A Prospective Cohort Study of Injury Incidence and Risk Factors in North Carolina High School Competitive Cheerleaders

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Abstract:

Background: Cheerleaders suffer nearly half of catastrophic injuries observed in female scholastic athletes in the United States. However, incidence of noncatastrophic injury in this population has not been described.
Hypothesis: Coach, athlete, and injury circumstance variables may predict the injury rate among cheerleaders.
Study Design: Prospective cohort.
***Methods*:** The authors investigated injury incidence in a sample of North Carolina female cheerleaders who competed interscholastically from 1996 to 1999. Injury, exposure, and demographic data were collected from squads that participated in the North Carolina High School Athletic Injury Study.
Results: Cheerleaders suffered 133 injuries during 1701 athlete seasons. More than 21 % of the injuries were ankle sprains. The injury rate was 8.7; the 95% confidence interval (CI) was 6.5 to 11.7 per 10,000 athlete exposures. In a multivariate Poisson regression model, cheerleaders supervised by coaches with the most education, qualifications, and training (coach EQT) had a nearly 50% reduction in injury risk (rate ratio [RR], 0.5; 95% CI, 0.3-0.9), and cheerleaders supervised by coaches with medium coach EQT had a nearly 40% reduction in injury risk (RR = 0.6; 95% CI, 0.3-1.2) compared to cheerleaders supervised by coaches with low coach EQT.
Keywords: athletic injuries; epidemiology; cheerleading; risk; Poisson regression

Article:

Over the past 20 years, the athleticism involved in cheerleading has increased dramatically. Cheerleading has evolved from service-oriented cheering on the sideline of other sports to a highly skilled athletic competition in its own right.[9] Today, cheerleading includes 3 interrelated forms: sideline spirit raising, halftime or pregame entertainment, and competition held separately from games.[24]

Ranked by number of participants at the high school level, competitive cheerleading is the ninth most popular sport for girls, nationally.[23] For the 2000-2001 school year, 29 states sponsored competitive cheerleading as an interscholastic sport, and an estimated 88,561 girls competed in interscholastic cheering competitions.[23]

As the sport has evolved, so have its safety training and regulations. The American Association of Cheerleading Coaches and Advisors (AACCA) has initiated a safety certification program that as of 1999 had been adopted by the state of Vermont and the following National Collegiate Athletic Association athletic conferences: the Big Ten, Southwest, Southeast, and the Western Athletic Conferences.[21] In 1990, the AACCA released a comprehensive cheerleading safety manual.[7] The Illinois State High School Association has also addressed cheerleader safety by banning the basket toss and pyramid formations higher than 2 levels.[21] To date, these injury prevention interventions have not been guided by epidemiologic studies that have identified risk factors for cheerleader injuries.

Studies and reviews of injuries in other sports have suggested possible risk factors such as age; grade in school and size of competition[16]; sex; out-of-control play and awkward landings[11]; extreme body weight, height, or

height-weight combinations[18]; and the training, qualifications, and experience of coaches.[15,17,19,30] However, one should be cautious about assuming these results apply to cheerleading because multisport studies consistently identify sport (ie, the unique characteristics that define each sport) as one of the strongest predictors of sport-related injuries.[6,20,25]

The elevation of cheerleading to skilled athletic competition has brought with it an increase in the absolute number of injuries. The number of emergency department visits attributed to cheerleading injuries increased more than 3-fold between 1980 and 1994, from 4954 to 16 ,000.[21] Nearly 50% of all catastrophic injuries (injuries resulting in death or permanent or partial disability) suffered by high school female athletes during competitions between 1980 and 1998 occurred during participation in cheerleading.[21] It appears that a major factor in the increase of catastrophic injuries to female athletes since the early 1980s has been the addition of gymnastic-type stunts to cheerleading activities. Even though both the overall number of injuries and the number of competitive cheerleaders is rising, there is little information about the type of injuries cheerleaders are incurring and whether the rate of cheer-leader injuries (as opposed to the absolute number of injuries) is rising or falling. It is also unknown how the cheerleader injury rate compares to injury rates for other interscholastic sports.

Given the changes in the nature of cheerleading, its popularity, and the injury prevention interventions being undertaken in the sport, it is essential that cheerleading injuries and injury rates be described and risk factors quantified. The purpose of this article is to describe the incidence and severity of cheerleading injuries and identify some of the athlete-level, coach-level, and injury circum-stance variables that best predict the cheerleader injury rate among a sample of 1675 North Carolina female high school cheerleaders who competed between 1996 and 1999.

MATERIALS AND METHODS

Sample Selection

These data were collected as part of the North Carolina High School Athletic Injury Study (NCHSAIS), a prospective cohort study of the injury experience of North Carolina high school athletes between 1996 and 1999. The current study included data on all the activities of 44 cheerleading squads that participated in organized interscholastic cheerleading competition—practice, sideline cheering, pregame and halftime entertainment, and com-petition. The sample was selected using a 2-stage stratified cluster sampling design. In the first stage of sampling, 100 schools were selected from among the 324 high schools that were members of the North Carolina High School Athletic Association (NCHSAA). In the second stage, 6 sports per school were randomly selected from the list of sports offered at each participating school. All of the athletes from the selected teams were included in the sample. Weaver et al[32] described the selection and recruitment of the study population in detail.

Response Rates and Data Quality

At the school level, participation was achieved for 91 of 100 schools. At the sport level, the response rate was 76.7%; and at the athlete level, participation was 75.5%.[32] The sampling probabilities and data on nonresponse at the first and second levels were used to construct sampling weights for the purpose of estimating incidence for the population of cheerleaders in all NCHSAA high schools in North Carolina. Concerning the quality of the reported data, the biggest problem was incomplete reporting of athlete participation. Project staff made use of the reported participation information and supplemented the reported information by contacting the school to obtain information on season, game, and practice times and notable absences. To ensure validity of the injury data, any school reporting 0 injuries for a sport was contacted to confirm that this was not an oversight in reporting.

Injury Definition

A reportable injury was defined as one that occurred as a result of participation in varsity high school cheerleading and either limited the student's full participation in cheer-leading the day following the injury or required medical attention by an athletic trainer, physician, nurse, EMT, emergency department personnel,

physical therapist, dentist, or other health professional. In addition, all brain concussions, nerve injuries, eye injuries, and fractures were reportable injuries even if they did not limit the athlete's full participation in his or her sport for even a day.

Questionnaires

The selected varsity cheerleaders were followed for 3 years. One contact person at each school, either an athletic trainer or athletic director, had ultimate responsibility for ensuring the timely and accurate completion of injury reports, baseline assessments, and participation data.

Each varsity cheerleader completed a baseline demo-graphic form at the beginning of each season. The form requested information regarding grade in school, weight, height, sex, and previous injury experience (regardless of whether the injury was cheerleading related). There were only 16 male cheerleaders in the NCHSAIS, and they were thought to perform different activities than the females. Consequently, the 16 male cheerleaders are not included in these analyses. Each head coach also completed a demo-graphic form that asked for information about sex, coaching experience, coaching training (but not specifically the AACCA safety training), highest level of education completed, and interscholastic and college cheerleading experience.

An injury report form requested information on injury circumstances such as whether the injury occurred during a game or practice, the length of time the injury kept the athlete from fully participating in cheerleading, medical attention required by the injured cheerleader, type of injury, body part injured, cheerleader's and squad's activity at the time of injury, where the injury occurred, and the contact proximate to the injury. Multiple injuries could be reported per injury event.

All the injuries reported here occurred during organized cheerleading competitions or practices. To document expo-sure to games or practices, participation forms similar to attendance sheets were completed for each team. This information was used to quantify the cheerleader's participation on a squad in terms of practice exposures (1 practice exposure equaled 1 cheerleader participating in 1 practice), game exposures (1 game exposure equaled 1 cheerleader participating in either a cheerleading inter-scholastic competition or cheering for her school at a com-petition for another sport), and athlete exposures (the sum of game exposures and practice exposures).

Data Analysis

North Carolina cheerleading events occur in all 3 athletic seasons (fall, winter, spring). For the purposes of this study, the regular cheerleading season was defined to be the fall athletic season (mid-August to mid-November). Injury rate models were limited to preseason and fall. However, all injuries (preseason, fall, and the remainder of the school year) were examined when the proportion of injuries associated with different injury event activities was tabulated.

Because cheerleaders could have more than 1 injury per season or even in a single-injury event, and because the study followed cheerleading squads for 3 years, there were multiple observations (athlete seasons) for many cheer-leaders. Consequently, a longitudinal data set was constructed that included between 1 and 3 athlete seasons for each cheerleader. The longitudinal data were summarized across cheerleader, school year, and athletic season to tabulate multiple injuries to a single cheerleader within an athletic season.

The cheerleading injury rate and unadjusted relative risks for the athlete-level, coach-level, injury-event-level, and 1 school-level variables were estimated using Poisson regression models of the injury rate. The 1 school-level variable was school size (based on the school size categories the NCHSAA uses to subdivide schools for state championship competition). The NCHSAA defines school size based on attendance figures. At the time of the study, class 4A included schools with attendance of 1314 to 2600 students. The attendance ranges for the other classes were the following: class 3A, 967 to 1308; class 2A, 668 to 957; and class 1A, more than 668. The school size variable was included as a crude proxy for the availability of athletic facilities. For the purposes of multivariate adjustment, a Poisson regression model was developed that included the variables that were most

strongly associated with the injury rate in bivariate analyses. Strength of association was evaluated by examining both the size of the rate ratio (RR) and its precision, which was evaluated by examining the 95% confidence interval (CI). Athlete characteristics included in the model were a cheerleader's history of previous injuries (yes/no) and body mass index (BMI), whereas coach-level variables included years of cheerleading coaching experience, whether the coach had completed a coaching training class, and highest level of education attained. The idea that highest level of education attained measures one's level of responsibility was the rationale for including it as a predictor variable.

Because the 3 coach-level variables were highly associated with one another, it was decided to combine them into a single index—coach experience, qualifications, and training (coach EQT)—for the multivariate model. Coach EQT was defined as a sum of 3 dichotomous coach variables, 1 or more years of experience coaching cheerleading (yes/no), whether the coach had completed a coaching class (yes/no), and whether the coach had a college degree (yes/no). Coach EQT was categorized as low if this EQT sum equaled 0 or 1 (5.8% of head coaching), medium if EQT = 2 (61.5% of head coaching), and high if EQT = 3 (32.7% of head coaching).

The objective of the Poisson regression model was to describe the cheerleading injury rate as a function of the covariates while accounting for these correlations between observations for a given athlete. Because athletes were clustered by school and team when selected for the study, the observations in the analysis (athlete seasons) were correlated. SUDAAN version 8. 01[27] was used to fit the model as it correctly calculates standard errors for clustered survey data with sampling weights.

RESULTS

A total of 1675 athletes (582 in 1996-1997, 556 in 1997- 1998, and 537 in 1998-1999) were followed for 1701 athlete seasons in the 3-year study period. Based on these data, we estimate there were 1115 cheerleader injuries statewide in North Carolina over the 3-year period, or 372 annually. Fifty-one and nine tenths percent of the injuries occurred during the regular season (fall athletic season), 3.0% occurred during the preseason, and 45.1% occurred during the postseason. The percentage of postseason injuries was large because North Carolina does not have a defined competitive cheerleading season, and many of the teams selected for the study reported injuries long after the NCHSAA fall athletic season ended.

Incidence

Even though cheerleading is a noncontact sport, 43.5% of injuries kept the cheerleader out of full participation in her sport for a week or more (Table 1), and 28.3% of cheerleader injuries resulted in a visit to an emergency department (Table 2). However, none of the injuries were catastrophic.

TABLE 1
Time Away From Full Participation After Cheerleading Injury: North Carolina High School Athletic Injury Study 1996 to 1999; n[a] = 133, N[b] = 1115

	Injuries	
Time Away From Participation	(N[b])	%[b]
No lost time	24	2.1
Part of a session	234	21.0
All of a session	70	6.3
1-2 days	130	11.7
3-6 days	138	12.4
1 week	78	7.0
1-3 weeks	251	22.6
>3 weeks	156	14.0
Unknown	34	3.1

[a] Number of cheerleading injuries.
[b] Weighted number or proportion of cheerleading injuries.

TABLE 2
Medical Attention[a] Received by Injured Female Cheerleaders, North Carolina High School Athletic Injury Study 1996 to 1999; n[b] = 133, N[c] = 1115

Treatment	Injuries (N[c])	Injuries %[c]
By school medical staff	585	52.4
Visited doctor's office	470	42.1
Visited emergency department	315	28.3
Hospital admission	28	2.5
Surgery	29	2.6
Rehabilitation	116	10.5

[a] The categories of medical attention are not mutually exclusive.
[b] Number of cheerleading injuries.
[c] Weighted number or proportion of cheerleading injuries.

Several common characteristics of the injury events were identified (Table 3). Nearly 60% of the injuries occurred in the gym. The cheerleading squad's activity at the time of the injury was either a partner stunt or a pyramid in 620 (55.7%) of the injuries. This proportion only increased slightly when subsets of more serious injuries were evaluated (59.4% for those requiring more than a week away from full participation or a trip to the emergency department or more serious treatment and 62.7% for those requiring more than 3 weeks away from full participation or a trip to the emergency department or more serious treatment). During stunts, injuries occurred in similar frequency to the base person and the top person (14.9% versus 15.5%). However, this equality may be more apparent than real because at least in pyramids there are more cheerleaders at the base than at the top. The most common mechanisms of injury for cheerleaders were falls from heights (25.3%) and contact with another cheerleader (25.3%).

TABLE 3
Distribution of Female Cheerleading Injuries by Characteristics of Injury Event, North Carolina High School Athletic Injury Study 1996 to 1999; n[a] = 133, N[b] = 1115

Location on Playing Field	N[b]	%[b]	Team's Activity at Time of Injury	N[b]	%[b]	Player's Activity at Time of Injury	N[b]	%[b]	Contact Proximate to Injury	N[b]	%[b]
Gym	663	59.4	Partner stunt	304	27.3	Base person in stunt	166	14.9	With another cheerleader	283	25.3
Inside (not gym)	78	7.0	Team cheer	278	25.0	Top person in stunt	173	4.5	With member of other sports team	15.5	51
Outdoor field	215	19.3	Pyramid: 2 tier	267	24.0	Dismounting	113	10.2	With object in environment	21	1.9
Outdoor track	77	6.9	Pyramid: 3 tier	49	4.4	Climbing	19	1.7	Fell from height	282	25.3
Outside, other	31	2.8	Dancing	25	2.2	Jumping	133	12.0	Fell on by other person	76	6.9
Practice area not specified	52	4.7	Warm-up	44	3.9	Tumbling	121	10.9	Fell from standing	6	0.6
Practice, not specified	39	3.5	Lifting	65	5.8	Slipped/tripped	58	5.2			
			Unknown	108	9.7	Spotting	88	7.9	Landed wrong when tumbling	157	14.1
						Cheering	96	8.6	Heat illness	20	1.8
						Dancing	18	1.6	Overuse injury	54	4.9
						Warm-up	32	2.9	Landed wrong from jump	46	4.1
									Dancing	18	1.6
						Unknown	90	8.1	Unknown	44	4.0

[a] Number of cheerleading injuries.
[b] Weighted number or proportion of cheerleading injuries.

Sprains and strains (48.3%) were the most common type of injury, and there were 193 (17.3%) fractures, including stress fractures (Table 4). The most common body part injured was the ankle (23.6%) followed by the knee (10.7%) (Table 5). A total of 23 1, more than 2 1% of all injuries, were ankle sprains.

TABLE 4
Female Cheerleader Injuries by Type of Injury, North Carolina High School Athletic Injury Study 1996 to 1999; n[a] = 133, N[b] = 1115

Type of Injury	Injuries (N[b])	Injuries %[b]
Abrasion/contusion	135	12.1
Laceration/puncture	43	3.8
Sprain	367	32.9
Strain	172	15.4
Dislocation	24	2.2
Fracture/stress fracture	193	17.3
Heat exhaustion	20	1.8
Concussion	70	6.3
Hemorrhage	12	1.1
Overuse injury	56	5.1
Other	23	2.1

[a] Number of cheerleading injuries.
[b] Weighted number or proportion of cheerleading injuries.

TABLE 5
Female Cheerleader Injuries by Body Part Injured, North Carolina High School Athletic Injury Study 1996 to 1999; n[a] = 133, N[b] = 1115

Body Part	Injuries (N[b])	Injuries %[b]
Eye, ear, nose, face	60	5.4
Teeth, tongue, mouth	44	4.0
Head and brain	90	8.0
Neck	37	3.3
Shoulder	44	3.9
Upper arm and elbow	51	4.6
Forearm and wrist	79	7.1
Hand, thumb, fingers	76	6.8
Spinal column and cord	29	2.6
Back	87	7.8
Pelvis, hip, groin, upper leg	41	3.6
Knee	119	10.7
Ankle	263	23.6
Lower leg	20	1.8
Foot and toes	64	5.8
Other	12	1.0

[a] Number of cheerleading injuries.
[b] Weighted number or proportion of cheerleading injuries.

Injury Rate and Poisson Regression Models

All the Poisson regression models were restricted to data from the preseason and the regular season (fall athletic season for the purpose of this study) because postseason exposure was not reliably estimated. Seventy-three injuries occurred during the preseason and regular season, and the cheerleader injury rate was 8.70 (95% CI, 6.46- 11.71 per 10,000 athlete exposures) (Table 6).

Initially, we examined the unadjusted effect of the predictor variables on the cheerleader injury rate (Table 7). Having a coach with scholastic cheerleading coaching experience and having a coach who had completed a training class on coaching in general (as opposed to coaching cheerleading specifically) were each inversely associated with the injury rate, as was having a BMI in the top 20% of all cheerleaders. Cheerleaders who had suffered previous sports or nonsports injuries were at an elevated risk of injury, and having a coach with only a high school degree was a moderate risk factor. All 5 of these variables exhibited some signs of a threshold effect (risk increased or decreased then remained at that plateau with each increment of risk factor). Having 1, 2, or 3 previous injuries each resulted in slightly more than a 2-fold increased risk of injury. Although both school size and grade in school appeared to be inconsistent and weak predictors of the injury rate, they both exhibited slight signs of threshold effects with class 1A schools (enrollment <668) and seniors being associated with higher injury rates.

The game injury rate was only slighter greater than the practice injury rate (RR = 1.03; 95% CI, 0.59-1.78), and the regular season rate was nearly identical to the preseason rate. Similarly, sex of coach and the high school and college cheering experience of the coach appeared to have little influence on the injury rate.

Before constructing a multivariate Poisson regression model of the cheerleader injury rate, we recoded the variables that exhibited signs of threshold effects—previous injuries, BMI, grade in school, school size, coach training, and interscholastic cheerleading coaching experience—as dichotomous variables. We also combined 3 coach-level variables (as described in the Methods section) to create a single variable—coach EQT—that

measured the education, qualifications, and training of the coach. As expected, the new composite variable, coach EQT, was inversely associated with the cheerleader injury rate. Cheerleaders over-seen by a coach with a high coach EQT had more than a 50% reduction in injury risk (RR = 0.48; 95% CI, 0.31-0.75), and cheerleaders supervised by coaches with medium coach EQT had a 33% reduction in injury risk (RR = 0.66; 95% CI, 0.42-1.01) compared to cheerleaders supervised by a coach with a low coach EQT (Table 6).

TABLE 6
Poisson Regression Models of Injury Rate[a] for Preseason and Regular Season Among 1675 North Carolina High School Female Cheerleaders, 1996 to 1999

Exposure	Unadjusted RR[b]	95% CI[c]	Multivariate Adjusted RR[b]	95% CI[c]
Athlete-level variables				
Injury history				
No history of injuries	1.0	Ref	1.0	Ref
1 or more previous injuries	2.2	1.1-4.7	2.0	0.8-4.7
BMI				
Lowest 80% of BMIs	1.0	Ref	1.0	Ref
Highest 20% of BMIs	0.3	0.1-1.0	0.4	0.1-1.4
Grade				
Seniors	1.0	Ref		
Ninth-graders/juniors	0.7	0.4-1.4		
School level variables				
Class 4A-2A (668-2600 students)		1.0	Ref	
Class 1A (<668 students)	1.4	0.7-2.6		
Head-coach-level variables				
College degree				
Yes	1.0	Ref		
No	1.5	1.0-2.3		
Coaching class completed				
No	1.0	Ref		
Yes	0.7	0.4-1.1		
High school cheerleading coaching experience				
No	1.0	Ref		
Yes	0.6	0.4-1.0		
Coach education, qualifications, and training[d]				
Low	1.0	Ref	1.0	Ref
Medium	0.7	0.4-1.0	0.6	0.3-1.2
High	0.5	0.3-0.8	0.5	0.3-0.9

[a] The cheerleader injury rate was 8.70; 95% confidence interval was 6.46-11.71 per 10,000 athlete exposures.
[b] RR, Rate ratio.
[c] CI, Confidence interval.
[d] Quality of coach is defined based on the following 3 dichotomous variables: 1 or more years experience coaching cheerleading (yes/no), whether the coach had completed a coaching class (yes/no), and whether the coach has a college degree (yes/no). A below-average coach has at most 1 "yes." An average coach has 2 affirmatives, and an above-average coach meets all 3 criteria.

As described in the Methods section, only those variables strongly associated with the risk of injury were entered into the multivariate model. These were coach EQT (3 levels), BMI (largest 20% versus the rest), and injury history (yes/no). When coach EQT was examined in the multivariate model, it remained protective. Cheerleaders supervised by coaches with the highest level of EQT still had a nearly 50% reduction in injury risk (RR = 0.52; 95% CI, 0.29-0.94), and cheerleaders supervised by coaches with medium coach EQT had a nearly 40% reduction in injury risk (RR = 0.61; 95% CI, 0.32-1.16) compared to cheerleaders supervised by coaches

with low coach EQT (Table 6). The protective effect of high coach EQT relative to low coach EQT remained strong (still approximately 50% reduced injury risk) when the dichotomous variables for school size and grade in school were added to the model (results not shown). Athletes with a prior self-reported history of injury had twice the risk of injury of athletes with no prior injuries. Athletes in the upper quintile of BMI were at 60%.

TABLE 7
Unadjusted Poisson Regression Models of Injury Rate, for Preseason and Regular Season

Exposure	Unadjusted RR[a]	95% CI[b]
Injury-event-level variables		
Preseason	1.0	Ref
Regular season	1.0	0.3-3.9
Practice	1.0	Ref
Game	1.0	0.6-1.8
Athlete-level variables		
Injury history		
No history of injuries	1.0	Ref
1 previous injury	2.1	0.9-4.9
2 previous injuries	2.3	1.0-5.3
3 or more previous injuries	2.4	1.1-5.6
BMI		
13.9 ≤ BMI < 18.6 (bottom quintile)	1.0	Ref
18.6 ≤ BMI < 19.7 (2nd quintile)	1.0	0.3-2.7
19.7 ≤ BMI < 20.8 (3rd quintile)	1.5	0.5-4.0
20.8 ≤ BMI < 22.1 (4th quintile)	1.4	0.7-3.0
22.1 ≤ BMI < 39.1 (top quintile)	0.3	0.1-1.4
Grade		
Seniors	1.0	Ref
Juniors	0.7	0.4-1.4
Sophomores	0.8	0.3-2.0
Ninth graders	0.8	0.2-2.6
School-level variables		
Class 4A (1314-2600 students)	1.0	Ref
Class 3A (967-1308 students)	0.7	0.3-1.8
Class 2A (668-957 students)	1.0	0.5-2.3
Class 1A (<668 students)	1.3	0.5-3.1
Head-coach-level variables		
Gender		
Female	1.0	Ref
Male	0.9	0.6-1.5
Education		
Any college degree	1.0	Ref
High school diploma (only)	1.5	1.0-2.3
Training: coaching class completed		
No	1.0	Ref
Yes, continuing education	0.7	0.3-1.6
Yes, American Sport Education Program course	0.5	0.1-2.7
Yes, college course	0.8	0.5-1.3
High school cheerleading coaching experience		
None	1.0	Ref
1-2 years	0.7	0.4-1.3
3-6 years	0.6	0.3-1.2
>6 years	0.5	0.2-0.8
High school cheerleading experience		
None	1.0	Ref
1 year	0.4	0.1-2.5
2 years	1.2	0.5-2.9
3 years	1.5	0.7-3.0
4 years	0.9	0.5-1.5
College cheerleading experience		
No	1.0	Ref
Yes	0.8	0.2-2.8

[a] RR, Rate ratio.
[b] CI, Confidence interval; Ref, reference category.

DISCUSSION

The competitive North Carolina high school cheerleaders in this study had a relatively low injury rate of 8.70 (95% CI, 6.46-11.71) per 10,000 athlete exposures compared to injury rates of other female and male high school sports. The cheerleading injury rate in the current study was the lowest of the 12 sports included in the NCHSAIS.[20] The only sports that had similarly low injury rates were volleyball (a sport limited to females in North Carolina high schools) and boys' track. In addition to having a low injury rate, most of the cheerleader injuries in the current study were not serious. The majority of the injuries (53.4%) limited the cheerleader's participation in her sport for less than a week, and more than 20% of all injuries were ankle sprains.

No catastrophic injuries were observed even though the study monitored the injury experience of 1675 cheerleaders participating on 44 high school squads. The absence of catastrophic injuries is not too surprising because even though cheerleaders have suffered nearly half of the catastrophic sports injuries among female high school athletes over the past 20 years in the United States, [21] more than 88,000 girls competed in interscholastic cheering competitions in the 2000-2001 school year, and no more than 3 catastrophic injuries have ever been documented among high school cheerleaders in a single academic year. Cheerleading suffers more catastrophic injuries per participant than other female high school sports. However, far fewer catastrophic injuries are documented per high school cheer-leader than per high school football player. [21,23]

Finally, supervision provided by more experienced, trained, and qualified coaches had a protective effect. Lower injury rates were found among cheerleaders supervised by more experienced, trained, and qualified coaches even when the injury rate was adjusted for the cheerleaders' injury history and BMI.

Strengths and Limitations

This study is the first time the injuries and injury rate of a randomly selected population of female competitive high school cheerleaders have been described. Previous articles have been limited to the enumeration of injuries reported to emergency departments, [3,4,12,13,21] the enumeration and description of catastrophic injuries,[3,21] or the enumeration and description of convenience samples.[1,14]

Male cheerleaders were not described in the current study because there were only 16 male cheerleaders in the NCHSAIS and their activities were expected to differ from those of the females.[13] Injuries that occurred during the winter sport season were not included in models of the cheerleading injury rate to limit the possibility of selection bias associated with which schools completed data collection after the fall season. Winter and spring season data were supplied voluntarily by less than half of the study schools, and we feared that those reporting were not representative of all the cheerleaders in the study. Because cheerleading lacks a competitive season that is consistently defined across the United States, investigators will need to be careful when comparing the injury rates from this study to future work, particularly if the injury rates are expressed in terms of injuries per athlete season. If, as in this analysis, the injury rate is expressed as injuries per athlete exposure, rates should be comparable between studies unless cheerleaders suffer a higher injury rate toward the end of a long season or the injury rate for cheerleaders varies according to athletic season because cheerleading activities, locations, or facilities vary with athletic season. One might expect injury rates to be higher in winter because of increased exposure to hard gym floor surfaces. On the other hand, one might expect higher injury rates to occur during fall because of greater exposure to uneven surfaces outside.

All the squads included in the study population engaged in competitive cheerleading, but the study did not estimate the percentage of the cheerleader's participation that was competitive cheerleading versus the percentage of participation that was spirit raising and pregame and half-time entertainment, the other 2 basic forms of cheerleading. As with studies of any sport, it is difficult to collect specific participation data that allow for calculation of rates by injury event strata more complex than practice and game events. However, collecting cheerleading exposure information by the categories of competitive cheerleading, spirit raising, and half-time and pre-game entertainment should be a priority for future research to better focus prevention.

Being situated within the NCHSAIS, a study of athletic injuries among North Carolina high school athletes was both a strength and a weakness for this study. It was a strength because it enabled valid comparisons of the cheerleading injury rate to injury rates for other high school sports. The comparisons of the current study's cheerleading injury rate to injury rates of the other 11 sports in the NCHSAIS are likely to be more valid than comparisons of the current study's cheerleading injury rate with injury rates of high school sports from other studies because data collection was done by the same personnel, using the same questions and injury definition. Being situated within the NCHSAIS was a weakness because some of the standardization that makes such a large study cost efficient resulted in unique aspects of cheerleading, such as the length of the cheerleading season and the importance of spotting, being overlooked.

Significance of Findings

Powell and Barber-Foss[25] have previously reported on high school injury rates. Although they did not include cheerleading, all 10 sport-specific high school athletic injury rates reported by Powell and Barber-Foss[25] were greater than the cheerleading injury rate in the current study. Volleyball, with an injury rate of 17 per 10,000 athlete exposures, was the only sport in the Powell and Barber-Foss study with an injury rate similar to the cheerleading injury rate in the current study.

Since the 1940s, authors have argued that coaches are a key figure in preventing injuries.[10,14,15,26,28,29,31] However, this study is the first to statistically investigate the relationship between the experience, qualifications,

and training of cheerleading coaches and cheerleader injury rates and show a protective effect associated with coaches with higher levels of experience, training, and education.

Because of the gymnastic element involved in cheerleading, one might expect cheerleading injury experience to be similar to that of girls' high school gymnastics. However, Garrick and Recqua[5,6] found the injury rate (per athlete season) for girls' gymnastics to be on the high end of the injury rates among the 9 girls' interscholastic sports they studied. Unfortunately, gymnastics was not 1 of the sports included in the NCHSAIS, and the gymnastics injury rate of Garrick and Recqua cannot be transformed into a rate per athlete exposure, which would be comparable with the current study, without knowing the number of games and practices in which the Garrick and Requa[5,6] study athletes participated. The low cheerleading injury rate in the current study relative to other sports in the NCHSAIS study[20] may be explained by the fact that gymnastic stunts are only a part of cheerleading, whereas they are the focus of gymnastics.

The high proportion of injuries in the current study that occurred during partner stunts and pyramids (55.7%) is an indication that the gymnastics element is the part of cheerleading with the highest injury risk. Hutchinson[14] reported similar results. Eighty-three percent of the college cheerleaders he studied were injured while performing gymnastics or partner stunts.

In addition to the overall cheerleader injury rate being low in the current study, the ratio of the game injury rate to the practice injury rate was very close to 1. In contrast, among the total NCHSAIS study population, across both genders and all sports, the game injury rate was 4 times the practice injury rate; and for boys' football, the game-to-practice injury RR was nearly 10.[20] Several possible reasons for the low game-to-practice injury RRs for cheerleading are that there are more and better qualified spotters in competitions than in practice, and judging of cheerleading competition emphasizes form as well as difficulty. This leads to more difficult routines and stunts being attempted, not only first but also sometimes only in practice if the cheerleaders do not develop good form on the routine or stunt.

Earlier studies[1,14] have identified cheerleading injuries as being unusually severe. Axe et al[1] noted that cheerleaders had the most days of participation lost per injury (an average of 28.8) in their 1-year study of sports injuries among adolescents age 14 to 18 in 23 sports treated at a major sports medicine clinic in Delaware. Similarly, Hutchinson[14] found the average days lost per injury to be 35 among 74 cheerleaders he surveyed in 7 central Kentucky high schools in 1993. In the current study, only 12.8% of the injured cheerleaders had their participation limited for more than 3 weeks. The large number of days of participation lost per injury in the studies of Axe et al[1] and Hutchinson[14] are probably due to their studies including only more severely injured athletes. Axe et al[1] included only those injuries that required treatment at a major Delaware sports medicine clinic, and the injury definition of Hutchinson[14] included only injuries that resulted in at least 1 day of lost participation. In contrast, the current study included all injuries that limited a cheerleader's full participation in the sport the day following the injury or required medical attention by an athletic trainer, physician, nurse, EMT, emergency department personnel, physical therapist, dentist, or other health professional. In addition, all brain concussions, nerve injuries, eye injuries, and fractures were reportable injuries in the current study even if they did not result in a single day of lost participation.

Lysens et al[18] hypothesized that athletes with extreme height, weight, or height and weight combinations might be more prone to sports injuries because of an imbalance between load and load-carrying capacity. In this study, high BMIs (ie, those in the top 20% of all cheerleaders) appeared to be protective rather than a risk factor. This result may reflect the fact that the cheerleaders with the highest BMIs are less likely to be at the top level of pyramids or stunts and thus are at a reduced risk of injury due to falls from heights.

The news media 2 and researchers[3,4,22] have identified cheerleading injuries as an important problem because of the growing number of cheerleaders and the changing nature of the sport. This study provides some reassurance that the injury rate for cheerleaders is low relative to other female and male high school sports. Just as important, this research points to the need to focus cheerleading injury prevention interventions in 2 areas: (1)

the gymnastic element of cheerleading, specifically, partner stunts and pyramids, the squad activity that comprises 57.1% of the injuries; and (2) ankle sprains, the body part–injury type combination that comprises 21% of all injuries. Finally, the study provides the first statistical support for the argument that more experienced, trained, and qualified coaching leads to lower injury rates for cheerleaders. By analogy, supplying high school cheerleading with enough resources to recruit, train, and retain educated coaches should help keep cheerleading injury rates low.

Looking to the future, studies are needed that focus on what kind of training cheerleading coaches need to prevent injuries. The current study indicates that general coaching training is beneficial. This seems congruent with the 10 injury prevention responsibilities of coaches that Rice[28] enumerated. The 10 responsibilities would be the sort of skills in injury prevention one would expect to be presented in a general coaching class. However, the efficacy for injury prevention of the cheerleading-specific AACCA safety certification should also be investigated. An ideal study would also investigate how any benefit of the safety certification changes over time. Currently, the AACCA safety certification is good for 4 years. Does the training need to be more frequent, or is this frequent enough?

In addition to examining coaching further, an ideal epidemiological study of cheerleading would expand on the current study by examining some of the unique aspects of cheerleading and observing the effect of some of the guide-lines for facilities and practice that are recommended in recent cheerleading safety manuals and guidelines. 4,8 Specifically, an ideal study would follow cheerleaders for the entire calendar year because they perform in all 3 high school athletic seasons, with cheerleading competitions tending to occur in the spring and participation in for-profit cheerleading camps occurring in the summer. Participation would be monitored by athletic season as well as by practice, cheering at a competition of other sports teams, and cheering in cheerleading competition. Injury events would be analyzed for the absence or presence of cheerleading specific safety (1) practices (such as having adequately trained spotters when cheerleaders are elevated above a certain height) and (2) facilities (such as mats and harnesses). At the school and for-profit summer camp level, the size of the cheerleading budget per cheer-leader, the number of cheerleaders per coach, and the level of access to a certified athletic trainer should be examined as potential predictors of the injury rate because concerns have been raised consistently about how limited resources hamper safety efforts.[4,12,13] Finally, the ideal high school study would oversample males because they are still a small minority of high school cheerleaders, yet they are thought to do different activities than those of the females.[13]

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