Journal of Athletic Training 2009;44(6):586–594

www.nata.org/jat

original research

Epidemiology of Cheerleading Stunt-Related Injuries in the United States

Brenda J. Shields, MS*; Soledad A. Fernandez, PhD†; Gary A. Smith, MD, DrPH*‡

*The Research Institute at Nationwide Children's Hospital, Columbus, OH; †The Ohio State University, Columbus, OH; ‡The Ohio State University College of Medicine, Columbus, OH

Context: Cheerleading-related injuries are on the rise. To date, no epidemiologic studies of cheerleading stunt-related injuries have been published.

Objective: To describe and compare cheerleading stunt-related injuries by type of cheerleading team (All Star, college, high school, middle school, or recreation league) and event (practice, pep rally, athletic event, or cheerleading competition).

Design: Prospective injury surveillance study.

Setting: Participant exposure and injury data were collected from US cheerleading teams via the Cheerleading RIO (Reporting Information Online) surveillance tool.

Patients or Other Participants: Athletes from enrolled cheerleading teams who participated in official, organized cheerleading practices, pep rallies, athletic events, or cheerleading competitions.

Main Outcome Measure(s): The numbers, types, and rates of cheerleading stunt-related injuries during a 1-year period (2006–2007) are reported.

Results: Stunt-related injuries accounted for 60% (338/567) of the injuries sustained by US cheerleaders who participated in the study and 96% (22/23) of the concussions and closed head injuries (CHIs) reported during the study. Collegiate cheerleaders were more likely to sustain a concussion or CHI than were cheerleaders on other types of teams ($P = .02$, odds ratio = 3.10, 95% confidence interval = 1.20, 8.06). Most injuries occurred while the cheerleader was spotting or basing another cheerleader (34%, 115/338), and these injuries comprised 32% (51/161) of all stunt-related strains and sprains. Four cheerleaders (1.2%, 4/335) were admitted to the hospital, and 9 cheerleaders (2.7%, 9/335) required surgery.

Conclusions: Cheerleading stunts pose an increased risk for injury, especially in terms of sustaining a concussion or CHI. Spotters and bases were most likely to be injured during the performance of cheerleading stunts and were at risk for sustaining strain and sprain injuries. The ankle, lower back, and wrist were the sites most likely to be reinjured while performing cheerleading stunts.

Key Words: injury surveillance, athletic injuries, collegiate athletes, high school athletes, youth athletes, recreational athletes

Key Points

- Cheerleading stunts were responsible for more than half the total injuries and almost all the concussions and closed head injuries sustained by the participants.
- Compared with cheerleaders on other types of teams, collegiate cheerleaders were more likely to experience concussions and closed head injuries.
- Spotters and bases were most at risk for injury during the performance of cheerleading stunts.

Cheerleading has experienced a dramatic increase in popularity during the past 3 decades.[1] Three decades ago, cheerleaders only performed very basic maneuvers, such as toe-touch jumps, the splits, and claps.[1,2] Today, many cheerleaders not only perform these basic maneuvers but have added gymnastic tumbling runs and partner stunts, which consist of human pyramids, lifts, catches, and tosses (eg, basket tosses).[3] This increase in the difficulty of maneuvers being performed by cheerleaders has been accompanied by an increase in the number of cheerleading injuries. Shields and Smith[4] reported that cheerleading injuries to children 5 to 18 years of age in the United States increased 110% from 10 900 in 1990 to 22 900 in 2002. The gymnastics element of cheerleading, specifically partner stunts and pyramids, is thought to be associated with the greatest risk for cheerleading injury.[5]

Compared with other sports, cheerleading injuries have not received the same attention with regard to tracking and reportability.[6] Few epidemiologic studies of cheerleading injuries exist in the literature, and none of the existing studies[4–6] describe the epidemiology of cheerleading injuries by type of cheerleading team (All Star, college, high school, middle school, elementary school, or recreation league) and type of cheerleading event (practices, pep rallies, athletic events, or cheerleading competitions). Furthermore, none of these existing studies focused primarily on cheerleading stunt-related injuries.

In the present study, we describe the epidemiology of cheerleading stunt-related injuries (type of injury, mechanism of injury, type of stunt, etc) sustained by US cheerleaders during the 1-year period from 2006 to 2007. These injuries are described by type of cheerleading team and type of cheerleading event.

METHODS

Cheerleading RIO (Reporting Information Online; The Research Institute at Nationwide Children's Hospital,

Columbus, OH), an Internet-based injury surveillance system for collecting cheerleading exposure and injury data, was described in detail previously.[2] All US cheerleading teams interested in participating in the study were permitted to enroll. Data regarding athlete-exposures (AEs), injuries sustained, circumstances surrounding the injury event, medical treatment for injured cheerleaders, and time lost from cheerleading participation were collected using Cheerleading RIO for a 1-year period extending from June 5, 2006, through June 3, 2007 (52 weeks). Only cheerleaders who actively participated in each practice, pep rally, athletic event, or cheerleading competition were counted in the AEs. A *reportable injury* was defined as an injury that met all 3 of the following criteria: (1) it occurred as a result of participation in an organized cheerleading practice, pep rally, athletic event, or cheerleading competition; (2) it prevented the injured cheerleader from participating in cheerleading for the remainder of that practice, pep rally, athletic event, or cheerleading competition or for a longer period of time; and (3) it required the injured cheerleader to seek medical attention. *Medical attention* was defined as treatment meeting all 4 of the following criteria: (1) provided at the scene or at a medical facility, (2) administered at the time of the injury or at a later date (no more than 2 weeks after the injury event), (3) required as a result of the injury, and (4) administered by a certified athletic trainer (AT), person trained in first aid, emergency medical technician, nurse, nurse practitioner, physician assistant, or physician. For the present study, a subset of the data collected from Cheerleading RIO, comprising data on stunt-related injuries sustained by cheerleaders on US cheerleading teams, was used. In this study, *stunts* included cradles, elevators, extensions, pyramids, single-based stunts, single-leg stunts, stunt-cradle combinations, transitions, and miscellaneous partner and group stunts. Descriptions of cheerleading stunts are available at https://secure.usasf.net/Documents/Rules/Cheer%2008-09/USASFGlossary0809.pdf. Type of injury was categorized as fracture or dislocation, strain or sprain, soft tissue injury (abrasion, contusion, hematoma, laceration, or puncture), or other (dental injury; epistaxis; friction burn; foreign body; cartilage, ligament, or tendon tear; crush or pinch; nerve damage; tendinitis; tenosynovitis; herniated disk; or spondylolysis) for the multivariate logistic regression analysis. These categories were created by combining categories from the Cheerleading RIO injury report form.

On the Cheerleading RIO injury report form, reporters were able to select more than 1 mechanism of injury. For data analyses, the main mechanism of injury was used for cases in which more than 1 mechanism was reported. For example, if the mechanisms of injury reported included *failed to complete maneuver* and *arms gave way*, the main mechanism of injury was coded as *failed to complete maneuver*.

Statistical Analyses

Data were analyzed using SPSS (version 15.0; SPSS Inc, Chicago, IL), Epi Info (version 5.01b; Centers for Disease Control and Prevention, Atlanta, GA), and Stata/SE (version 9.2; StataCorp LP; College Station, TX) software. Statistical analyses included calculation of odds ratios (ORs) with 95% confidence intervals (CIs), χ^2 tests with the Yates correction, Fisher exact tests, and logistic regression. The level of significance for all statistical tests was $\alpha = .05$. Descriptive statistics included all US stunt-related injuries, including multiple injury events for the same cheerleader, during the 1-year study period. Injury rates were calculated using the AEs presented in a previous manuscript.[2] An *AE* was defined as 1 cheerleader participating in 1 cheerleading event.

Logistic regression was used to build predictive models for stunt-related injuries. A cluster variable, unique cheerleading team ID, was used to account for the existing correlations among athletes within teams, resulting in more precise estimates. Only 1 stunt-related injury per participant was considered in the data analyses to avoid the use of more complex models with a random ''subject'' effect. In cases of multiple stunt-related injuries per cheerleader, the stunt-related injury with the earliest date of injury was used in the analyses. When no reference category was obvious, the category with the fewest number of injuries was selected as the reference category for each variable. The *P* values were adjusted for multiple comparisons by multiplying the *P* value by a factor equal to the number of comparisons that were made (Bonferroni adjustment). Variables entered into the multivariate logistic regression model were selected by including variables that were significant at $P \leq .2$ in the univariate models. The univariate models assessed the relationship of the outcome (stunt-related injury or non–stunt-related injury) to each of the independent variables separately. Potentially relevant interactions were assessed in the multivariate models. Odds ratios with 95% CIs were reported for the final multivariate model.

Ethical Consideration

This study was approved by the institutional review board at the authors' institution. We were granted a waiver of the informed consent/assent requirement under the Institutional Review Board Latitude to Approve a Consent Procedure that Alters or Waives Some or All of the Elements of Consent (§46.116).[2]

RESULTS

Sample Description

Stunt-related injuries accounted for 338 of the 567 injuries (60%) sustained by US cheerleaders who participated in the 1-year study (0.57 injuries per 1000 AEs). The results presented in this article refer only to these stunt-related injuries. The rates of stunt-related injuries per 1000 AEs by team type were as follows: All Star, 0.36; college, 1.59; high school, 0.59; middle school, 0.23; and recreation league, 0.41. All Star teams were generally under the direction of cheerleading or gymnastic gyms, were strictly competitive teams (ie, they did not support another athletic team), and had rules that were different than those for school and recreation league teams. Recreation league teams were under the direction of a city recreation department or a nonprofit youth association, such as Pop Warner or Police Athletic Leagues, and generally cheered for recreation or youth football and basketball teams, although they may also have participated in cheerleading competitions. Cheerleaders sustaining stunt-related injuries

Table 1. Characteristics of Injured Cheerleaders by Team Type

	All Star	Collegiate	High School	Middle School	Recreation League	Total
No. of cases, n (%)	69 (100.0)	88 (100.0)	159 (100.0)	9 (100.0)	13 (100.0)	338 (100.0)
Sex, n (%)						
Male	2 (2.9)	20 (22.7)	2 (1.2)	0 (0.0)	0 (0.0)	24 (7.1)
Female	67 (97.1)	68 (77.3)	157 (98.8)	9 (100.0)	13 (100.0)	314 (92.9)
Age, y						
Mean ± SD	13.0 ± 2.5	19.6 ± 2.0	15.7 ± 1.1	13.2 ± 1.0	12.5 ± 2.9	16.0 ± 3.0
Time as cheerleader, n (%)						
Less than 7 mo	1 (1.4)	3 (3.4)	9 (5.7)	4 (44.4)	2 (16.7)	19 (5.7)
7–12 mo	13 (18.9)	3 (3.4)	14 (8.9)	0 (0.0)	0 (0.0)	30 (9.0)
2 y	11 (15.9)	1 (1.2)	30 (18.9)	3 (33.4)	1 (8.3)	46 (13.7)
3 y	13 (18.9)	3 (3.4)	34 (21.5)	0 (0.0)	2 (16.7)	52 (15.5)
4 y	11 (15.9)	11 (12.7)	29 (18.4)	2 (22.2)	0 (0.0)	53 (15.8)
5 y or longer	20 (29.0)	66 (75.9)	42 (26.6)	0 (0.0)	7 (58.3)	135 (40.3)
Unknown[a]	0 (NA)	1 (NA)	1 (NA)	0 (NA)	1 (NA)	3 (NA)
Frequency of conditioning and strength building, n (%)						
Daily	3 (4.3)	5 (5.8)	22 (14.0)	1 (11.1)	0 (0.0)	31 (9.3)
2 to 3 times/wk	33 (47.8)	69 (79.3)	82 (52.2)	2 (22.2)	9 (75.0)	195 (58.4)
Weekly	29 (42.0)	10 (11.5)	45 (28.7)	4 (44.5)	0 (0.0)	88 (26.3)
Monthly	1 (1.5)	1 (1.1)	4 (2.6)	1 (11.1)	0 (0.0)	7 (2.1)
Never	2 (2.9)	0 (0.0)	4 (2.5)	1 (11.1)	3 (25.0)	10 (3.0)
Other	1 (1.5)	2 (2.3)	0 (0.0)	0 (0.0)	0 (0.0)	3 (0.9)
Unknown[a]	0 (NA)	1 (NA)	2 (NA)	0 (NA)	1 (NA)	4 (NA)

Abbreviation: NA, not applicable.
[a] The number of unknowns was eliminated from the denominators used to calculate the percentages.

were members of 143 cheerleading teams, as follows: All Star (24%, 34/143), college (15%, 21/143), high school (51%, 73/143), middle school (4%, 6/143), and recreation league (6%, 9/143). The percentages of teams with a dedicated (ie, assigned to the cheerleading team) certified athletic trainer (AT) or team physician (or both) were as follows: All Star, 9% (3/34); college, 52% (11/21); high school, 46% (34/73); middle school, 17% (1/6); and recreation league 0% (0/9).

Injured cheerleaders ranged in age from 5 to 29 years, and 93% (314/338) were female (Table 1). The majority of injured cheerleaders were members of high school teams (47%, 159/338), and most of the injured cheerleaders had 5 or more years of cheerleading experience (40%, 135/335) (Table 1). All of the injured cheerleaders performed stretching and flexibility exercises before practices and performances, and most participated in conditioning and strength building 2 to 3 times per week (58%, 195/334) (Table 1).

Injury Event Description

Type of Event and Location. Most of the stunt-related injuries occurred during practice (86%, 292/338), and the majority of the practice injuries occurred 61 to 90 minutes into the practice session (41%, 117/288) (Table 2). All Star cheerleaders were more likely to be injured during a cheerleading competition than were cheerleaders on other types of teams ($P < .01$, OR = 4.90, 95% CI = 1.74, 13.83). Most of the injuries occurred indoors (82%, 279/338) (Table 2). Of the 59 outdoor injuries, extreme heat was involved in 3 and extreme cold in 2 injuries.

Maneuver Attempted. The stunt most frequently being attempted at the time of injury was a cradle (31%, 102/338) (Table 3). High school cheerleaders were more likely to be injured while attempting a single-leg stunt ($P < .01$, OR = 2.61, 95% CI = 1.42, 4.85), and collegiate cheerleaders were more likely to be injured while attempting a pyramid ($P < .01$, OR = 3.48, 95% CI = 2.16, 6.26) compared with cheerleaders on other types of teams. For most of the injured cheerleaders (82%, 278/338), the stunt being attempted was a mastered skill. The remaining cheerleaders had attempted the stunt once before (15%, 51/338) or were attempting the stunt for the first time (3%, 9/338).

Surface Type. All Star cheerleaders were more likely to be injured while performing on a spring floor compared with cheerleaders on other types of teams ($P < .01$, OR = 27.65, 95% CI = 13.38, 57.91) (Table 3). One high school cheerleader (1%, 1/159) was injured while catching another cheerleader, who was performing a cradle over a concrete surface. Another high school cheerleader (1%, 1/159) was injured when she slipped during a cradle on a tile or linoleum surface.

Mechanism of Injury. Most stunt-related injuries occurred while the cheerleader was spotting or basing another cheerleader (34%, 115/338). These 115 cheerleaders comprised the following categories from Table 3: catching cheerleader (66), lifting or tossing cheerleader (29), and spotting or basing cheerleader (20).

Falls resulted in 20% (66/338) of stunt-related injuries. Fall height ranged from 1 to 11 ft (0.30–3.35 m) (mean = 5.1 ± 1.9 ft [16.7 ± 6.2 m]). The cheerleader who fell 11 ft (3.35 m) landed on a traditional foam floor, and the cheerleader who fell 10 ft (3.05 m) landed on a spring floor. Compared with other types of maneuvers, falls were most likely to occur while the injured cheerleader was attempting a single-leg stunt ($P < .01$, OR = 2.90, 95% CI = 1.50, 5.58).

Table 2. Cheerleading Events and Locations Associated With Stunt-Related Injuries by Team Type

	All Star	Collegiate	High School	Middle School	Recreation League	Total
Cases, n (%)	69 (100.0)	88 (100.0)	159 (100.0)	9 (100.0)	13 (100.0)	338 (100.0)
Athlete-exposures, n	193 788	55 220	271 195	39 236	31 827	591 266
Type of event, n (%)						
Practice	59 (85.5)	76 (86.4)	137 (86.2)	8 (88.9)	12 (92.3)	292 (86.4)
Pep rally	0 (0.0)	2 (2.3)	1 (0.6)	0 (0.0)	0 (0.0)	3 (0.9)
Athletic event	0 (0.0)	8 (9.1)	15 (9.4)	1 (11.1)	0 (0.0)	24 (7.1)
Cheerleading competition	10 (14.5)	2 (2.2)	6 (3.8)	0 (0.0)	1 (7.7)	19 (5.6)
Time into practice session, n (%)						
Within first 30 min	3 (5.2)	9 (12.0)	12 (8.9)	0 (0.0)	1 (8.3)	25 (8.7)
31–60 min	22 (37.9)	24 (32.0)	43 (31.9)	4 (50.0)	3 (25.0)	96 (33.3)
61–90 min	21 (36.2)	26 (34.7)	59 (43.7)	3 (37.5)	8 (66.7)	117 (40.6)
91–120 min	6 (10.4)	12 (16.0)	9 (6.7)	0 (0.0)	0 (0.0)	27 (9.4)
More than 120 min	6 (10.3)	4 (5.3)	12 (8.8)	1 (12.5)	0 (0.0)	23 (8.0)
Unknown[a]	1 (NA)	1 (NA)	2 (NA)	0 (NA)	0 (NA)	4 (NA)
Location, n (%)						
Indoors	68 (98.6)	78 (88.6)	114 (71.7)	7 (77.8)	12 (92.3)	279 (82.5)
Outdoors	1 (1.4)	10 (11.4)	45 (28.3)	2 (22.2)	1 (7.7)	59 (17.5)

Abbreviation: NA, not applicable.
[a] The number of unknowns was eliminated from the denominators used to calculate the percentages.

Table 3. Description of Injury Event by Team Type

	All Star	Collegiate	High School	Middle School	Recreation League	Total
Cases, n (%)	69 (100.0)	88 (100.0)	159 (100.0)	9 (100.0)	13 (100.0)	338 (100.0)
Athlete-exposures, n	193 788	55 220	271 195	39 236	31 827	591 266
Maneuver attempted, n (%)						
Cradle	21 (30.4)	24 (27.3)	48 (30.2)	3 (33.4)	6 (46.2)	102 (30.2)
Elevator	6 (8.7)	0 (0.0)	8 (5.0)	3 (33.3)	1 (7.7)	18 (5.3)
Extension	3 (4.4)	5 (5.7)	4 (2.5)	1 (11.1)	2 (15.4)	15 (4.4)
Miscellaneous stunt[a]	10 (14.5)	17 (19.3)	19 (11.9)	1 (11.1)	1 (7.7)	48 (14.2)
Pyramid	4 (5.8)	15 (17.0)	2 (1.3)	0 (0.0)	0 (0.0)	21 (6.2)
Single-based stunt	2 (2.9)	8 (9.1)	10 (6.3)	0 (0.0)	0 (0.0)	20 (5.9)
Single-leg stunt	11 (16.0)	8 (9.1)	41 (25.8)	1 (11.1)	1 (7.6)	62 (18.4)
Stunt-cradle combo	5 (7.2)	5 (5.7)	15 (9.5)	0 (0.0)	2 (15.4)	27 (8.0)
Transition	7 (10.1)	3 (3.4)	12 (7.5)	0 (0.0)	0 (0.0)	22 (6.5)
Partner stunt, not specified	0 (0.0)	1 (1.1)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.3)
Group stunt, not specified	0 (0.0)	2 (2.3)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.6)
Performing surface, n (%)						
Artificial turf	0 (0.0)	12 (13.6)	1 (0.7)	0 (0.0)	0 (0.0)	13 (3.8)
Concrete	0 (0.0)	0 (0.0)	1 (0.6)	0 (0.0)	0 (0.0)	1 (0.3)
Grass	0 (0.0)	8 (9.1)	31 (19.5)	1 (11.1)	1 (7.7)	41 (12.1)
Mat	0 (0.0)	12 (13.6)	31 (19.5)	0 (0.0)	0 (0.0)	43 (12.7)
Rubberized track	0 (0.0)	1 (1.1)	10 (6.3)	1 (11.1)	0 (0.0)	12 (3.6)
Spring floor	51 (73.9)	14 (15.9)	11 (6.9)	0 (0.0)	0 (0.0)	76 (22.5)
Tile or linoleum	0 (0.0)	0 (0.0)	1 (0.6)	0 (0.0)	0 (0.0)	1 (0.3)
Traditional foam floor	18 (26.1)	34 (38.7)	66 (41.5)	6 (66.7)	10 (76.9)	134 (39.7)
Wood	0 (0.0)	7 (8.0)	7 (4.4)	1 (11.1)	2 (15.4)	17 (5.0)
Mechanism of injury, n (%)						
Catching cheerleader	12 (17.4)	14 (15.9)	34 (21.4)	2 (22.2)	4 (30.8)	66 (19.5)
Contact with another cheerleader[b]	19 (27.6)	10 (11.4)	20 (12.6)	1 (11.1)	2 (15.4)	52 (15.4)
Failed to complete maneuver	5 (7.2)	12 (13.6)	17 (10.7)	0 (0.0)	2 (15.4)	36 (10.7)
Fall	14 (20.3)	16 (18.2)	33 (20.7)	3 (33.4)	0 (0.0)	66 (19.5)
Improper execution of maneuver	2 (2.9)	2 (2.3)	8 (5.0)	0 (0.0)	1 (7.7)	13 (3.8)
Lifting or tossing cheerleader	4 (5.8)	9 (10.2)	14 (8.8)	2 (22.2)	0 (0.0)	29 (8.6)
Spotting or basing cheerleader	6 (8.7)	6 (6.8)	6 (3.8)	1 (11.1)	1 (7.7)	20 (5.9)
Twisted body part	3 (4.3)	3 (3.4)	14 (8.8)	0 (0.0)	2 (15.4)	22 (6.5)
Other[c]	4 (5.8)	16 (18.2)	13 (8.2)	0 (0.0)	1 (7.6)	34 (10.1)

[a] Includes spotting or basing a stunt, bump down, chair, and helicopter.
[b] Includes collided with, kicked by, or stepped on by another cheerleader.
[c] Includes lost balance, slipped or tripped, and arms or legs gave way.

Table 4. Body Part Injured and Type of Injury by Team Category

	All Star	Collegiate	High School	Middle School	Recreation League	Total
Cases, n (%)	69 (100.0)	88 (100.0)	159 (100.0)	9 (100.0)	13 (100.0)	338 (100.0)
Athlete-exposures, n	193 788	55 220	271 195	39 236	31 827	591 266
Body part injured, n (%)						
Head	4 (5.8)	12 (13.6)	16 (10.1)	0 (0.0)	1 (7.7)	33 (9.8)
Face	23 (33.4)	11 (12.5)	27 (17.0)	1 (11.1)	3 (23.1)	65 (19.2)
Neck	5 (7.2)	5 (5.7)	19 (11.9)	2 (22.2)	2 (15.4)	33 (9.7)
Trunk	8 (11.6)	23 (26.1)	39 (24.5)	2 (22.2)	2 (15.4)	74 (21.9)
Upper extremity	16 (23.2)	16 (18.2)	23 (14.5)	3 (33.4)	1 (7.6)	59 (17.5)
Lower extremity	13 (18.8)	21 (23.9)	35 (22.0)	1 (11.1)	4 (30.8)	74 (21.9)
Type of injury, n (%)						
Abrasion, contusion, or hematoma	9 (13.0)	15 (17.0)	30 (18.9)	2 (22.2)	2 (15.4)	58 (17.2)
Concussion or closed head injury	1 (1.4)	11 (12.5)	9 (5.7)	0 (0.0)	1 (7.7)	22 (6.5)
Fracture or dislocation	8 (11.6)	9 (10.2)	14 (8.8)	0 (0.0)	1 (7.7)	32 (9.5)
Laceration or puncture	11 (15.9)	3 (3.4)	8 (5.0)	0 (0.0)	1 (7.6)	23 (6.8)
Strain or sprain	26 (37.8)	39 (44.3)	84 (52.8)	6 (66.7)	6 (46.2)	161 (47.6)
Other[a]	14 (20.3)	11 (12.6)	14 (8.8)	1 (11.1)	2 (15.4)	42 (12.4)

[a] Includes dental injury; epistaxis; friction burn; foreign body; cartilage, ligament, or tendon tear; crush or pinch; nerve damage; tendinitis; tenosynovitis; herniated disk; and spondylolysis.

Injuries Sustained

Body Part Injured. The body parts injured are shown in Table 4. Ankles were injured most often (12%, 39/338). Spotting or basing another cheerleader most frequently resulted in head injuries (11%, 13/115), followed by neck and knee injuries (10%, 12/115 each). Falls most often resulted in neck injuries (17%, 11/66).

Type of Injury. Types of injuries sustained are presented in Table 4. The 3 most common injuries were ankle strain or sprain (11%, 37/338), neck strain or sprain (7%, 23/338), and concussion or closed head injury (CHI) (6%, 22/338).

One cheerleader sustained a cervical vertebra fracture when she was dropped from the top of a pyramid while attempting a diamond (a hanging pyramid in which 2 partners are supported away from the cheering surface by holding onto the arms of a third partner in a shoulder stand; the shoulder-stand base supports the 2 suspended partners with his or her arms) during practice. The height from which she was dropped was not reported. The pyramid was being performed on a traditional foam floor, the coach was present and actively supervising the execution of the maneuver, and 3 spotters were actively spotting the cheerleader at the time of the injury event. There were no permanent sequelae (ie, no functional impairments). This injury can be categorized as a serious direct catastrophic injury based on the criteria specified by the National Center for Catastrophic Sports Injury Research[7] and is the only injury in our study meeting the Center's criteria for a catastrophic injury.

Approximately one-third of the strains and sprains (32%, 51/161) were sustained while the injured cheerleader was spotting or basing another cheerleader. A spotter is a person who is in direct contact with the performing surface and who may help to control the building of, or dismounting from, a stunt. A base is a person with at least 1 foot on the floor who is in direct, weight-bearing contact with the performing surface and who provides primary support for another person. Of these strains and sprains, the knee (10%, 11/115) and lower back (9%, 10/115) were most commonly injured. Ankle strains and sprains were most frequently associated with falls (15%, 10/66).

Although concussions and CHIs comprised only 6% of the stunt-related injuries, 22 of the 23 concussions and CHIs (96%) reported to Cheerleading RIO during the 1-year study period were associated with performing a stunt. Of these 22 concussions, 21 were new injuries, as opposed to reinjuries. The status of 1 concussion or CHI was unknown.

Stunt-related concussions and CHIs occurred during practices (82% [18/22], 0.04 injuries per 1000 AEs) and athletic events (18% [4/22], 0.05 injuries per 1000 AEs). The overall injury rate for stunt-related concussions and CHIs was 0.04 injuries per 1000 AEs. Cheerleaders on collegiate teams were more likely to sustain a concussion or CHI than were cheerleaders on other types of teams ($P = 0.02$, OR = 3.10, 95% CI = 1.20, 8.06). Factors associated with the 22 concussions and CHIs are summarized in Table 5.

Reinjuries. The majority of the stunt-related cheerleading injuries were new injuries (89%, 299/337). The previous injury was cheerleading related for 26 of the 38 (68%) reinjuries. Of these 26 reinjuries, the ankle was most often involved (23%, 6/26), followed by the lower back (19%, 5/26) and wrist (15%, 4/26). Most of the 26 reinjuries were sustained by cheerleaders on collegiate (38%, 10/26) and high school (38%, 10/26) teams, followed by cheerleaders on All Star (16%, 4/26), middle school (4%, 1/26), and recreation league (4%, 1/26) teams.

Multivariate Logistic Regression Model for Stunt-Related Injuries

Univariate Analysis. The following variables were significant at the $P \leq .2$ level, after adjusting for the correlations among athletes within teams using a cluster variable: type of event, presence of spotters, type of injury, number of times cheerleader had performed maneuver being attempted, surface on which the stunt was performed, and mechanism of injury. Age, height, weight, and body mass index of the injured cheerleader were also considered as possible predictors of stunt-related injuries

Table 5. Factors and Characteristics Associated With Concussions and Closed Head Injuries Sustained While Performing a Stunt

	n (%)
Team type	
All Star	1 (4.6)
Collegiate	11 (50.0)
High school	9 (40.9)
Middle school	0 (0.0)
Recreation league	1 (4.5)
Total	22 (100.0)
Type of event	
Practice	18 (81.8)
Athletic event	4 (18.2)
Total	22 (100.0)
Performing surface	
Artificial turf	1 (4.6)
Grass	6 (27.3)
Mat	3 (13.6)
Rubberized track	2 (9.1)
Spring floor	3 (13.6)
Traditional foam floor	6 (27.3)
Wood	1 (4.5)
Total	22 (100.0)
Maneuver attempted	
Cradle	9 (40.9)
Extension	1 (4.6)
Miscellaneous stunt[a]	1 (4.5)
Single-based stunt	2 (9.1)
Single-leg stunt	4 (18.2)
Stunt-cradle combo	4 (18.2)
Transition	1 (4.5)
Total	22 (100.0)
Mechanism of injury	
Contact with another cheerleader[b]	1 (4.6)
Failed to complete maneuver	7 (31.8)
Fall	5 (22.7)
Lost balance	1 (4.6)
Spotting or basing cheerleader	7 (31.8)
Twisted body part	1 (4.5)
Total	22 (100.0)
Time lost from cheerleading participation	
Resumed at next practice or performance	3 (13.6)
Did not continue for nonmedical reasons	1 (4.6)
2 d	2 (9.1)
3 d	3 (13.6)
4 d	1 (4.6)
5 d	1 (4.5)
7 d	7 (31.8)
10 d	2 (9.1)
14 d	2 (9.1)
Total	22 (100.0)

[a] Includes spotting or basing a stunt, bump down, chair, and helicopter.
[b] Includes collided with, kicked by, or stepped on by another cheerleader.

but were not linear in the logit. Natural logarithmic transformations of these variables were also not linear in the logit. Age was grouped into the following 4 categories, based on the age groups typically associated with different types of schools: 5 to 11 years (elementary school), 12 to 14 years (middle school), 15 to 17 years (high school), and 18 years and older (college). Age group was not significant in the univariate model. Concussion or CHI was nearly completely confounded with performing a stunt in the univariate model for type of injury (22 of the 23 concussions and CHIs occurred while performing a stunt); therefore, this type of injury was excluded from the multivariate models.

Multivariate Analysis. The final multivariate logistic regression model for stunt-related injuries is presented in Table 6. Variables included in this model were presence of spotters during execution of the stunt, type of injury sustained, and mechanism of injury. Stunt-related injuries were more likely to occur when spotters were present and actively spotting the execution of the maneuver ($P < .01$, OR = 5.04, 95% CI = 3.03, 8.40) than when no spotters were present. Compared with fractures and dislocations, cheerleaders were most likely to sustain a soft tissue injury (abrasion, contusion, hematoma, laceration, or puncture) while performing a stunt ($P < .01$, OR = 4.38, 95% CI = 1.98, 9.67). Stunt-related injuries were more likely to occur while the injured cheerleader was spotting or basing another cheerleader ($P < .01$, OR = 14.20, 95% CI = 5.20, 38.77) than when the injured cheerleader slipped or tripped, lost his or her balance, or had his or her arms or legs give way (''miscellaneous mechanisms of injury'') while performing a stunt. The interaction of the presence of spotters and mechanism of injury was not included in the model as a result of the collinearity of several categories of mechanism of injury with the presence of spotters.

Medical Treatment and Time Lost

Medical Treatment. Approximately one-third of the injured cheerleaders were treated at the scene (32%, 108/334), followed by treatment in a hospital emergency department (23%, 76/334), doctor's office (21%, 71/334), certified athletic trainer's office (19%, 63/334), and urgent care center (5%, 15/334). One cheerleader (0%, 1/334) was treated at a dentist's office. The location of medical treatment was unknown for 4 cheerleaders (1%, 4/338).

Time Lost. One-half of injured cheerleaders resumed participation in cheerleading at the next practice or performance (50%, 168/335). One cheerleader did not continue participating in cheerleading for nonmedical reasons, 1 was medically prohibited from participating in cheerleading for her entire career, and 8 were medically prohibited from participating in cheerleading for the remainder of the season. The amount of time lost was unknown for 3 cheerleaders. The remaining cheerleaders were medically prohibited from participating in cheerleading for a specified number of days (47%, 157/335). Total number of days of cheerleading participation lost by these 157 cheerleaders was 2218 (mean = 14 ± 17 days, minimum = 1 day, median = 7 days, maximum = 120 days, and mode = 7 days).

Admission to Hospital. Four cheerleaders were admitted to the hospital for treatment of their injuries (1.2%, 4/335). One All Star cheerleader sustained a torn anterior cruciate ligament when she fell 9 ft (2.74 m) onto a traditional foam floor while attempting a single-leg stunt (bow and arrow). One high school cheerleader sustained 2 herniated disks in her lower back when she failed to complete a cradle from an extended liberty while performing on a wood surface. One collegiate cheerleader sustained a neck strain or sprain while attempting a single-base stunt (toss hands) on a wrestling mat. The mechanism of injury was unknown for

Table 6. Multivariate Logistic Regression Model: Relationship of Outcome (Stunt-Related Injury or Non–Stunt-Related Injury) to Selected Independent Variables

Variable	Odds Ratio	95% Confidence Interval	Adjusted *P* Value[a]
Presence of spotters			
No	Reference		
Yes	5.04	3.03, 8.40	<.01
Type of injury			
Fracture or dislocation	Reference		
Strain or sprain	3.03	1.56, 5.89	<.01
Soft tissue injury[b]	4.38	1.98, 9.67	<.01
Other[c]	4.00	1.67, 9.56	<.01
Mechanism of injury			
Miscellaneous[d]	Reference		
Fall	9.32	3.55–24.47	<.01
Spotting or basing cheerleader[e]	14.20	5.20–38.77	<.01
Contact with another cheerleader[f]	9.31	3.29–26.34	<.01
Twisted body part	2.23	0.90–5.50	.40
Failed to complete maneuver	2.49	1.14–5.46	.11

[a] Adjusted for multiple comparisons.
[b] Includes abrasion, contusion, hematoma, laceration, and puncture.
[c] Includes dental injury; epistaxis; friction burn; foreign body; cartilage, ligament, or tendon tear; crush or pinch; nerve damage; tendinitis; tenosynovitis; herniated disk; and spondylolysis.
[d] Includes slipped or tripped, lost balance, and arms or legs gave way.
[e] Includes catching, lifting, or tossing cheerleader.
[f] Includes collided with, kicked by, or stepped on by another cheerleader.

this cheerleader. Another collegiate cheerleader dislocated her shoulder when she fell 5 ft (1.52 m) onto a wood surface while attempting a reverse fireman carry.

Surgery. Nine cheerleaders sustained injuries requiring surgery. These injuries included 3 torn anterior cruciate ligaments, 1 torn meniscus, 1 nasal laceration, 1 dental injury, 1 chin injury (not specified), 1 elbow dislocation, and 1 ankle fracture.

DISCUSSION

We are the first to describe the epidemiology of cheerleading stunt-related injuries. Stunt-related injuries comprised 60% (338/567) of the injuries sustained by US cheerleaders who participated in the 1-year study, and 22 of the 23 concussions and CHIs (96%) reported during the study were associated with stunts. Although concussions and CHIs only accounted for 4% (23/567) of the injuries reported during the study period and 6% (22/338) of the stunt-related injuries, they have the potential to be life threatening. Mild to moderate concussion has recently been recognized as an epidemic in sports and can affect the scholastic performance of young athletes.[8]

Schulz et al[5] reported that 6.3% of all injuries sustained by North Carolina high school competitive cheerleaders from 1996 to 1999 were concussions. This value is somewhat higher than the 4% we report for all types of cheerleaders and may reflect the increased difficulty of maneuvers performed by competitive cheerleaders. Football has the highest rate of concussions of all sports.[9–12] Among high school sports, football accounted for 63% (773) of the 1219 concussions reported for 10 sports during a 3-year study period; wrestling accounted for 10% (128); girls' soccer for 6% (76); girls' basketball for 5% (63); boys' basketball for 4% (51); softball for 2% (25); and baseball for 1% (15) of concussions.[9] In collegiate women's gymnastics, concussions represented 2.6% of all injuries reported during competition and 2.3% of all injuries reported during practice.[13]

Because collegiate athletes are more experienced than younger athletes and, in the case of cheerleading, perform more advanced stunts, it seems plausible that collegiate athletes are at greater risk for sustaining serious injuries. However, Gessel et al[11] found that the rate of concussions among high school athletes (8.9%) was greater than that among collegiate athletes (5.8%). Boden et al[14] noted that the number of catastrophic high school cheerleading-related injuries was greater than the number of catastrophic collegiate cheerleading-related injuries; however, the rate of catastrophic injuries per 100 000 cheerleaders was 5 times higher for collegiate cheerleaders than for high school cheerleaders. In the present study, collegiate cheerleaders sustained 50% (11/22) of the concussions and CHIs (2.0 per 10 000 AEs), whereas high school cheerleaders sustained 41% (9/22) of the concussions and CHIs (0.3 per 10 000 AEs). Further research is needed to evaluate the number, rate, and severity of injuries sustained by high school and collegiate athletes relative to the experience of the athletes and the difficulty of skills and maneuvers they perform.

Universal agreement is lacking with regard to the definition of a concussion and the grades of concussion.[10,15] Lack of recognition of concussion is a common problem,[10] and a concussion in an athlete may go untreated because few symptoms are visible to casual observers.[16] In addition, many athletes experience considerable emotional pressure to resume sport participation and may be reluctant to report symptoms of concussion to their coach, AT, or team physician.[16,17] More than 90% of concussive injuries are not associated with any loss of consciousness.[17] Changes in mental status may not be immediately apparent and may evolve over minutes or hours.[18] Many teams do not employ an AT or team physician who is on site for all practices, pep rallies,

athletic events, and cheerleading competitions. The lack of daily qualified medical coverage increases the likelihood that a concussion will remain unidentified, which could lead to more serious injury and a poor outcome.[19] Only 34% of the cheerleading teams in our study had a dedicated AT or team physician (or both), which may have resulted in underreporting of concussions. The National Athletic Trainers' Association[20] recommends that all secondary schools provide the services of a full-time, on-site AT to student-athletes and has published recommendations and guidelines[21] for the appropriate medical coverage of intercollegiate athletes. Providing the services of an AT to all cheerleading teams would ensure prompt identification and treatment of cheerleading-related injuries. Injured athletes who do not receive timely evaluation and treatment are at greater risk for improper healing, reinjury, extended time loss from athletic participation and school, and potentially life-threatening consequences.[22]

Collisions in all forms are a contributing factor for mild traumatic brain injury in sports.[9] In our study, contact with another cheerleader accounted for 15% (52/338) of stunt-related injuries and 5% (1/22) of concussions or CHIs sustained while performing a stunt. Contact with another cheerleader accounted for 25% of cheerleading-related injuries in a study by Schulz et al.[5]

In the present study, spotting or basing another cheerleader resulted in 115 of the 338 (34%) stunt-related injuries. This category also included catching, lifting, or tossing another cheerleader. These cheerleaders most frequently sustained head injuries (11%, 13/115), neck injuries (10%, 12/115), knee strains or sprains (10%, 11/115), and lower back strains or sprains (9%, 10/115). The head and neck injuries most likely resulted when the top cheerleader(s) fell onto the bottom cheerleader(s). Lower back strains and sprains may indicate improper lifting techniques. Knee strains and sprains may have occurred from loading or twisting the knee while trying to lift, toss, or catch the top cheerleader. Data in the literature regarding injuries to cheerleading spotters and bases are lacking; this issue should be further evaluated in future studies.

We suggest that spotters and bases focus on conditioning and strength-building training, as well as on proper lifting techniques. Cheerleading coaches should attend safety certification classes, such as those offered by the American Association of Cheerleading Coaches and Administrators (AACCA) and the National Council for Spirit Safety and Education (NCSSE), to learn proper techniques for teaching cheerleaders to perform stunts.[2] Newly certified coaches should work with experienced coaches when they first attempt to teach stunts to their cheerleaders.

One instance of a cradle being performed over a concrete surface was reported to Cheerleading RIO. The 2007–2008 AACCA College Cheerleading Safety Rules[23] state the following: "Technical skills should not be performed on concrete, asphalt, wet or uneven surfaces, or surfaces with obstructions." Although this rule was specifically written for collegiate cheerleaders, it should apply to cheerleaders on all types of teams. A fall onto a hard surface, such as concrete, could potentially result in a catastrophic injury. A full discussion of cheerleading fall-related injuries and the impact-absorbing capacity of various cheerleading surfaces is beyond the scope of this study.

This study has several limitations. First, we did not have a "free text" box on the injury-report form to allow reporters to write a detailed description of the injury event. Therefore, we may be missing important information about the mechanisms of injury. Second, because the teams participating in the study were not selected based on a probability sample, due to the lack of a comprehensive, authoritative list of all cheerleading teams in the United States, the study results may not be generalizable to all cheerleading teams in the United States.[2] Third, numerous cheerleading maneuvers are referred to by more than 1 name by different coaches, making categorization of the maneuvers difficult. We asked 3 experts from the cheerleading industry to help categorize the maneuvers reported to Cheerleading RIO. Fourth, some of the types of injuries listed in our *other* category possibly could have been included in the soft tissue injury category; however, categorization of injury type is subjective, and the number of *other* injuries was small. Therefore, moving some of them to the soft tissue injury category would not have changed our results. Finally, because cheerleading coaches in the United States are not required to maintain an injury log or submit injury reports to state agencies, a source for cross-checking the accuracy of the injury data reported to Cheerleading RIO was not available.[2] However, questionable data were verified by contacting the reporter. In most cases, the reporter was the team coach, and in some cases, the injured cheerleader provided additional information regarding the injury event.

In summary, this is the first study to describe the epidemiology of cheerleading stunt-related injuries. Stunt-related injuries accounted for 60% of the injuries sustained by US cheerleaders who participated in the 1-year Cheerleading RIO study and 96% of the concussions and CHIs (22/23) reported during this study.

Performing stunts poses an increased risk of injury to cheerleaders, and additional steps should be taken to minimize this risk. Stunts should never be performed over hard surfaces, such as concrete or asphalt. We suggest that spotters and bases focus on conditioning and strength-building training, as well as on proper lifting techniques, to decrease the risk of injury while lifting, tossing, and catching other cheerleaders. The services of an AT should be provided for all cheerleading teams. Coaches, ATs, cheerleaders, and parents should be educated about the signs and symptoms of concussion, and cheerleaders should be encouraged to inform the coach, AT, or team physician immediately if they experience any of these symptoms or observe a teammate experiencing these symptoms. Cheerleading coaches should complete coaches' safety certification programs, such as those offered by AACCA and NCSSE, before being allowed to coach a cheerleading team. Newly certified coaches should work with experienced coaches when they first start teaching stunts to cheerleaders.

ACKNOWLEDGMENTS

Funding for this study was provided by the Research Institute at Nationwide Children's Hospital. Debbie Bracewell, Lisa Thompson, and Steve Wedge helped to categorize the cheerleading maneuvers.

REFERENCES

1. Giannone L, Williamson TL. A philosophy of safety awareness. In: George GS, ed. *American Association of Cheerleading Coaches and Administrators Cheerleading Safety Manual*. Memphis, TN: UCA Publications Department; 2006:1–4.
2. Shields BJ, Smith GA. Cheerleading-related injuries in the United States: a prospective surveillance study. *J Athl Train*. 2009;44(6): 567–577.
3. Hutchinson MR. Cheerleading injuries: patterns, prevention, case reports. *Physician Sportsmed*. 1997;25(9):83–96.
4. Shields BJ, Smith GA. Cheerleading-related injuries to children 5 to 18 years of age: United States, 1990–2002. *Pediatrics*. 2006;117(1): 122–129.
5. Schulz MR, Marshall SW, Yang J, Mueller FO, Weaver NL, Bowling JM. A prospective cohort study of injury incidence and risk factors in North Carolina high school competitive cheerleaders. *Am J Sports Med*. 2004;32(2):396–405.
6. Jacobson BH, Hubbard M, Redus B, et al. An assessment of high school cheerleading: injury distribution, frequency, and associated factors. *J Orthop Sports Phys Ther*. 2004;34(5):261–265.
7. Mueller FO, Cantu RC. National Center for Catastrophic Sports Injury Research: twenty-fourth annual report, fall 1982–spring 2006. http://www.unc.edu/depts/nccsi/AllSport.htm. Accessed April 24, 2008.
8. Proctor MR, Cantu RC. Head and neck injuries in young athletes. *Clin Sports Med*. 2000;19(4):693–715.
9. Powell JW, Barber-Foss KD. Traumatic brain injury in high school athletes. *JAMA*. 1999;282(10):958–963.
10. Buzzini SRR, Guskiewicz KM. Sport-related concussion in the young athlete. *Curr Opin Pediatr*. 2006;18(4):376–382.
11. Gessel LM, Fields SK, Collins CL, Dick RW, Comstock RD. Concussions among United States high school and collegiate athletes. *J Athl Train*. 2007;42(4):495–503.
12. Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: summary and recommendations for injury prevention initiatives. *J Athl Train*. 2007;42(2):311–319.
13. Marshall SW, Covassin T, Dick R, Nassar LG, Agel J. Descriptive epidemiology of collegiate women's gymnastics injuries: National Collegiate Athletic Association Injury Surveillance System, 1988–1989 through 2003–2004. *J Athl Train*. 2007;42(2):234–240.
14. Boden BP, Tacchetti R, Mueller FO. Catastrophic cheerleading injuries. *Am J Sports Med*. 2003;31(6):881–888.
15. Cantu RC. Return to play guidelines after a head injury. *Clin Sports Med*. 1998;17(1):45–60.
16. Kushner DS. Concussion in sports: minimizing the risk for complications. *Am Fam Physician*. 2001;64(6):1007–1014.
17. Cobb S, Battin B. Second-impact syndrome. *J School Nurs*. 2004; 20(5):262–267.
18. Lovell MR, Collins MW, Iverson GL, Johnston KM, Bradley JP. Grade 1 or "ding" concussions in high school athletes. *Am J Sports Med*. 2004;32(5):47–54.
19. Cantu RC. Recurrent athletic head injury: risks and when to retire. *Clin Sports Med*. 2003;22(3):593–603.
20. National Athletic Trainers' Association. Secondary school official statement. http://www.nata.org/statements/official/secondaryschool.pdf. Accessed October 7, 2008.
21. National Athletic Trainers' Association. Recommendations and guidelines for appropriate medical coverage of intercollegiate athletics. Revised June 2007. http://www.nata.org/statements/support/AMCIARecsandGuides.pdf. Accessed October 7, 2008.
22. National Athletic Trainers' Association. Appropriate medical care for the secondary school-age athlete communication. 2004. http://www.nata.org/statements/support/secondary_school_medcarecommunication.pdf. Accessed October 10, 2008.
23. American Association of Cheerleading Coaches and Administrators. 2007–2008 AACCA college cheerleading safety rules. http://www.aacca.org/collegesafety.asp. Accessed June 16, 2008.

Brenda J. Shields, MS, contributed to conception and design; acquisition and analysis and interpretation of the data; and drafting, critical revision, and final approval of the article. Soledad A. Fernandez, PhD, contributed to conception and design, analysis and interpretation of the data, and critical revision and final approval of the article. Gary A. Smith, MD, DrPH, contributed to conception and design and critical revision and final approval of the article.

Address correspondence to Brenda J. Shields, MS, Center for Injury Research and Policy, The Research Institute at Nationwide Children's Hospital, 700 Children's Drive, Columbus, OH 43205. Address e-mail to brenda.shields@nationwidechildrens.org.