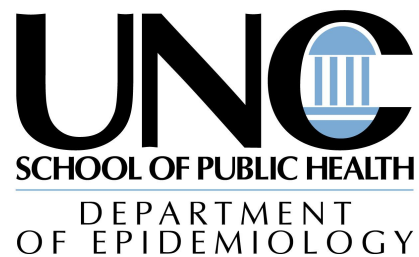
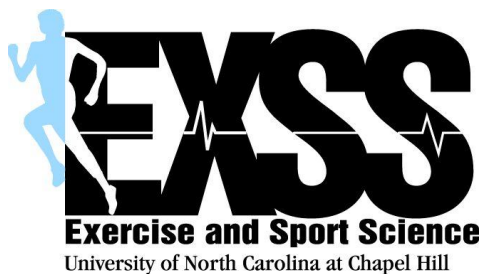


**FINAL REPORT:**

**BATTED BALL INJURIES**

**TO THE PITCHER**

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## **INTRODUCTION**

The issue of wood versus metal bats has sparked great controversy in the world of baseball. Wood bat advocates argue that the ball leaves the metal bat at greater velocity and the reaction time for the pitcher to avoid being hit by the batted ball is correspondingly reduced. Metal bat advocates point to the overwhelming popularity of metal bats in many sectors of the youth game and to the fact that serious injuries to the pitcher are rare.

Although there is some concern that the use of metal bats in baseball is associated with an increased risk of injury for pitchers on the opposing team, until now there has been a lack of scientific data on the issue. There have been anecdotal reports of pitchers and infielders injured by balls hit by metal bats, but no research to date has scientifically quantified the association between metal vs. wood bat use and the risk of injury to pitchers. In part, this is because the overwhelming popularity of the metal bat makes a comparison of injury risks between metal and wood bats within the same population problematic.

We conducted an observational epidemiologic study on injuries to the pitcher from line drive batted balls, comparing the wood bat to the metal bat. Data on injuries from metal bats were drawn from the National Collegiate Athletic Association's (NCAA) Injury Surveillance System. Data on injuries from wood bats were collected in the college summer baseball leagues around the country. The purpose of the study was to determine whether the use of metal bats in baseball increases the risk of injury to pitchers from batted balls, relative to the use of the wood bat.

## **BASEBALL INJURIES**

Baseball comprises a significant number of sports and recreational injuries resulting in visits to hospital-based emergency departments, and is the fifth most common sport in injured males overall, and the fourth most common for males ages 10-14 years (CDC, 2002). Baseball and softball account for 10% of all sports and recreational injuries seen in hospital-based emergency departments (Burt and Overpeck, 2001), and 10% of all medically-attended sports and recreational injuries (Conn et al., 2003).

However, the significance of youth baseball injury extends beyond simple incidence figures, and derives in part from the significance of the game of baseball as part of the cultural fabric of the United States (Rader 1992; Ward & Burns 1994). Historically, the game dominated the United States sports landscape during the first half of the 20<sup>th</sup> Century (Rader 1992; Ward & Burns 1994) and, although its popularity relative to other sports has declined in the post-war period, it retains a strong player base with 12 million participants nationwide (SMGA, 1996). Perhaps more importantly, the game serves as a point of initiation for U.S. youth into team sports and organized physical activity (SMGA 1996; Rader 1992). Major league baseball has considerable prominence as a professional sport within the United States. Amateur baseball, however, is largely a sport of youth athletes; nearly two-thirds of baseball participants are less than 18 years of age (SMGA 1996).

Historically, health professionals have exhibited a strong desire to make youth baseball as safe as possible (Hale 1979; Hart 1992; Andrews 1998; Yen 2000; American Academy of Pediatrics 2001). Given the sustained popularity of the sport (12 million participants; SMGA, 1996), even small reductions in the injury risk in youth baseball have considerable significance.

## **METAL BAT AND INJURY**

The metal baseball bat has been an area of controversy. Metal bats were first used extensively in the early 1970's and have all but replaced the wood bat with the exception of Major League Baseball, high school baseball in North Dakota, and a number of schools in the Massachusetts Interscholastic Athletic Association. However, several concerns about the metal bat have been voiced, included whether there an increased risk of ball-related injury for youth players on the pitching mound and in the infield as a result of the wood or metal bat, and whether high school and collegiate pitchers have the reaction times to avoid a ball driven at a higher velocity by a wood or metal bat.

Because there has been limited injury data available comparing metal batted ball injuries to wood batted ball injuries, much of the debate that has raged over the metal bat has been driven by anecdotal case reports. There has been little or no epidemiologic information about whether there is an increased injury risk due to metal bats. A recent review paper supports the plausibility of the hypothesis that the baseball may come off of the metal bat faster than it would off of the wood bat and pose a greater risk to pitchers and other infielders, however the author also stated that hitters using wood bats could also produce potentially dangerous line drives. Other variables in the risk analysis that must be considered are the increasing size and strength of batters, the variation of reaction time of pitchers, and the role of the baseball in the exit speed off of the bats. (Nichols et al., 2004).

The National Federation of State High School Associations announced on March 22, 2002, that a bat must meet a Ball Exit Speed Ratio (BESR) performance standard (BESR certification mark on the bat) in order to be legal for high school baseball competition governed by National Federation of State High School Associations rules. No matter what materials are used in the bat composition, if it has the BESR certification mark, it is legal. The National Collegiate Athletic Association (NCAA) also adopted a BESR standard effective January 1, 2000, and introduced a revised BESR standard in 2002 (effective January 1, 2003). The NCAA has published a BESR white paper (NCAA Baseball Research Committee, undated) detailing the basis for the standard.

The NCAA conducted an unpublished one-year study in 1997-98 on Division 1 pitchers being hit with a batted ball during games. Seventy-two of the 273 schools responded with 176 events of pitchers being hit with a batted ball. Ninety-seven percent of the balls were hit with a metal bat. Seventy-one percent of the pitchers continued to pitch after being hit and were not removed from the game. Twenty-eight (16%) were treated by a trainer or physician but not removed from the game, 22 (13%) were removed from the game, two were hospitalized, and one had surgery. Six percent were hit in the head or face, 2% to the neck, 64% to the lower extremities, and 7% to the torso. Ninety percent of the injuries were contusions, 1% concussions, and 1% fractures.

Equipment interventions for preventing baseball injury have been carefully researched. Breakaway bases (Janda et al., 1989; Sentre et al., 1994), faceguards (Danis et al., 2000; Marshall et al., 2003), and safety balls (Marshall et al., 2003) have been shown to be effective. The effect of the type of bat (metal or wood) in injury risk, however, has not previously been comprehensively studied.

## **METHODS**

*Overview.* This three-year study was based in collegiate and college summer league baseball. The college summer leagues almost exclusively use wood or wood composite bats, while college teams almost exclusively use the metal bat. The injury event of interest in this study is line drive batted ball injuries to pitchers in games.

*Data Collection.* Prior to the data collection period contact was made with the National Collegiate Athletic Association (NCAA) concerning the use of baseball data from their Injury Surveillance System (ISS). They agreed to share data on injuries to the pitcher from batted balls from the metal bat.

During the summer of 2005 we collected data from 129 summer league teams in 15 leagues and arranged for them to participate through the reporting of injury data. Prior to the 2005 season we mailed letters explaining the research, human subject information, and copies of the injury form to all leagues and teams. In the 2006 and 2007 seasons we re-contacted all teams. The research assistant assisted in all of the mailings, contacted the summer league teams by telephone during the season, and traveled to the majority of the 15 Leagues to observe games and meet the coaches.

*Injury Definition.* An injury was defined as impact from a line drive batted ball which resulted in either medical care or restricted participation, and was a traumatic injury (overuse injuries were not reportable). For both the NCAA and the summer league play, this includes 0 day time-loss injuries. Since there are essentially no practices in summer league, we did not include injuries in NCAA practices. For similar reasons, we did not include NCAA injuries from pre-season games. Even though we limited the injury definition to line drives, including ground ball injuries would have little effect on the results, since there were very few of these.

*Injury Rate.* Obviously, there are potential differences in terms of the proportion of all pitches that are hit into the field of play between the NCAA and college summer leagues. To control for this, we computed injury rates per 100,000 balls in play. We computed this injury rate in the NCAA and in the summer leagues. The ratio of these two rates (NCAA injury rate per 100,000 balls in play divided by summer league injury rate per 100,000 balls in play) is a measure of the increased rate of injury (to pitchers from line drives) in the NCAA (metal bats) relative to summer leagues (wood bats).

*Balls in play.* Balls in play was calculated by taking the total number of at-bats and subtracting strike-outs in order to give a reliable measure of how many balls are actually hit into the field of play. Obviously, not all balls in play are line drives at the pitcher. However, there is no simple means to measure line drives towards the pitcher. The proportion of balls in play that are line drives towards the pitcher was assumed to be similar in NCAA and summer league play. The limitation of balls in play measure is that it includes foul balls caught as outs, which obviously pose no injury risk to the pitcher. However, the number of foul balls caught as outs is a very small proportion of all balls in play and is probably similar between NCAA and summer leagues. This small over-counting would have minimal effect on the results.

To compute balls in play, we abstracted data on the websites for the summer league teams on the total number of at-bats and strike-outs. For the NCAA teams, we randomly selected a team from the same conference as the institution contributing data to the NCAA ISS. This was because the NCAA ISS, in the interests of confidentiality, does not disclose to external researchers the names of schools contributing ISS data.

## **RESULTS**

*Injury Rates.* The total number of line drive injuries to the pitchers from batted balls on the NCAA teams was 7 injuries on 38 teams in 2005, 9 injuries on 55 teams in 2006, and 11 injuries in 50 teams in 2007, for a total of 27 injuries over the 3 years. The total number of balls in play on these teams was 40,668 in 2005, 71,043 in 2006, and 72,201 in 2007. The rate of line drive batted ball injuries to the pitcher in 2005 was 17.2 per 100,000 balls in play, in 2006 the rate was 12.7, and in 2007 the rate was 15.2. Thus, the overall rate of line drive batted ball injury for NCAA pitchers was 14.7 per 100,000 balls in play.

The total number of line drive injuries to the pitchers from batted balls on the college summer league teams was 10 injuries on 129 teams in 2005, 5 injuries on 117 teams in 2006, and 5 injuries on 129 teams in 2007, for a total of 20 injuries over the 3 years. The total number of balls in play on these teams was 138,911 in 2005, 125,989 in 2006, and 139,065 in 2007. The rate of line drive batted ball injuries to the pitcher in 2005 was 7.2 per 100,000 balls in play, in 2006 the rate was 4.0, and in 2007 the rate was 3.6. Thus, the overall rate of line drive batted ball injury to summer league pitchers was 5.0 per 100,000 balls in play.

Thus, over the 3 years, 27 line-drive batted-ball injuries were observed in the NCAA teams, and 20 in the college summer league teams. The rate of these injuries was 14.7 per 100,000 balls in play in the NCAA and 5.0 per 100,000 balls in play in summer leagues. This means that a pitcher was 3.0 times more likely (95% Confidence Interval: 1.7 to 5.3;  $p < 0.001$ ) to be injured in games involving metal bats, relative to games involving wood bats. There was an elevated (although not always statistically significant) rate of injury in NCAA play, relative to summer league play, in every year of study (Table 1).

As stated above (and shown in Table 1), the rate ratio's 95% Confidence Interval for the three years was 1.7 to 5.3, which essentially means that there is a 95% chance that the true rate ratio is within this interval, and a 5% chance that the true rate ratio could be higher or lower. Note that there was an elevated (although not always statistically significant) rate of injury in NCAA play, relative to summer league, in every year of study (Table 1). In 2005 the rate was not significantly different and the rate ratio's 95% Confidence Interval was 0.9 to 6.3. The rate ratio indicated a significant difference in 2006 with 95% Confidence Interval from 1.1 to 9.5. In 2007 the rate ratio also indicated a significant difference, with a 95% Confidence Interval from 1.5 to 12.2.

*Overall Incidence.* It is important to note that the rate of these injuries in the collegiate playing population was very low. The study followed an average of 48 NCAA and 125 college summer league teams for 3 seasons and observed only 27 and 20 injuries respectively, for a total of 47 injuries total over the 3 years in an annual equivalent of 173 teams (note that the NCAA season is much longer than the summer league season, hence the higher number of summer league teams enrolled). Because there were only 47 injuries over three year study period, the researchers recommend that the study should be continued on an on-going basis.

To underscore the low incidence, the rates can be expressed as the average rate of injury per single ball in play (instead of per 100,000 balls in play). In the summer leagues, the rate of injury is

0.000050 injuries for every ball in play, whereas in the NCAA the rate is 0.000147 for every ball in play.

*Description of Injuries.* All of the 27 NCAA injuries were contusions. The average time lost from these injuries was 3.7 days. There were 2 impacts to the face/head (7.4%), 7 arm/hand impacts (25.9%), 2 chest impacts (7.4%), and 16 leg/foot impacts (59.3%) (Table 2). Thirteen injuries (48%) occurred in Division 1, 7 (26%) occurred in Division 1, and 7 (26%) occurred in Division 3. The distribution of schools contributing data by division was 37% from Division 1 (annual average of 18 schools), 22% in Division 2 (annual average of 11 schools), and 41% in Division 3 (annual average of 19 schools).

A majority of the summer league injuries were also contusions to the hand, arm, and lower leg, but injuries to the head/face numbered seven (35% of total summer league injuries). In addition to the non-head contusions, there was also one fractured hand, two fractures to the face, one fractured skull, two contusions to the face, and one concussion (Table 3). Thus, the injuries in summer league play were much more severe than the injuries in NCAA play, since they involved one concussion and three fractures to the head and face, whereas all the NCAA injuries were contusions.

In addition to the 27 NCAA line drive batted ball injuries, there were 4 ground ball batted ball injuries to pitchers over the study period. The total number of all injuries to pitchers in NCAA in-season and post-season games over the study period was 152. Therefore, 18% (27/152) of all game injuries to pitchers were due to line-drive batted balls. It was not possible to determine comparable information on the total number of all injuries to pitchers for summer leagues.

## **COMMENT**

As with any epidemiologic study, bias cannot be completely ruled out. In this study, teams reported their own injuries. All the NCAA teams have assigned athletic trainers, but not all college summer teams are assigned athletic trainers. It is therefore possible that summer league injuries were under-reported to us. However, we worked closely with the summer leagues to ensure accurate and complete reporting, and we consider that under-reporting bias is unlikely to completely account for the observed 3-fold greater rate in NCAA play relative to college summer play. For the observed 3-fold rate ratio to be completely spurious, i.e., entirely due to under-reporting bias, the under-ascertainment of pitching injuries would have to be 3 times higher in summer leagues than in the NCAA (e.g. no under-reporting in the NCAA and 66% under-reporting in summer leagues, or 10% under-reporting in the NCAA and 70% under-reporting in summer leagues). These extreme differentials in reporting are unlikely.

It is important to replicate and extend this study to other playing populations, such as high school athletes. Our findings are not guaranteed to translate beyond collegiate players into other age groups. Also, in addition to the injuries to pitchers, there may have been injuries to 3<sup>rd</sup> basemen and other infielders. However, the study did not attempt to collect data on any playing position other than the pitcher.

It would also be helpful to conduct a study in which leagues were randomly assigned to metal or wood bats. A randomized study has greater methodological strength than an observational study and would be an important contribution to the debate over metal bats. However, we fully acknowledge such a study would likely be expensive and time-consuming to implement and conduct. Furthermore, adherence by teams to their randomized treatment arm (wood or metal) could be problematic.

The existing biomechanical studies largely pre-date the introduction of the revised BESR standard into NCAA play (Crisco et al., 2002; Nicholls et al., 2003). All metal bats in use in the NCAA during the course of this study were BESR-certified under the 2002 revised standard. Additional biomechanical studies of ball velocities between BESR-certified metal and wood bats would be very helpful.

## **RECOMMENDATIONS**

The study observed a 3.0-fold increase (rate ratio between 1.7 and 5.3) in the injury rate associated with the metal bat. An increase of this kind is unlikely to be solely due to bias and is consistent with the hypothesis that there may be a greater risk of injury to the pitchers in play involving the metal bat, relative to wood. However, it is important to bear in mind that the rate of injury to pitchers from batted balls is very low. In addition, the injuries in summer leagues were more severe than the injuries in NCAA play (7 head/face injuries in summer leagues (3 fractures and 1 concussion), and 2 in NCAA – both contusions).

In light of these findings, we have three recommendations:

1. Current bat standards (such as the BESR standard) should be studied again and improved, with the goal of eliminating what appears to be an increased injury risk posed by the metal bat. As an example it would be interesting for the Crisco et al. team to replicate their research study using modern (2007) bats. (The previous Crisco et al. study dates from prior to the 2002 revision of the BESR).
2. An injury surveillance system, analogous to the NCAA ISS, should be created in the college summer leagues, and overseen by an independent authority, so that the increased injury risk posed by the metal bat can be continuously monitored by comparing NCAA injuries to summer league injuries on an on-going basis.
3. All baseball leagues and teams – youth, high school, college, and professional - should keep accurate and complete data on injuries to pitchers and infielders from batted balls.

We believe that implementing the above three recommendations will lead to improvements in the safety of the sport for pitchers and infielders.

## SUMMARY

The researchers conducted a three year observational epidemiological study on injuries from batted balls to the pitcher, comparing the wood bat to the metal bat. The purpose of the study was to determine whether the use of metal bats in baseball increases the risk of injury to pitchers from batted balls, relative to use of the wood bat. Data on injuries from metal bats was drawn from the National Collegiate Athletic Association's Injury Surveillance System. Data on injuries from wood bats was prospectively collected in 15 summer collegiate baseball leagues around the country.

It is important to note that the rate of these injuries in the collegiate playing population is very low. The study followed an average of 48 NCAA and 125 summer league teams for 3 seasons and observed only 27 and 20 injuries respectively, for a total of 47 injuries total over the 3 years in an annual average total of 173 teams. In addition, the injuries in summer league play were more severe than the injuries in NCAA play, since they involved one concussion and three fractures to the head and face, whereas all the NCAA injuries were contusions.

Data was collected over three seasons: 2005, 2006, & 2007. Over the 3 years, 27 line-drive batted-ball injuries were observed in the NCAA teams sampled (48 on average), and 20 in the summer league teams (125 on average). The rate of these injuries was 14.7 per 100,000 balls in play in the NCAA and 5.0 per 100,000 balls in play in summer leagues. Thus, pitchers were 3.0 times more likely to be injured in games involving metal bats, relative to games involving wood bats (95% Confidence Interval: 1.7, 5.3;  $p < 0.001$ ).

Clearly there are numerous differences between NCAA play and summer leagues. However, our analysis conditioned on balls in play, in order to statistically control for most of the differences between NCAA play and summer leagues.

In this study, teams reported their own injuries. All the NCAA teams have assigned athletic trainers, but not all summer teams are assigned athletic trainers. It is therefore possible that summer leagues under-reported their injuries to us. However, we worked closely with the summer leagues to ensure accurate and complete reporting, and we consider that under-reporting bias is unlikely to completely account for the observed difference of a 3.0 times greater rate in NCAA play relative to summer play. It is important to replicate this type of study in other playing populations, such as high school athletes. Additional biomechanical studies of ball velocities between BESR-certified metal and wood bats, and a study in which leagues were randomly assigned to metal or wood bats, are also recommended.

We recommend that current bat standards (such as the BESR standard) should be studied again and improved, with the goal of eliminating the possibility of a pitcher being hit by a line drive batted ball. We further recommend that an injury surveillance system, analogous to the NCAA ISS, should be created in the summer leagues, and overseen by an independent authority, so that the risk of the metal bat can be continuously monitored by comparing NCAA injuries to summer league injuries on an on-going basis.

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**Table 1. Injuries, Balls in Play, Injury Rate per 100,000, and Rate Ratio, by Study Year**

	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2005-2007</b>
<b>Number Balls in Play- Summer Leagues</b>	138,911	125,989	139,065	403,965
<b>Number Balls in Play- NCAA</b>	40,668	71,043	72,201	183,912
<b>Number of Injuries- Summer Leagues</b>	10	5	5	20
<b>Number of Injuries- NCAA</b>	7	9	11	27
<b>Injury Rate- Summer Leagues<sup>1</sup></b>	7.2	4.0	3.6	5.0
<b>Injury Rate- NCAA Leagues<sup>1</sup></b>	17.2	12.7	15.2	14.7
<b>Rate Ratio (95%CI)</b>	2.4 (0.91, 6.3)	3.2 (1.1, 9.5)	4.2 (1.5, 12.2)	3.0 (1.7, 5.3)

<sup>1</sup>Rate per 100,000 balls in play

**TABLE 2**  
**INJURY TYPE AND BODY PART - NCAA**

<b><u>INJURY TYPE</u></b>	<b><u>BODY PART</u></b>
<b><u>2005</u></b>	
CONTUSION	FOOT/TOE
CONTUSION	UPPER LEG
CONTUSION	HAND/FINGER
CONTUSION	HAND/FINGER
CONTUSION	LEG
CONTUSION	LEG
CONTUSION	RIB
<b><u>2006</u></b>	
CONTUSION	HAND
CONTUSION	LOWER LEG
CONTUSION	UPPER LEG
CONTUSION	FOOT/TOE
CONTUSION	LOWER LEG
CONTUSION	ANKLE
CONTUSION	UPPER ARM
CONTUSION	HAND/FINGER
CONTUSION	UPPER LEG
<b><u>2007</u></b>	
CONTUSION	ANKLE
CONTUSION	ELBOW
CONTUSION	FACIAL
CONTUSION	FOOT/TOE
CONTUSION	FOOT/TOE
CONTUSION	HAND/FINGER
CONTUSION	HEAD
CONTUSION	LOWER LEG
CONTUSION	UPPER LEG
CONTUSION	UPPER LEG
CONTUSION	RIB

**TABLE 3**  
**INJURY TYPE AND BODY PART - SUMMER LEAGUES**

<b><u>INJURY TYPE</u></b>	<b><u>BODY PART</u></b>
<b><u>2005</u></b>	
CONCUSSION	HEAD
CONTUSION	ANKLE
CONTUSION	UPPER LEG
CONTUSION	LOWER LEG
CONTUSION	LOWER LEG
CONTUSION	SHOULDER
CONTUSION	FACE
CONTUSION	LOWER ARM
FRACTURE	FACE
FRACTURE	HEAD
<b><u>2006</u></b>	
CONTUSION	ANKLE
CONTUSION	FACE
CONTUSION	LOWER LEG
FRACTURE	FACE
FRACTURE	HAND
<b><u>2007</u></b>	
CONTUSION	EAR
CONTUSION	ANKLE
CONTUSION	ANKLE
CONTUSION	LOWER LEG
CONTUSION	LOWER LEG