch compared previous reported data on high school and collegiate level competitive baseball [9]. This distinction is also important in further support of the use of protective equipment for softball fielders even if such equipment is not used in baseball.

There were a number of limitations that must be considered when reviewing the data in this study. First, the study is based on the assumption that all cases occurring when the patient was 21 or younger were related to fast pitch softball or caused during slow-pitch softball when the patient was 22 or older. While this approach allowed for the most logical division between slow-pitch and fast-pitch softball, this assumption over simplifies the relationship between the type of softball played and age of the concussed patient. While older adult fast-pitch softball leagues do exist, they are not common. The same can be said for slow-pitch leagues for those younger than 21. Second, the NEISS database only accounts for patients diagnosed with a concussion at an ED, it does not account for undiagnosed cases or cases that present to a trainer, primary care physician, or ambulatory care center. Therefore our reported rates may be an underestimation of the overall incidence of concussions occurring in softball.

Thus, by utilizing national epidemiological data we were able to elucidate trends in the incidence and mechanism of concussions in a common U.S. sport. This study provides a timely update to the sports literature regarding concussions in softball players of all ages and highlights yet another sport where proper

diagnosis and management of concussions is crucial to the overall health and safety of its participants.

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