SYSTEMATIC REVIEW

Interventions to prevent softball related injuries: a review of the literature

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Objectives: To examine the published evidence on interventions to prevent softball related injuries among adults, and to encourage more epidemiologic research as a foundation for future softball injury prevention efforts.

Methods: The authors reviewed literature identified from six electronic databases for studies on softball related injuries. The search was limited to studies written in the English language, published between 1970 and 2002, and involving adult populations. Research was excluded that evaluated baseball ("hard ball") related injuries or was aimed at injury treatment. Identified studies were categorized by study design. Intervention/prevention papers were evaluated further and described in detail.

Results: The search strategy identified 39 studies specifically related to softball. Most studies were case reports/case series (n=13) or descriptive studies (n=11); only four were analytic or intervention/prevention studies. Studies collected data in a variety of ways, often without denominator data to permit calculation of injury rates. Studies also did not differentiate between slow or fast pitch softball activities and most did not mention the type of softball that was used.

Conclusions: Surprisingly few studies exist on interventions to reduce injuries during softball, one of the most popular recreational sports in the US. Of the existing literature, much attention has been on sliding related injuries, which comprise only a segment of softball injuries. Basic epidemiologic studies describing the nature, severity, and risk factors for softball injuries in a variety of populations are needed, followed by additional intervention evaluation studies aimed at modifiable risk factors.

Sports related injuries account for a substantial proportion of non-fatal injury and disability in the United States. Estimates from the National Health Interview Survey indicate that approximately seven million individuals receive medical attention each year for sports related injuries.¹ Emergency room visits alone are costly—medical charges for US emergency department visits for sports injuries put this figure at roughly \$500 million annually.²

Although sports injury rates are high for children and adolescents, adults are also impacted significantly by sports injuries.^{3–4} During the summer months of 2000 and 2001, 35% of all non-fatal sports injuries seen in emergency departments were to adults 20 years and older.⁵ Among adult military personnel, Lauder *et al* found that over a six year period, US Army rates of hospitalized injuries related to sports and physical training were 38 and 18 per 10 000 person-years for men and women, respectively.⁶ These injuries were responsible for an average of nearly 30 000 lost duty days each year.

Among US Army personnel, softball, one of the most popular recreational activities, was the third leading cause of sports injury hospitalizations, behind basketball and football.^{6–8} Softball injuries also result in considerable lost work time among Army servicemen and women.⁶ Specifically, for women in the US Army, softball was the most common cause of sports related fractures to the ankle, hand, and tibia.⁶ Beyond the popularity of softball in the military, there are also 40 million US adult recreational softball participants.^{9–10}

To further the prevention of sports injuries among physically active adults, we sought to identify effective interventions to prevent softball injuries. In this paper we present the findings from selected descriptive studies of softball injuries; describe the findings from intervention studies; offer directions for future research; and demonstrate

the need for a more evidence based approach to softball injury prevention.

METHODS

The following databases were searched for potential articles published from 1970–2002: Medline, EMBASE, Cumulative Index to Nursing & Allied Health Literature (CINAHL), SPORTDiscus, the Centers for Disease Control and Prevention's Morbidity and Mortality Weekly Reports database (MMWR), and Physiotherapy Evidence Database (PEDro). Chosen electronic databases were identified with the assistance of a subject matter expert and a University librarian, and from published reviews in the sports medicine and sports injury literature.

Search terms were identified a priori using the following Medical Subject Headings (MeSH) and text words: "intervention", "prevention", "injury", and derivatives of these (for example, injury, injuries); "sliding", "athletic", and "sports" in conjunction with "injury", "prevention", and "intervention". All of the aforementioned terms were combined with "softball". The study title and abstract were reviewed to identify potentially relevant articles.

All study designs were accepted for inclusion if they met the following criteria: (1) published in English; (2) contained data on softball; (3) conducted in civilian or military populations, ages 18–65 years; (4) reported on a human research study that assessed the association between injury and a potential risk factor, prevention strategy, or intervention; (5) focused on primary prevention. Even though softball is a game derived from baseball, the playing surfaces and the balls used are not the same; thus studies of baseball related injuries were excluded.¹¹ Studies examining treatment

Abbreviations: HIB, Hollywood Impact Base.

options for softball injuries were beyond the scope of this study and were also excluded.

The age inclusion criterion reflected the demographics of the military population, even though exclusion of adolescent and child sports participants meant that softball studies covering a leading cause of injury for younger populations were not evaluated. An ad hoc search of softball injuries among youth revealed that baseball, excluded in this review, was more often researched than softball in youth populations.^{12–19}

Studies that met inclusion criteria were classified as reviews, laboratory studies, case series or case reports, descriptive epidemiologic studies, analytic epidemiologic studies, or intervention trials, as defined in *A Dictionary of Epidemiology*.²⁰ Table 1 displays the categorization of these 39 papers by study design and year of publication.

Results from a few selected descriptive studies are presented to highlight what is known about the distribution and risk factors for softball injuries. As our focus was on identifying preventive strategies, the intervention studies were evaluated in detail and are described in table 2. The three intervention studies identified were each qualitatively rated using a published scoring system developed by Thacker and colleagues.²¹ The list of potential confounders was modified to include variables pertinent to the outcome of interest, softball related injury. However, the general scoring system of the instrument was maintained, and study quality was assessed on a 100 point scale. Three authors independently evaluated each of the intervention studies, and the median score and range are listed in table 2.

RESULTS

Descriptive epidemiologic studies

The prevalence of softball related injuries has been described in physically active adult populations. In the earliest descriptive study found (1984), Wheeler analyzed slow pitch softball injuries referred to the orthopedic clinic at a military hospital.⁸ Over a one year period, 83 athletes were seen with 93 softball related injuries. Injuries occurred when the softball jammed into a player's fingers or hand during an attempted catch. Most injuries, 42% of total injuries, occurred during sliding. Ankle injuries and fractures to the lower extremity were the most common injuries resulting from sliding. Among all sliding injuries, roughly 83% of the players were injured sliding foot first and injuries occurred primarily at second and third bases. Wheeler stated that sliding injuries resulted from the tendency for players to use the base to rapidly decelerate and reduce overrunning, and suggested base modifications or sliding technique training as potential injury countermeasures.⁸

Shesser and colleagues found that among all recreational softball related injuries seen in the emergency department, a fall was the most common mechanism of injury (43%).²² Falls often occurred while a player was running bases, sliding, or trying to catch a ball in an outfield position. Use of alcohol

during softball play was also reported for 34% of the 175 injured players. The authors suggested that players be cautious when playing on slippery surfaces and proposed the elimination of purposeful sliding, as a potential injury reduction technique.

Loosli *et al* analyzed slow pitch softball injuries presented at a sports medicine clinic and found that 44% were knee sprains or strains.¹⁰ The knee was the most common injury site (26%) among players who went to the clinic for treatment. No data were provided on the mechanisms of injury. The authors stated that as most injuries in their sample appeared to be non-traumatic, preseason conditioning could be a potential injury reduction strategy.

Nadeau *et al* conducted an evaluation of athletes seen at an Air Force emergency department and found that over 14 months, 150 presented with injuries related to softball.²³ Approximately 45% of the injuries occurred during sliding, followed by collisions (28%), and falls (6%). Forty three percent of injuries during sliding were ankle sprains or ankle fractures. As sliding was the most widespread cause of injury, the authors recommended the use of low profile or break-away bases.

The most recent descriptive study was a review of 458 medical records of attendees at the US Army War College. This study found that sports and exercise were associated with 41% of incident injury cases during academic year 1999, and 45% in 2000.²⁴ Of the total 314 incident injury cases, 16% (n = 51) occurred during softball. Knapik *et al* found that strains (33%), contusions (27%), and fractures (9%) were the most frequent injuries associated with softball. Although these authors were not able to ascertain the specific mechanisms of injury, they suggested that softball specific injury countermeasures such as the use of breakaway bases, overrunning second and third bases, or training on sliding techniques might be beneficial.

Analytic epidemiologic studies

We found only one study that tested a hypothesized association between a risk factor and softball injury. Hosey and Puffer tested whether sliding injury rates differed between head first or foot first techniques for seven Division 1 collegiate softball teams.²⁵ Data were presented for 422 softball games. There were 2226 slides, an average of 5.3 per game, and 4756 athlete-game exposures. The total incidence of sliding injuries was 9.5 per 1000 slides and 4.9 per 1000 athlete-game exposures. Higher injury rates were seen for head first slides (25% of all slides) compared with foot first slides (63% of all slides); the rates were 19.5 and 10.0 per 1000 slides, respectively.

The body part injured was directly related to the sliding technique (ankle and lower extremity during foot first, and head and shoulder during head first). Results also showed that nearly half (49%) of the injuries occurred while sliding into second base. Based on the risk of injury related to sliding, the authors stated that use of breakaway bases

Table 1 Distribution of identified softball injury studies by type of study and year of publication

Year of publication	Reviews	Laboratory studies	Case reports/ case series	Descriptive epidemiologic studies	Analytic epidemiologic studies	Intervention and prevention studies	Total
1970–79	0	1	0	0	0	0	1
1980–89	3	2	5	7	0	1	18
1990–99	1	1	7	2	0	2	13
2000–03	1	2	1	2	1	0	7
Total	5	6	13	11	1	3	39
Reference list numbers	7, 9, 29–31	32–34, 36–38	39–51	6, 8, 10, 22–24, 52–56	25	26–28	

Table 2 Results of intervention studies to prevent softball injuries

First authors, year of publication (reference)	Study design	Population	Prevention strategy or intervention	Study or prevention groups (subjects)	Outcome risk	Injury rate ratio	Quality score (100 points maximum)
Janda <i>et al</i> , 1988 ²⁶	Intervention Softball players on various teams by skill level Two seasons	Men and women, ages 18–55 years Recreational players Teams divided according to skill level	Rogers Breakaway bases installed on playing fields; other fields kept standard stationary bases Teams assigned to playing fields on a random and rotating basis	Games played with breakaway bases (n=633) Games played with stationary bases (n=627)	Base sliding related injuries that required first aid treatment or higher Breakaway: 2/633=0.0031 = 1 injury every 316 games Stationary: 45/627=0.0718 = 1 injury every 14 games Base sliding related injuries that required first aid treatment or higher Post intervention: 2/1035=0.0019 = 1 injury every 517 games	RR (stationary base: breakaway base) = 23.2 (p<0.001)	Median = 38 Range 33–44
Janda <i>et al</i> , 1990 ²⁷	Intervention Softball players on various teams by skill level Long term follow up of Janda 1988	Men and women, ages 18–55 years Recreational players Teams divided according to skill level	Rogers Breakaway bases installed on playing fields; other fields kept standard stationary bases Teams assigned to playing fields on a random and rotating basis	Games all played with breakaway bases (n = 1035)	Base sliding related injuries that required first aid treatment or higher Post intervention: 2/1035=0.0019 = 1 injury every 517 games	Compared with rates reported in Janda 1988 (p<0.001)	Median = 14 Range 13–16
Sendre <i>et al</i> , 1994 ²⁸	Intervention Two year period: 1990 and 1991	Men and women, age 15–48 years Recreational softball leagues, intramural softball leagues, American legion and Colt leagues, women's softball team	Hollywood Impact Base (HIB) compared with a stationary base	627 total games 472 games played with HIBs (33 153 total athlete exposures) and 155 games played with standard stationary bases (3999 total athlete exposures)	Base sliding related injuries HIB = 0.00003 injuries/athlete exposure Stationary = 0.001 injuries/athlete exposure	RR (stationary base: HIB) = 33.3 (p<0.05)	Median = 21 Range 18–25

instead of standard bases could reduce sliding related injuries.

Intervention evaluation studies

The search identified only three intervention studies, all of which were published during the 1980s and early 1990s (table 2). In the first of these (1988), Janda *et al* compared approximately 1200 softball games, of which nearly equal numbers were played with stationary or breakaway bases (627 and 633 games, respectively).²⁶ Leagues consisted of players of varying skill levels, and teams rotated among the playing fields to enable exposure to both base types. Over two seasons, 45 sliding injuries occurred with the stationary bases, and only two injuries occurred with the breakaway bases. The injury rates for stationary and breakaway bases were 0.072 and 0.003 sliding related injuries per game respectively (p<0.001); 53% related to stationary bases affected the ankle. Based on these findings, using breakaway bases could lead to a 95% reduction in sliding injuries.

Janda *et al* conducted a subsequent prospective study in 1989, based on the same intervention, that involved surveillance of softball related injuries in 1035 games played on fields that in the prior year had switched to breakaway bases.²⁷ During the follow up period, two ankle injuries were reported: one during a foot first slide and the other when a player's cleat was caught on the ground. The authors compared the sliding injury rate during the follow up period, 1989, (0.002 sliding injuries per game) to the rate in the 1988 study (0.072 sliding injuries per game) and concluded that the results reinforced the ability of breakaway bases to reduce injuries during sliding.

Sendre *et al* used recreational and collegiate teams of various skill levels in the Central Michigan area that agreed to use either a breakaway base (Hollywood Impact Base (HIB)) or the stationary base for practices and games.²⁸ All teams rotated so that each team played roughly the same proportion of games on stationary versus breakaway bases. Over a two year period, five injuries were directly related to base type: one with the HIB and four with the stationary base. The single injury with the HIB resulted from a foot first slide, whereas the four injuries from the standard base were two foot first slides at third base, a running injury at first base, and a head first slide at third base.

Sendre *et al* used the definition from the National Collegiate Athletic Association for an athlete-exposure—“one athlete participating in one practice or game where he or she is exposed to the possibility of athletic injury”.²⁸ During the two year study period, there were 33 153 athlete-exposures with the HIBs and 3999 athlete-exposures with the stationary bases. The injury rate with the standard stationary base was 0.001 per athlete-exposure and 0.00003 per athlete-exposure with the HIBs. Statistical testing of the injury rate difference supported the hypothesis that the HIB reduced sliding injuries.

DISCUSSION

This study was conducted to identify the evidence for interventions to prevent injuries associated with adult recreational softball. At the time this study was conducted, none of the published softball review papers describing articles focused on injury prevention strategies.^{7 9 9–31} In our review, only three interventions aimed at reducing softball related injuries in players age 18–65 were identified. Descriptive studies showed that sliding was the most common mechanism of injury. Therefore, it made sense that the most often discussed injury countermeasures were related to the prevention of sliding related injuries—breakaway bases, recessing second and third bases, and teaching proper sliding and running techniques.^{9 10 24 29 30}

The evidence showed that breakaway bases reduced sliding related injuries. A breakaway base is designed to dislodge when a runner slides into the base, thus minimizing direct contact and injury. The Centers for Disease Control and Prevention estimate that the exclusive use of breakaway bases in softball leagues would prevent about 1.7 million sliding injuries each year and could save over \$1.9 billion in medical costs.²⁹ However, as of 1988, one report stated that “breakaway bases have been well received, but they are not widely used”, perhaps because of their cost.²⁹ Average costs for these bases are roughly \$290 for a set of three breakaway bases (\$97/base) and \$120 for a set of stationary low profile, flat bases (\$30/base).^{9, 29} Limited field research has tested specific base types, but laboratory testing by Janda *et al* has supported the use of the Rogers model of breakaway bases.³²

Even though breakaway bases have consistently been shown to reduce injury, further intervention studies are needed to evaluate other base designs before they can be specifically recommended. For instance, low profile bases instead of elevated bases could be a less costly, yet equally effective preventive strategy.³⁰

As most sliding related injuries occurred during foot first slides, better sliding techniques could also reduce injury.^{7, 25} A laboratory study found that most sliding injuries occurred during the landing phase of a slide.³³ The continued use of biomechanical studies to understand sliding technique could result in modifications to sliding as an additional injury prevention tactic. However, in light of the wide range of skill levels among recreational softball players, interventions aimed at modifying sliding may be impractical and difficult to teach.

A study by Kane *et al* mentioned that head first slides have been banned in some recreational softball leagues.³⁴ Although no citation was provided, this suggests that an analysis of injuries pre and post policy implementation could be conducted to determine the effectiveness of such a ban on the reduction of upper extremity injuries during sliding. Besides sliding, policies allowing overrunning of second and third bases is another potential prevention technique.²⁴ As many injuries occurred at these bases, it is possible that required overrunning of specific bases, in lieu of sliding, would be a beneficial injury reduction strategy.^{25, 27}

Limitations

Although we comprehensively reviewed studies on softball injuries, there are some research limitations. First, studies for this review came from electronic databases of publications, so unpublished articles were not collected. Articles published in languages other than English were also not included. Despite these search limitations, we believe that key articles were identified. Before starting the search, the lead author worked with a consultant and librarian to develop an effective study identification process. Additionally, search criteria were pilot tested to ensure the study identification process was accurate and complete for the specified study purpose and population of interest.

Second, as the primary research aim was to identify strategies to prevent softball injuries, this review relied heavily on findings from intervention papers. The quality ratings of the intervention studies that we reviewed indicated that these studies were, at best, of poor to fair quality. Additionally, the studies did not present confidence intervals when reporting the evidence regarding the effectiveness of the intervention under examination. These factors, the quality rating and the limited information regarding statistical significance, support the need for future intervention research with stronger study design and methodology.

Lastly, this project was initiated to identify and recommend interventions to reduce sports injuries in the military.

As a consequence, this review focused on prevention of injuries to adult softball players. Although this may be seen as a limitation, injury risks to children may be different, and therefore deserve a separate review.

Implications for prevention

This study provided a review of the published literature for interventions to reduce injuries during softball, one of the most popular recreational sports in the US. Only 39 studies were published in the past 33 years, barely more than one per year. Study findings indicated that the most common softball injuries were ankle sprains and fractures, and that over 40% of acute traumatic injuries occurred during base running and, more specifically, during sliding.^{6, 7, 9, 10, 22} As a result, it was not surprising that all three of the intervention studies focused on the prevention of sliding injuries.^{26–28}

Although more research is needed to identify the most cost effective strategies to prevent sliding injuries, it is clear that sliding related ankle injuries are only part of the problem. Emergency department data show that 20% to 25% of softball injuries involve the head and neck.²² Army hospitalization data indicate that concussions and other intracranial injuries were among the top 10 causes of hospitalization of softball players.^{6, 7} Emergency room and clinic data also indicate that hand, wrist and finger fractures, sprains, and jamming injuries are common.^{10, 22} Sports medicine clinic data reveal that knee injuries account for as many as 45% of non-emergency injuries among softball players and another 15% involve the shoulder.¹⁰

As a start, more surveillance research is needed to fully capture the scope of the injury problem for softball injuries. Future studies should meet minimum methodological standards and should report key data elements, such as sample demographics, nature and severity of injuries, rates, and exposure data (for example, total time spent in games and practices). Moreover, studies should report on the skill level of recreational softball players, as the level of players may affect the feasibility of prevention strategies. The intervention studies in this review did not present results by skill level.

Obtaining complete surveillance data and conducting descriptive and analytic epidemiologic studies are a necessary step of the public health process, which requires problem description and risk factor identification before intervention implementation and evaluation.³⁵ Such research is a necessary foundation for future softball injury prevention efforts. These studies will allow for the identification of the most important and preventable types of non-sliding injuries and

Key points

- Sports injuries are a problem not only for youth, but for physically active adult populations as well.
- Among military personnel, softball injuries are a leading cause of sports injury hospitalizations.
- Basic epidemiologic studies describing the types, causes, and risk factors for softball injuries are needed.
- Published literature supports breakaway bases as a prevention strategy for softball injuries, but epidemiologic and intervention evaluation studies are lacking for the prevention of injuries related to mechanisms other than sliding.
- Methodologically strong intervention evaluation studies are essential for future softball injury prevention efforts.

the subsequent prioritization of the “next steps” in softball injury prevention.

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