Mechanisms of Slow-Pitch Softball Injuries Reported to the HQ Air Force Safety Center

A 10-Year Descriptive Study, 1993–2002

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Background: Softball is a popular sport in civilian and military populations and results in a large number of lost-workday injuries. The purpose of this study is to describe the mechanisms associated with softball injuries occurring among active duty U.S. Air Force (USAF) personnel to better identify potentially effective countermeasures.

Methods: Data derived from safety reports were obtained from the USAF Ground Safety Automated System in 2003. Softball injuries for the years 1993–2002 that resulted in at least one lost workday were included in the study. Narrative data were systematically reviewed and coded in order to categorize and summarize mechanisms associated with these injuries.

Results: This report documents a total of 1181 softball-related mishap reports, involving 1171 active duty USAF members who sustained one lost-workday injury while playing softball. Eight independent mechanisms were identified. Three specific scenarios (sliding, being hit by a ball, and colliding with a player) accounted for 60% of reported softball injuries.

Conclusions: Mechanisms of injury for activities such as playing softball, necessary for prevention planning, can be identified using the detailed information found in safety reports. This information should also be used to develop better sports injury coding systems. Within the USAF and U.S. softball community, interventions to reduce injuries related to the most common mechanisms (sliding, being hit by a ball, and colliding with a player) should be developed, implemented, and evaluated.

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Introduction

Injuries are the leading cause of emergency department visits in the U.S.[1] Sports and recreational injuries account for 15% to 20% of such emergency department visits[2,3] and result in almost 7 million medical encounters in the U.S. annually.[4] Furthermore, softball and baseball were among the leading causes of sports and recreation injury in age categories 20–24, 25–44, and those older than 45.[2] A recent survey of mishaps reported to the HQ Air Force Safety Center (AFSC) showed that softball injuries were one of the leading causes of lost workdays for active duty United States Air Force (USAF) personnel.[5] Softball has also been ranked as one of the leading team sports associated with injury hospitalizations,[6] injuries among senior officers,[7] and lost man-days[8] in the U.S. Army (USA). Although no accurate figures for participation levels are available, USAF softball participation rates are most likely higher than general U.S. population rates and similar to USA rates, due to a younger population that is encouraged to be physically active. Typically every squadron sponsors a team, and every USAF base has multiple softball fields. As a consequence, softball-related injuries in the USAF as in young U.S. populations, are likely to be an important medical problem.

In order to prevent softball injuries, knowledge of the causes, mechanisms, and effective prevention strategies is necessary. However, literature specific to softball injury

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prevention is sparse. Several case reports focus on rare events such as ball throwers' fracture of the humerus[9] and traumatic hyphema.[10] A few papers categorize mishaps by injury type[11–13] or by affected organ systems such as neurologic injuries.[14] Some studies of softball injury have attempted to describe the mechanism of injury.[8,15–20] However, only a few prospective studies[17,18,20] and a single retrospective study[16] provided any information on mechanisms. These studies are mostly based on medical data, resulting in either small sample size, a lack of detail necessary for development of prevention strategies, or both. Other common deficiencies include small case numbers, short periods of observation, single types of injury, or narrow focus on selected cases. A recent systematic review of interventions to prevent softball-related injuries identified a need for studies describing the mechanisms of softball injuries.[21]

The present study uses a large, detailed mishap reporting (safety) database to fill some gaps in the present literature regarding the different mechanisms of injuries in adult slow-pitch softball. This paper reports on a subset of results, specific to organized softball, that are part of a larger effort of the AFSC to focus on nonfatal injury prevention and to better understand the nature of lost-workday injuries among USAF personnel. This study helped answer a request for information from a Department of Defense (DoD) authority, the Defense Safety Oversight Council's Military Training Task Force, that wanted to know if military safety data could be used to assist with injury prevention efforts. While safety data have historically been used to monitor and prevent fatal injuries, this paper demonstrates the potential capabilities of using safety data to define and support priorities for the prevention of nonfatal injuries.

The purpose of this paper was to determine whether sufficiently detailed mechanisms or hazard scenarios (descriptions) of softball injuries in the USAF safety database could be developed to meaningfully inform injury prevention planning.

Methods

This paper describes the results of a retrospective, descriptive epidemiologic study that focused on identifying the mechanisms of softball injuries. It should be kept in mind that this endeavor to accurately describe softball injuries was part of a larger initiative to describe and categorize 32,812 USAF safety reports.[5] The safety reports were reported to the AFSC over a 10-year period from 1993 to 2002. The USAF population over that time varied from a high of 439,902 in Fiscal Year 1993 to a low of 347,782 in 2001 (Table 1).

Table 1. USAF population numbers and softball lost-workday injury frequencies and rates per 10,000 active duty service members, 1993–2002

Fiscal year	Population (N)	Lost-workday injury frequency (#)	Rate (#/10,000 service members)
1993	439,902	190	4.3
1994	422,024	172	4.1
1995	396,102	121	3.1
1996	384,719	116	3.0
1997	373,082	115	3.1
1998	363,206	100	2.8
1999	356,214	88	2.5
2000	351,104	86	2.4
2001	347,782	92	2.6
2002	363,787	91	2.5

Detailed methods for developing and identifying mechanisms are given in a separate paper in this supplement.[5] In brief, the process involved air force safety data contained in the Ground Safety Automated System (GSAS) for Fiscal Years 1993 through 2002, which were analyzed and grouped by injury-causing activities (e.g., operating a vehicle, climbing stairs, playing basketball, lifting, or carrying). This paper specifically describes slow-pitch softball mishaps. Within each injury activity, descriptive mechanisms were developed that would potentially inform prevention efforts. As a list of mechanisms had not been previously developed in GSAS, the list was formulated using a systematic and time-intensive process of reading reports (one-line descriptions and longer narratives), aggregating similar mishaps, and continually refining the list to capture the greatest number of mishaps in the fewest mechanistic categories. The final list of eight common mechanisms (Table 2) captures 89% of the softball mishaps that occurred during the study period.

The GSAS does not contain reports on all injuries as, at the time of this study, reporting was required only on injuries resulting in at least one lost workday. Reporting requirements at that time for the DoD stipulated that injuries resulting in 1 or more days of lost work time be reported.[5] Thus only the more severe injuries are captured in the safety data presented.

The GSAS contains safety reports on the USAF active duty population—which is young, physically active, and predominately male (80%–85%). Descriptive statistics (frequencies, distributions) were produced for a wide variety of factors such as fiscal year, age, major command, functional area, injury type, and activity; however, this paper presents primarily aggregate (men and women combined) data on mechanisms, frequencies, and percentage distribution of injuries. Analyses by gender and age are not presented in this paper because the frequencies and percentages of injury

Table 2. Top ten activities associated with lost-workday injuries reported to the HQ AFSC, active duty USAF personnel, 1993–2002[a]

Rank	Activity	Total lost-workday injuries	Total lost workdays	Lost workdays per injury	% on-base
1	Operating vehicles or equipment	4,390	46,818	10.7/3	13
2	Basketball	2,165	12,520	5.8/2	78
3	Slips/trips/falls[b]	2,032	14,554	7.2/3	61
4	Lifting/carrying (not slips, trips, or falls)	1,231	3,386	2.8/2	72
5	Softball	1,181	6,843	5.8/3	71
6	Riding in/on vehicles or equipment	1,147	13,023	11.4/4	16
7	Climbing/descending stairs or ladder	965	6,902	7.2/3	59
8	Flag football	939	5,406	5.8/3	74
9	Being struck/struck by object[c]	932	5,208	5.6/2	73
10	Trail riding: dirt bike/ATV/Quad	454	5,563	12.3/7	8
	Total	15,426	120,223		

[a]Excludes categories such as "standing," which convey only incidental activities.
[b]Numerous activities were associated with this category, but specific well-defined activities (e.g., slips, trips, and falls due to playing basketball or softball, or climbing a ladder or stairs) were included in those more-specific categories rather than being included under this general slips, trips, and falls category. Activity breakdown: general walking (n=2363); stepping up or down from/to uneven surfaces such as curbs (n=380); entering/exiting buildings or vehicles (n=368); carrying items (n=254); while handling or carrying items or equipment (n=155); running not associated with sports, jogging, or physical training (n=138); and dozens of other activities.
[c]Does not include people being struck by objects that they dropped; being struck by a dropped object is categorized here as lift/carry/handle; also does not include being hit by a motor vehicle (pedestrian injuries are included in lower-frequency categories not included in this table).
ATV, all-terrain vehicle

among women and by age categories would have been too small to interpret reliably. As the proportion of active duty USAF personnel involved in softball activities is unknown, it is difficult to calculate actual rates of injury among softball players. Nevertheless, rates of softball injury resulting in 1 or more days of lost duty (i.e., lost-workday injury) for the USAF as a whole are calculated by dividing the number of individual safety reports by the USAF active duty population for a given year (Table 1).

Results

From 1993 to 2002, USAF active duty population decreased 17% from 439,902 to 363,787 (Table 1). Over the same 10-year period, rates of softball mishap (injury) reports to the AFSC decreased 42%, from 4.3 softball-related lost-workday injuries per 10,000 active duty population to 2.5 per 10,000 (Table 1).

Of 32,812 lost-workday injuries from all causes reported to the AFSC from 1993 to 2002, sports and recreation activities accounted for 25% (Table 2). Four of the top ten activities for active duty USAF personnel were from the sports and recreation category (Table 2). With 1181 total lost-workday injury reports among active duty USAF military personnel, softball ranked fifth overall, and second only to basketball in total number of injuries within the sports and recreation category.

Table 3 lists the top eight mechanisms, and summarizes the 1181 softball injuries reported by mechanism. Three mechanisms (sliding, being hit by a ball, and colliding with a player) accounted for almost 60% of the injuries. Mechanisms such as running, falling, tripping, diving, or swinging each accounted for between 3% and 11% of injuries reported. The "Other" category includes such incidents as getting hit by a bat, running into a fence, and six unspecified mechanisms.

Table 4 summarizes injury types by mechanism. Fractures, strains, and sprains accounted for 75% of the injury types. Fractures were the predominant injury type (40%) for all mechanisms and dominated the sliding category (54%). Not surprisingly, collisions with other players had the highest average number of lost workdays among the eight mechanisms (Table 3). These data illustrate how safety reports are dominated by the more severe injuries.

Discussion

This descriptive study shows that safety mishap injury reports contain sufficient information to determine the mechanism of injuries resulting from softball. Such information could be used to develop and monitor injury prevention strategies or countermeasures. The same process of reviewing, categorizing, and coding mechanisms

Table 3. Frequency and percentage distribution of mechanisms producing softball injuries and potential prevention modalities, active duty USAF personnel, 1993–2002

Mechanism	Example(s)	Injuries reported[a] (*n* [%])	Average # of lost workdays (days)	Possible prevention
Sliding	Sliding into second Sliding into third, face first	272 (23)	6.0	Breakaway bases Ban sliding Two home plates
Being hit by a ball	Being struck on jaw by ball Being hit in left eye by ball	236 (20)	4.9	Helmet, face guard worn at all times Reduced Injury Factor (RIF) balls
Colliding with player	Colliding with another player Being run over by another player	187 (16)	8.6	Training to "call balls" to warn off other fielders Two home plates
Running	Tearing Achilles tendon running Running and knee buckling under	126 (11)	5.4	Preseason conditioning Shift emphasis from stretching to warming up prior to play
Falling, unspecified	Falling and landing on elbow Running and falling	81 (7)	4.8	Training to improve balance Improved fields
Tripping or stepping on base, bat, ball	Tripping over base Stepping on base	58 (5)	5.6	Recessed bases
Diving or jumping	Jumping and twisting back Diving for ball and dislocating elbow	52 (4)	6.1	Balance training Recognize this is not the Majors!
Swinging bat	Swinging bat and twisting knee Swinging bat and straining back	34 (3)	4.2	Pre-game warm-up Conditioning
Other	Being hit by bat Running into fence	135 (11)	5.4	

[a]Total softball-related lost-workday injuries reported to the AFSC, 1993–2002=1181

of softball injuries can be applied to other sports and occupational activities for the USAF and other Services. The eight mechanisms of softball injuries described in this paper have clear value for injury prevention, not only for the air force, but also for other military and civilian populations.

The USAF safety data presented in this paper are consistent with other civilian and military data on injury causes that show sports are among the leading causes of serious injuries.[2–5,22–24] In civilian populations, it is estimated that 7 million Americans seek treatment for sports injuries each year.[4] In young U.S. populations, it is also estimated that sports account for 15% to 20% of emergency department visits,[2,3] which would rival falls and surpass motor vehicle crashes as causes of emergency visits as reported by the National Center for Health Statistics.[1] Both civilian and military studies have shown softball to be one of the leading causes of sports injuries.[2–6]

In order to prevent softball and other injuries, knowledge of the mechanisms of injury is necessary. This paper identifies eight mechanisms of softball injuries (Table 3), of which three (sliding, being hit by a ball and colliding with a player) account for 60% of the softball injuries resulting in lost workdays. These three mechanisms would be good targets for prevention.

Several papers in the literature on softball injury have attempted to define the mechanisms of softball injury. Janda reasoned that softball injuries could be grouped into three categories: sliding, collisions, and falls. He provides data supporting sliding as the primary mechanism, but does not provide substantiating data for collisions and falls.[19] In a later paper, Janda added overuse injury to make the list more comprehensive.[20] Nadeau evaluated 150 emergency room visits and found that 82% could be captured by the same three categories of sliding, collisions (with both players and balls), and falls.[16] Wheeler examined 100 referrals to orthopedics for softball injuries and found that sliding, jamming, and falls were major mechanisms of softball/baseball injuries among army personnel.[8] Where most softball studies have identified only a few mechanisms of injury, this study, using USAF safety data, documented eight different mechanisms of softball injuries, with 34 to 272 injury case examples per mechanism (Table 3).

Table 4. Frequency of injury type by mechanism for active duty USAF personnel, 1993–2002

Mechanism (*n*)	Types of injury[a]	Number of injuries (*n*)
Sliding (272)	Fracture (chipped bones/compression/compound)	146
	Strain (includes muscle injuries/whiplash/spasm)	56
	Other	21
	Dislocation (separation/subluxation)	16
	Abrasion/scrape/scratch	10
	Internal injuries, other	10
	Concussion	9
	Rupture (complete organ tears/Achilles tendon)	4
Being hit by a ball (236)	Fracture (chipped bones/compression/compound)	129
	Contusion	37
	Other	24
	Laceration (tears/cuts)	22
	Concussion	15
	Dislocation (separation/subluxation)	9
Colliding with player (187)	Fracture (chipped bones/compression/compound)	103
	Sprain (tear of ligament/joint/cartilage/tendon)	25
	Other	17
	Strain (includes muscle injuries/whiplash/spasm)	16
	Contusion	10
	Concussion	8
	Dislocation (separation/subluxation)	8
Running (126)	Strain (includes muscle injuries/whiplash/spasm)	56
	Rupture (complete organ tears/Achilles tendon)	27
	Sprain (tear of ligament/joint/cartilage/tendon)	26
	Fracture (chipped bones/compression/compound)	12
	Other	5
Falling, unspecified (81)	Fracture (chipped bones/compression/compound)	38
	Sprain (tear of ligament/joint/cartilage/tendon)	16
	Other	10
	Dislocation (separation/subluxation)	9
	Strain (includes muscle injuries/whiplash/spasm)	8
Tripping or stepping on object (e.g., base, bat) (58)	Fracture (chipped bones/compression/compound)	28
	Sprain (tear of ligament/joint/cartilage/tendon)	20
	Other	10
Diving or jumping (52)	Fracture (chipped bones/compression/compound)	20
	Other	13
	Sprain (tear of ligament/joint/cartilage/tendon)	11
	Strain (includes muscle injuries/whiplash/spasm)	8
Swinging bat (34)	Strain (includes muscle injuries/whiplash/spasm)	19
	Other	15
Other/unspecified		135
Total		1181

[a]Total softball-related lost-workday injuries reported to the AFSC, 1993–2002=1181

Almost one fourth of injuries reported in this study resulted from sliding. Much attention has deservedly been placed on sliding in the sports literature as well. Janda reported that 52 of 73 (71%) injuries were caused by sliding in a retrospective review of community and hospital records.[15] Nadeau reviewed three summers of emergency room records related to softball injuries at Yokota Air Base and found that 45% were caused by sliding.[16] A 1-year prospective study of orthopedic referrals on an army post found that 42% of softball injuries were due to sliding.[8] A prospective study of collegiate baseball and softball players found that softball produced a higher rate of sliding injuries than baseball and, in softball, head-first slides resulted in a higher injury rate.[17] Because of their numbers and severity, sliding injuries should be a prevention priority.

The mechanisms of softball injury resulting in the most frequent and most severe injuries provide the greatest opportunity for prevention. In addition to sliding, being hit by a ball and colliding with other players not only were the most common mechanisms (Table 3), but also resulted in the most serious injuries (Table 4). With regard to injury types, fractures (n=476, 40% of all reported injuries), tendon ruptures (6%), and concussions (3%) were the most serious softball-related injuries reported to the AFSC. The percentage of fractures reported in this study was higher than in other reports of softball injuries,[15,16,17] with the exception of Wheeler's orthopedic case

series.[8] More fractures (n=146) resulted from sliding than from any other mechanism (Table 4). This again emphasizes the importance of preventing sliding injuries.

Sliding is not only the most commonly reported mechanism of softball-related injury, but also the only softball injury for which a "proven" prevention strategy exists. Breakaway bases have been shown to reduce the incidence of sliding-related injuries by as much as 95%.[21] Although the USAF has mandated the use of breakaway bases, sliding still accounted for 23% of USAF softball injuries during this time period. The use of breakaway bases at many USAF bases may explain why the USAF proportion of softball injuries due to sliding was lower than their current civilian counterparts (70%)[15] and historic military accounts (42% USA,[8] 45% USAF[16]).

Breakaway bases are currently mandated, but this policy may need greater enforcement. These data also suggest that sliding injuries will still occur even with the wide implementation of breakaway bases, so other prevention strategies may be needed. For instance, some sliding injuries occur before the runner even contacts the base. The soft, uneven dirt found in batter's boxes may make separate home plates and rule changes necessary for preventing sliding injuries at home. This countermeasure would also have the added benefit of eliminating collisions near home plate. Other rule changes that restrict sliding could further reduce sliding injuries.

Although the only effective softball injury prevention strategy identified in the sports medicine literature is breakaway bases,[15,21] this paper suggests possible prevention strategies for each mechanism listed in Table 3. For example, two thirds of the players injured when hit by a ball were hit somewhere on the head. Helmets equipped with face guards in theory could reduce this injury if worn throughout the game. In contrast to baseball, protection from the ball in slow-pitch softball appears to be most important when not batting. Reduced Injury Factor (RIF) balls provide another way to decrease the incidence of injuries from being hit by balls. Such RIF balls have a lower coefficient of restitution and compression, and hence travel with less velocity when hit. This lower velocity could reduce hit-by-ball injuries at a number of other anatomic sites by reducing the velocity of the ball and the resulting energy of impact. The emerging popularity of balance training for all sports provides another potential prevention tool for injuries in several categories. If the suggested potential prevention strategies are implemented before intervention trials are conducted, rigorous evaluation and monitoring for their effectiveness should be conducted.

It is evident from the foregoing discussion that this analysis had several advantages and provided information not generally found in the literature on softball injuries. The first advantage was the large number of cases, almost 1200. Although the data did not encompass all softball injuries, the safety data by regulation captured serious injuries—injuries that were most likely to affect an individual's life and work, or lost-workday injuries. Finally, the safety data clearly contained enough information to accurately describe and code the mechanisms of softball injury, information that is necessary to focus prevention efforts.

The mechanism information gained from this analysis fills a gap in knowledge necessary for prevention; information that is not readily available in the electronic medical records. Currently, military electronic medical records capture only general causes on injury hospitalizations, which represent a relatively small percentage of the total injuries. More-specific information regarding mechanism of injury is necessary for developing effective countermeasures. Whether or not a more detailed medical cause coding scheme should be developed to capture information on mechanisms is a dilemma faced by the military and civilian sports medicine communities. This dilemma is further complicated because resolving it increases the burden on already heavily tasked medical providers. The military has the advantage of having safety officers at every installation charged with investigating mishaps, thereby providing the necessary data without placing an additional burden on medical care providers.

If the civilian community decides to further develop cause coding to include mechanisms for sports and recreation activities, the military safety database would be an excellent source of information. As these data show, the historic record of hundreds of detailed accounts of softball injuries provides the necessary information to identify, aggregate, and code the most common mechanisms.

Safety reports are more likely to be initiated for hospitalized cases; however they also capture a large number of outpatient visits. In the present study, 912 (78%) of the 1181 softball mishap reports were outpatient visits. Compared to most other softball studies, the large number of mishap reports facilitated more precise identification of a greater number of injury mechanisms, such as running and stepping on objects, rather than just sliding and collisions. The list of eight mechanisms expands on the usual two or three found in reports such as those by Janda[16] and Nadeau.[13] The extended list of identified mechanisms gives important information for developing countermeasures and future coding systems.

Despite its strengths, this analysis also has some limitations, including possible underreporting of injuries by safety officers. Currently, the reporting process relies on a chain of events with a number of weak links. The report-

ing process requires the injured player to notify the supervisor, the supervisor to notify the safety officer, and the safety officer to investigate the mishap and finally write a report to the AFSC. Internal and external estimates of underreporting have varied from 50% to 90% under-reporting (unpublished data). This problem of underreporting is probably due to many factors, and a full exploration of the problem is beyond the scope of this paper. Nevertheless, safety reports represent a valuable sample of the more severe and duty-limiting injuries.

One factor affecting reporting of injuries during this study may have been changes in military medical practices in the early and mid-1990s. During the early 1990s, there was a move to treat more injuries and other health problems on an outpatient basis rather than hospitalizing patients (Armed Forces Health Surveillance Center, personal communication,). Decreases in military hospitalization rates would in turn reduce the number of lost-workday injuries reported to safety officials. In fact, hospitalizations rates for injuries and musculoskeletal conditions decreased 62% between 1993 and 2002, the period of this study (unpublished data, Armed Forces Health Surveillance Center). Over this same period, safety reports of lost-workday injuries decreased 42% (Table 1).

A final limitation of this study was the lack of accurate denominator data. Estimating softball participation is far different than other activities such as driving, where one can assume much higher rates of participation. Without data on how many USAF personnel play softball or engage in other sports, it is difficult to calculate risks or rates of injuries.

In summary, the results of this analysis allowed the development of a useful list of mechanisms for the Air Force Safety Automated System, the USAF's new mishap reporting system, and should contribute to progress in coding and preventing softball and other sports and occupational injuries. This paper also illustrates, for epidemiologists and others, the richness of detail not available from medical records or medical surveillance data, and provides the foundation for future studies that include calculation of rates, trends, and multivariate analyses of more detailed causes and risk factors.

Apart from the fact that breakaway bases are mandated in the USAF, softball play in the military should closely compare to play in the civilian sector. Therefore this study should also provide details that may suggest both preventive measures and prioritization of those measures that should be developed and evaluated for military and civilian players. It also provides more-specific data for creation of improved civilian external cause coding for sports and recreation activities.

In conclusion, safety mishap injury reports provide sufficiently detailed information to identify mechanisms of injuries resulting from softball and to develop countermeasures to reduce these injuries. However, due to under-reporting and established thresholds for reporting, safety data do not provide a full picture of the total burden of sports or other injuries. Conversely, medical records, such as emergency room visits, give important information for estimating the burden of injury and type of injury, but valuable detail for prevention is usually missing. Consequently, both data sources are necessary to assess the magnitude of the injury problem in the U.S. military. The information from these data sources should in turn be used to improve existing sports injury cause coding, which is necessary for the development, implementation, and evaluation of prevention strategies for softball and other sports injuries. The leading mechanisms of softball mishaps (sliding, colliding with a player, and being hit by a ball) identified by this analysis should be a priority in intervention efforts.

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