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Catastrophic High School and Collegiate Cheerleading Injuries in the United States: An Examination of the 2006-2007 Basket Toss Rule Change

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Background: Cheerleading is a specialized athletic activity that can lead to catastrophic injuries. Cheerleading rules are in place to maximize safety of participants. The purpose of this study was to describe catastrophic cheerleading injuries among high school and collegiate-level participants in the United States and to explore whether the 2006-2007 basket toss rule change was effective at reducing the number of catastrophic injuries.

Hypothesis: The 2006-2007 basket toss rule change contributed to a reduction in the number of catastrophic injuries among high school and collegiate cheerleaders.

Study Design: Case series.

Level of Evidence: Level 4.

Methods: Data on catastrophic cheerleading injuries were collected by the National Center for Catastrophic Sport Injury Research from July 2002 to June 2017. Information collected included cheerleader, event, and injury characteristics. The impact of the 2006-2007 rule change banning the basket toss on any hard surfaces was assessed by comparing injury rates and 95% CIs before and after the rule change.

Results: There were 54 catastrophic cheerleading injuries, or 3.6 injuries per year. From July 2002 through June 2017, the injury rate was 2.12 per 1,000,000 cheerleaders (95% CI, 1.56-2.69). Most cheerleaders sustained serious injuries (n = 27; 50%) during practice (n = 37; 69%) to the head (n = 28; 52%) and cervical spine (n = 17; 32%). From July 2002 through June 2017, basket tosses were the stunt that accounted for the highest proportion of injuries (n = 19; 35%). The basket toss injury rate decreased from 1.55 to 0.40 per 1,000,000 cheerleaders among both high school and collegiate cheerleaders after the rule change.

Conclusion: Catastrophic injury rates in cheerleading decreased dramatically after the 2006-2007 rule change banning basket tosses from being performed on any hard surfaces. In particular, there was a nearly 4-fold reduction in the rate of catastrophic basket toss injuries.

Keywords: injury prevention; epidemiology; head injuries/concussion; cervical spine; cheerleading

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Cheerleading is a specialized athletic activity involving complex routines and stunts (eg, basket toss) that can also lead to life-threatening injuries. From 1990 through 2012, a total of 500,000 children aged 5 to 18 years were treated in US emergency departments for cheer-related injuries.[12] A prior study reviewing catastrophic cheerleading injuries from 1982 to 2002 reported an average of 1.95 injuries per year among high school and collegiate cheerleaders; basket tosses accounted for 21% of injuries.[2]

Cheerleading rules maximize the safety of participants and are written and enforced by different organizations in the United States. At the high school level, cheerleading rules are written by the National Federation of State High School Associations (NFHS) and the American Association of Cheerleading Coaches and Administrators (AACCA) but are adopted and enforced by individual states' associations. At the college level, the National Collegiate Athletic Association does not write cheerleading rules and defers to AACCA rules. Since 2002, key rule changes have been implemented by the AACCA and NFHS. Most notably, starting in the 2006-2007 academic year, basket tosses on hard surfaces (eg, basketball courts) were banned for both high school and college cheerleading.[13]

The purpose of this study was to describe catastrophic cheerleading injuries from 2002 to 2017 for high school and collegiate-level participants and to explore the effect of the new basket toss rule implemented at the beginning of the 2006-2007 academic year on catastrophic cheerleading injuries. We hypothesized that the new basket toss rule reduced the incidence of catastrophic cheerleading basket toss injuries.

METHODS

All study procedures were approved by the institutional review board at the University of North Carolina at Chapel Hill. Since 1982, the National Center for Catastrophic Sport Injury Research (NCCSIR) has conducted surveillance of catastrophic injuries related to participation in organized sports in the United States; this methodology has been described previously.[7] Briefly, catastrophic injuries were identified through online media reports and reports from coaches, athletic trainers, athletic directors, and officers of state and national sport organizations.[7] Direct (ie, traumatic) catastrophic injuries were those resulting from participating in skills related to the sport[7] and were classified into categories of severity: serious (severe injuries without permanent functional disability), nonfatal (severe injuries with permanent functional disability), and fatal (injuries resulting in death).[2,7]

For the present study, catastrophic cheerleading injury data were collected by the NCCSIR from July 1, 2002, through June 30, 2017. Additionally, from 2008 through 2012, catastrophic cheerleading injuries identified by the National Cheer Safety Foundation (NCSF) were shared with the NCCSIR.[10,11] Furthermore, to improve overall capture of catastrophic cheerleading injuries, NCCSIR developed an online portal (https://www.sportinjuryreport.org) where catastrophic injuries can be reported. The portal was activated in January 2015.[6] Cheerleading injuries were reported by academic year; an academic year spanned from July 1 through June 30. Information collected included cheerleader characteristics (sex, level of participation, position at the time of injury), event characteristics (setting, month of injury, activity performed at time of event), and injury characteristics (body part injured, type of ailment, severity).

Annual estimates of US cheerleader participation divided by age categories were obtained from Sports Market Analytics (SMA).[19] For this study, participation for those aged 12 to 17 and 18 to 24 years served as estimates for high school and college cheerleading participation, respectively. SMA calculated participation estimates for the years 2001, 2004, 2005, 2006, 2008, and 2011 through 2016. We inputed participation for the missing years by assuming a constant change in participation during missing years. To assess impacts of the basket toss rule change implemented by the AACCA at the beginning of the 2006-2007 academic year, we calculated injury incidence rates, rate differences (comparing post–rule change with pre–rule change), and 95% CIs per 1,000,000 participants. To account for a potential lag in effect of the rule change, we used 3 different categorizations of time periods:

1. No lag: pre–rule change was 2002-2003 through 2005-2006 and post–rule change was 2006-2007 through 2016-2017
2. 1-year lag: pre–rule change was 2002-2003 through 2006-2007 and post–rule change was 2007-2008 through 2016-2017
3. 2-year lag: pre–rule change was 2002-2003 through 2007-2008 and post–rule change was 2008-2009 through 2016-2017

Injury rate differences and 95% CIs were also separately explored for high school and college athletes. We also looked exclusively at basket toss injuries.

RESULTS

From July 2002 through June 2017, there were 54 catastrophic cheerleading injuries (3.6 injuries per year) among high school and collegiate participants. Cheerleader, event, and injury characteristics stratified by level (high school vs college) and injury severity are presented in Tables 1 and 2, respectively.

For basket tosses, injuries were most commonly sustained to the head (9/19; 47%) and cervical spine (5/19; 26%). For tumbling/floor routines, most injuries were sustained to the cervical spine (6/7; 86% [1 injury to the head]). For pyramids, most injuries were sustained to the head (4/6; 67% [1 injury to the cervical spine, 1 injury to another location on the spine]).

The annual count of catastrophic injuries is presented in Figure 1. The overall rate (95% CI) was 2.12 (1.56-2.69) per 1,000,000 (2.32 [1.63-3.01] and 1.88 [0.86-2.91]) for high school and college, respectively. The annual injury rate ranged from 0.00 to 7.48 and 0.00 to 7.39 per 1,000,000 for high school and collegiate cheerleaders, respectively (Figure 2).

Table 1. Catastrophic traumatic injuries by sport level, July 2002-June 2017

	Level					
	College (n = 13)		High School (n = 41)		Total (N = 54)	
	n	Column %	n	Column %	n	Column %
Sex						
Female	12	92	40	98	52	96
Male	1	8	1	2	2	4
Injury month						
January–March	9	69	13	32	22	41
April–June	0	0	6	15	6	11
July–September	1	8	6	15	7	13
October–December	3	23	16	39	19	35
Injury severity						
Serious	8	62	19	46	27	50
Nonfatal	5	38	19	46	24	44
Fatal	0	0	1	2	1	2
Unknown	0	0	2	5	2	4
Body part injured						
Brain/head	6	46	22	54	28	52
Cervical spine	6	46	11	27	17	32
Other[a]	0	0	4	10	4	7
Other spine	1	8	4	10	5	9
Position						
Base	0	0	4	10	4	7
Flyer	10	77	28	68	38	70
Tumbler	2	15	6	15	8	15
Unknown	1	8	3	7	4	7
Activity						
General play	0	0	1	2	1	2
Basket toss	5	38	14	34	19	35
Pyramid	2	15	4	10	6	11
Any other team formation involving 3+ persons	2	15	6	15	8	15
Two-person stunt (eg, shoulder stand)	2	15	3	7	5	9

(continued)

Table 1. (continued)

	Level				Total (N = 54)	
	College (n = 13)		High School (n = 41)			
	n	Column %	n	Column %	n	Column %
Tumbling and floor routine	2	15	5	12	7	13
Other	0	0	6	15	6	11
Unknown	0	0	2	5	2	4
Type of ailment						
Fracture	8	62	21	51	29	54
Traumatic brain injury	3	23	10	24	13	24
Other[b]	1	8	6	15	7	13
Unknown[c]	1	8	4	10	5	9
Event						
Competition	5	38	9	22	14	26
Practice	8	62	29	71	37	69
Other	0	0	1	2	1	2
Unknown	0	0	2	5	2	4

[a]Among 4 injuries occurring outside of the brain/head or spine, 2 were to the coccyx, and the remaining 2 were to the heart and spleen.
[b]Among 7 injuries due to other types of injury, 2 were due to contusions to the neck or spinal cord, 1 was a nerve injury, 1 was due to commotio cordis, 1 was due to a spleen rupture, and 2 were due to other unspecified trauma.
[c]Among 5 unknown injury types, 4 were to the head and 1 was to the thoracic vertebrae.

The annual count of basket toss injuries ranged from 0 to 6 per year (Figure 1). The average annual count of basket toss injuries pre– and post–rule change was 3.0 and 0.6, respectively. The overall basket toss injury rate (95% CI) was 0.75 (0.41-1.08) per 1,000,000 cheerleaders (0.76 [0.36-1.15] and 0.72 [0.09-1.36] for high school and college, respectively). The combined basket toss injury rate for high school and college athletes was reduced by 74% when the comparison started the year after the 2006-2007 basket toss rule changes. Among high school and college cheerleaders, there was a lower rate of basket toss injuries when accounting for a potential lag in effect of rule changes (see Appendix Table A1, available in the online version of this article).

Among high school cheerleaders, there was a lower rate of non–basket toss injuries after the rule change (2.74 vs 0.92 per 1,000,000 [$P = 0.02$], 2.45 vs 0.86 per 1,000,000 [$P = 0.02$], and 2.21 vs 0.87 per 1,000,000 [$P = 0.02$] for no lag, 1-year lag, and 2-year lag, respectively). Among college cheerleaders, there was not a lower rate of non–basket toss injuries after the rule change (0.44 vs 1.52 per 1,000,000 [$P = 0.14$], 0.37 vs 1.67 per 1,000,000 [$P = 0.08$], and 1.28 vs 1.06 per 1,000,000 [$P = 0.79$] for no lag, 1-year lag, and 2-year lag, respectively).

DISCUSSION

Basket Toss Injuries

In this 15-year study, basket tosses were the stunt accounting for the greatest number of injuries (n = 19). Fourteen of these injuries occurred in the study's first 5 years; none occurred in the study's last 7 years. The basket toss involves 1 cheerleader being tossed into the air by multiple people with interlocked hands.[1] The tossed cheerleader could potentially not be caught and subsequently fall to the ground or be caught improperly. At the beginning of the fifth year of the study (2006-2007), the AACCA implemented a rule limiting the performance of basket tosses to mat, grass, or rubberized track surfaces (effectively banning this stunt from hard surfaces such as basketball courts). The number of catastrophic injuries related to basket tosses decreased once this rule change was implemented. It is possible that other factors aside from the rule change contributed to a decrease in basket toss injuries, as non–basket toss injuries also decreased among high school cheerleaders during our study. Nonetheless, the significant reduction in both high school and college basket toss injuries indicates the rule change was effective. Future research should investigate the effectiveness of

Table 2. Catastrophic nonfatal catastrophic injuries by severity, July 2002-June 2017

	Injury Severity[a]				Total	
	Serious		Nonfatal			
	n	Row %	n	Row %	n	Row %
Sex						
Female	26	53	23	47	49	100
Male	1	50	1	50	2	100
Injury month						
January-March	12	55	10	46	22	100
April-June	2	33	4	67	6	100
July-September	4	67	2	33	6	100
October-December	9	53	8	47	17	100
Event						
Competition	9	69	4	31	13	100
Practice	16	46	19	54	35	100
Other	0	0	1	100	1	100
Unknown	2	100	0	0	2	100
Level						
College	8	62	5	38	13	100
High school	19	50	19	50	38	100
Body part injured						
Brain/head	12	46	14	54	26	100
Cervical spine	12	71	5	29	17	100
Other	1	33	2	67	3	100
Other spine	2	40	3	60	5	100
Position						
Base	1	25	3	75	4	100
Flyer	19	53	17	47	36	100
Tumbler	6	75	2	25	8	100
Unknown	1	33	2	67	3	100
Activity						
General play	1	100	0	0	1	100
Basket toss	6	33	12	67	18	100
Pyramid	5	83	1	17	6	100

(continued)

Table 2. (continued)

	Injury Severity[a]				Total	
	Serious		Nonfatal			
	n	Row %	n	Row %	n	Row %
Any other team formation involving 3+ people	2	29	5	71	7	100
Two-person stunt (eg, shoulder stand)	4	80	1	20	5	100
Tumbling and floor routine	5	71	2	29	7	100
Other	3	50	3	50	6	100
Unknown	1	100	0	0	1	100
Type of ailment						
Fracture	16	57	12	43	28	100
Other	3	50	3	50	6	100
Traumatic brain injury	5	42	7	58	12	100
Unknown	3	60	2	40	5	100

[a]There was 1 fatal injury resulting from a ruptured spleen to a high school–aged flyer who was performing a basket toss.

this rule change on reducing noncatastrophic basket toss injuries, as well as the effect of other rule changes on other cheerleading injuries.

Overall Injury Counts

In our study, there were 3.6 direct catastrophic cheerleading injuries annually, increasing from 1.95 per year from the prior study investigating the years 1982 through 2002.[2] Some possible reasons exist for this increase, which have been previously suggested.[8] Although participation numbers are not available before 2001, it is possible more athletes were participating in cheerleading in the current study, increasing the number of cheerleaders who could be potentially injured. However, SMA data revealed that cheerleading participation among those aged 12 to 24 years decreased from 1.9 million in 2001 to 1.8 million in 2016.

A more plausible reason for the increase in injuries is that a greater proportion of catastrophic cheerleading injuries were captured by the NCCSIR during this period. While the NCCSIR does not track statistics on how catastrophic cheerleading injuries are captured, the increasing popularity and accessibility of digital media on the internet since the late 1990s and early 2000s has expedited the process of finding catastrophic cheerleading injuries in digital media, potentially leading to an increasing number of cheerleading injuries identified. For example, *The New York Times* and *The Wall Street Journal* started posting articles online in 1996.[3,9] In addition, the collaboration between the NCCSIR and the NCSF from 2008 to 2012, as well as the new NCCSIR web-based injury report mechanism in 2015, may have also identified more events. However, despite these developments, we saw a decrease in the catastrophic injury rate over the 15 years of this study.

A final reason for the increase in injuries is that cheerleading has become a more difficult activity, leading to a corresponding increase in research and attention on cheer safety.[8,10] Research studies published from 2004 through 2009 described cheer-related injuries and risk factors calling for increased safety efforts, including making cheer a sponsored sport at both the collegiate and high school levels.[4,5,10,16-18] Increased attention would result in greater media coverage and public concern, both of which could have led to improved catastrophic injury reporting.

Strengths and Limitations

This study had several key strengths. We used 15 years of direct catastrophic cheerleading injury data, allowing us to investigate potential differences in injury counts across time. Additionally, the NCCSIR has the most comprehensive database for catastrophic injuries in the United States and has been conducting catastrophic injury surveillance among all high school and collegiate sports in the United States since 1982.

This study also had limitations. Details on injury and incident characteristics were unknown for some cases. The study calculated injury rates using SMA participation data based on age groups (rather than actual cheerleading participation in high school and college). However, SMA had the only data with

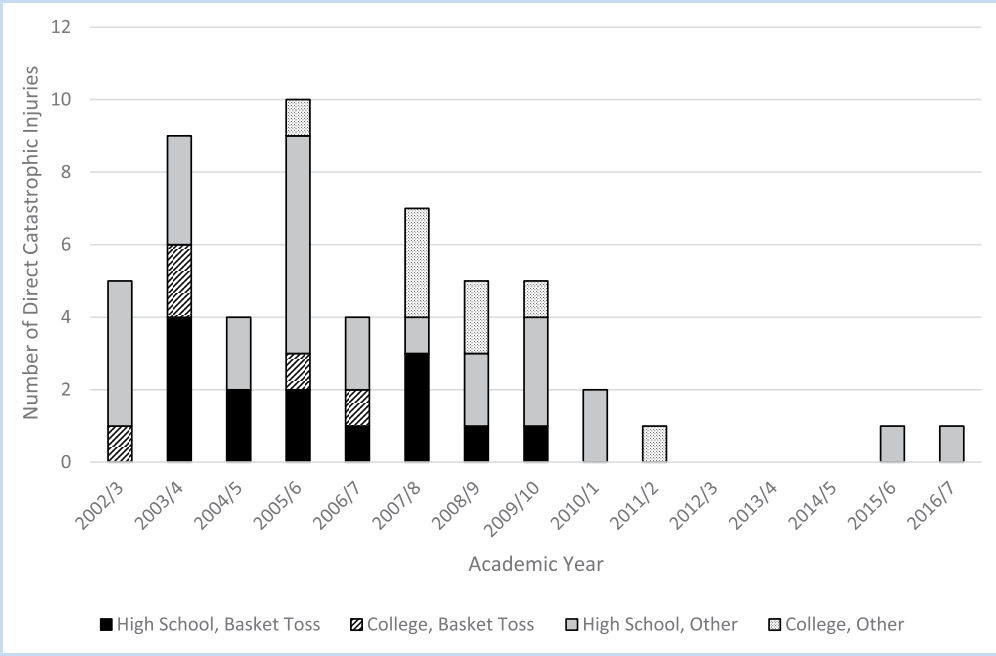

Figure 1. Number of catastrophic cheerleading injuries by activity, July 2002-June 2017.

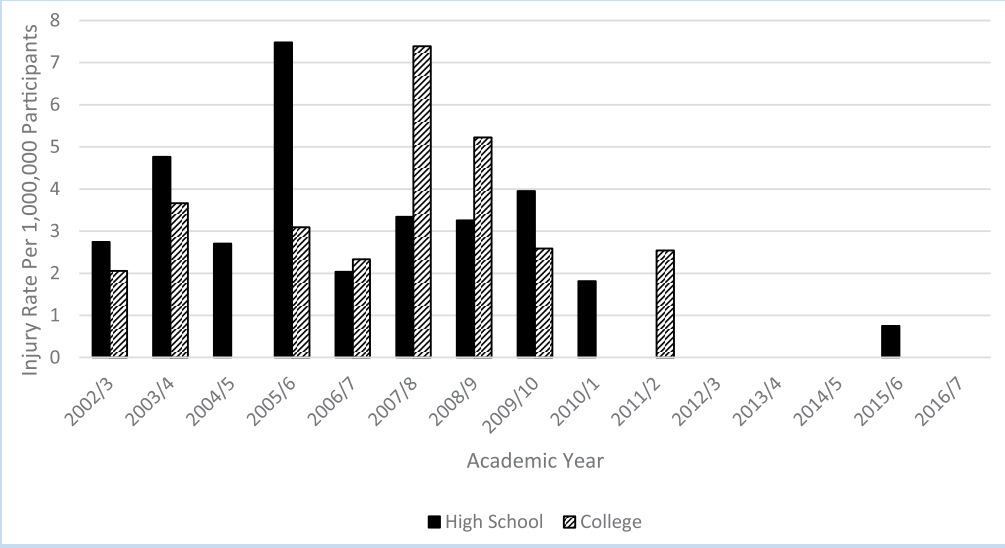

Figure 2. Rate of catastrophic cheerleading injuries by level, July 2002-June 2017.

annual estimates of cheerleading participation in high school and college; reliable annual data on cheerleading participation currently do not exist. Although the NFHS collects competitive cheerleading participation data annually for high schools that sponsor cheer, these numbers do not reliably reflect the total number of high school cheerleaders in the United States, as cheer is not sponsored in most high schools. In the academic year 2007-2008, the NFHS estimated that 113,980 high school athletes participated in competitive cheerleading,[15] while a separate survey conducted that year by the NFHS found 394,694 cheerleading participants.[14] Cheerleading participation data are unavailable at the collegiate level. A national collaborative effort is needed to collect reliable cheerleading participation data regularly.

Another limitation is that given the NCCSIR's reliance on media reports for event capture, some catastrophic cheerleading

injuries may not have been identified. Although the NCCSIR actively searches for instances of catastrophic cheerleading injuries and receives information about potential catastrophic injuries from other individuals, it is possible that some injuries were not identified. Nonetheless, the NCCSIR is the only US organization that collects catastrophic injury information on all youth, high school, and college sports (including cheerleading), as there is no mandated reporting of the injuries to any organization at either the state or the national level. Increased collaboration between stakeholders in cheerleader health and safety could help increase identification of catastrophic cheerleading injuries.

CONCLUSION

The basket toss rule banning stunts from being performed on hardwood surfaces has contributed to a 74% reduction in the catastrophic basket toss injury rate. Nonetheless, further work is necessary to eliminate catastrophic injuries from other stunts that still occur at a low rate. Continued injury surveillance should be conducted, and further rule changes should be implemented to reduce the number of catastrophic injuries from other cheerleading stunts.

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REFERENCES

1. American Association of Cheerleading Coaches and Administrators. 2015-6 AACCA school cheer safety rules. http://www.cheerrules.org/wp-content/uploads/2015/04/2015-2016-School-Rules.pdf. Accessed March 15, 2018.
2. Boden BP, Tacchetti R, Mueller FO. Catastrophic cheerleading injuries. *Am J Sports Med*. 2003;31:881-888.
3. Flynn L. Wall Street Journal bets internet readers will pay a fee. *The New York Times*. April 29, 1996. http://www.nytimes.com/1996/04/29/business/wall-street-journal-bets-internet-readers-will-pay-a-fee.html. Accessed March 15, 2018.
4. Jacobson BH, Hubbard M, Redus B, et al. An assessment of high school cheerleading: injury distribution, frequency, associated factors. *J Orthop Sports Phys Ther*. 2004;34:261-265.
5. Jacobson BH, Redus B, Palmer T. An assessment of injuries in college cheerleading: distribution, frequency, associated factors. *Br J Sports Med*. 2005;39:237-240.
6. Kucera KL, Thomas LC, Cantu RC. *Catastrophic Sports Injury Research: Thirty-Fourth Annual Report; Fall 1982–Spring 2016*. Chapel Hill, NC: National Center for Catastrophic Sport Injury Research; 2017. https://nccsir.unc.edu/files/2013/10/NCCSIR-34th-Annual-All-Sport-Report-1982_2016_FINAL.pdf. Accessed March 15, 2018.
7. Kucera KL, Yau R, Thomas LC, Wolff C, Cantu RC. *Catastrophic Sports Injury Research: Thirty-Third Annual Report; Fall 1982–Spring 2015*. Chapel Hill, NC: National Center for Catastrophic Sport Injury Research; 2016. https://nccsir.unc.edu/files/2013/10/NCCSIR-33rd-Annual-All-Sport-Report-1982_2015.pdf. Accessed March 15, 2018.
8. Labella CR, Mjaanes J, Brenner JS, et al. Cheerleading injuries: epidemiology and recommendations for prevention. *Pediatrics*. 2012;130:966-971.
9. Lewis PH. The New York Times introduces a web site. *The New York Times*. January 22, 1996:D7. http://www.nytimes.com/1996/01/22/business/the-new-york-times-introduces-a-web-site.html. Accessed March 15, 2018.
10. Mueller FO. Cheerleading injuries and safety. *J Athl Train*. 2009;44:565-566.
11. Mueller FO, Kucera KL, Thomas LC, Cantu RC. *Catastrophic Sports Injury Research: Thirtieth Annual Report; Fall 1982–Spring 2012*. Chapel Hill, NC: National Center for Catastrophic Sport Injury Research; 2012. http://nccsir.unc.edu/files/2014/06/NCCSIR-30th-Annual-All-Sport-Report-1982_2012.pdf. Accessed March 15, 2018.
12. Naiyer N, Chounthirath T, Smith GA. Pediatric cheerleading injuries treated in emergency departments in the United States. *Clin Pediatr*. 2017;56:985-992.
13. National Federation of State High School Associations. News release: basket tosses limited to soft surfaces in high school cheerleading. March 16, 2006. http://aiaonline.org/files/4929/basket-tosses-limited-to-soft-surfaces-in-high-school-cheerleading.pdf. Accessed March 15, 2018.
14. National Federation of State High School Associations. New release: survey indicates nearly 400,000 high school cheerleaders. May 21, 2009. https://www.ihsa.org/archive/announcements/nfhs_cheerleading_release.pdf. Accessed March 15, 2018.
15. National Federation of State High School Associations. Participation statistics. http://www.nfhs.org/ParticipationStatics/ParticipationStatics.aspx/. Accessed March 15, 2018.
16. Schulz MR, Marshall SW, Mueller FO, et al. Incidence and risk factors for concussion in high school athletes, North Carolina, 1996-1999. *Am J Epidemiol*. 2004;160:937-944.
17. 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;32:396-405.
18. Shields BJ, Smith GA. Epidemiology of cheerleading fall-related injuries in the United States. *J Athl Train*. 2009;44:578-585.
19. Sports Market Analytics. Market research/demographics. http://www.sportsmarketanalytics.com/research.aspx?subRID=93. Accessed January 2, 2018.