

Pediatric Injuries at an Annual Motocross Competition: Rates and Severity

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Purpose: Pediatric motocross injuries occur frequently and with significant associated morbidity; however, data are limited regarding injury occurring during competition. North Central Florida hosts an annual motocross competition with numerous pediatric competitors. We sought to evaluate the rate and severity of injuries sustained at this event over a multiyear period. Our primary hypothesis was that motocross injury rates and severity in competition exceed that of other competitive sports in this age group.

Methods: A retrospective review was performed to identify pediatric patients (17 and younger) presenting to a single Level 1 Trauma Center as a result of injury sustained at an annual motocross competition from 2009 to 2012. Demographic, diagnostic, and treatment data were collected including injuries, procedural interventions, and length of hospital stay. Rate, type, and severity of injury were evaluated and compared with established norms of other competitive sports in a similar age group.

Results: Over a 4-year period, 51 pediatric motocross competitors sustained 75 injuries. Injured riders were 14.2 ± 2.51 years (range, 8 to 17 y) old and 92% (47/51) male. Forty (78%) patients sustained at least 1 orthopaedic injury and 17 (33%) patients suffered polytrauma. The majority of injuries occurred in the upper extremity (36%). Twenty-four (47%) patients required procedural intervention, 15 of which were operative. Thirty-nine (76%) patients necessitated surgical specialty care. Average injury severity score was 6.5 (1 to 75) and 1 death occurred. The injury rate for pediatric motocross riders in this study was 19.9 injuries per 1000 competitors.

Conclusions: High rates of injury occur among pediatric patients in competitive motocross, exceeding those seen in other competitive sports in a comparable age group. Significant morbidity and at least 1 fatality were demonstrated in the group studied. The majority of patients suffer at least 1 orthopaedic injury and nearly all patients require pediatric surgical specialist care.

Polytrauma is common. Motocross participants and parents should be aware of these risks of competition and event organizers should arrange events near facilities with appropriate pediatric surgical specialty services.

Level of Evidence: Level IV—case series.

Key Words: pediatric trauma, motocross, polytrauma, injury severity score

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Motocross is an international, organized sport consisting of off-road motorcycles (also known as dirt bikes) racing on dirt tracks. Competition is predominated by teenage and young adult riders. Given speeds of over 60 miles per hour reached by these machines and the irregularity of tracks, it is not surprising that injuries—orthopaedic and otherwise—occur frequently and are associated with significant morbidity, long hospital stays, and tremendous cost to the medical care system.^{1–6} However, data regarding rates and severity of injury sustained during competition by pediatric motocross riders are lacking.

The (blinded event name) is an annual, weeklong motocross competition held in (blinded location) each year. It is one of the premier motocross events of the racing season and attracts riders from around the country and abroad, many of whom are among the most experienced and advanced riders within their respective age groups. Medical staffs are available at the event for immediate assessment and triage of injured riders. Our institution (blinded) is the only Level 1 Trauma Center and the only hospital with a broad range of pediatric surgical specialty providers in the vicinity. Therefore, pediatric riders with significant injuries are brought to our center for evaluation and management.

The purpose of this study was to identify the prevalence and severity of injuries sustained by pediatric competitors over a multiple year period at an annual motocross competition. Our main hypothesis was that injury prevalence at this competition exceed those published of other competitive sports.^{7,8} We also hypothesized that the severity of injuries occurring in motocross competition would be greater than in other sports. Given the popularity of the motocross and the frequency of injuries sustained, this data will aid in addressing safety concerns about the sport.

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METHODS

Institutional review board approval was obtained to complete a retrospective study identifying pediatric patients (≤ 17 y old) presenting to our Level 1 Trauma Center as a result of injury sustained at an annual motocross competition. Study patients were identified through a Faculty Practice Decision Support request for individuals presenting with injury-related ICD-9 diagnoses (800 to 899) to the emergency department during the annual competitions held between 2009 and 2012. Emergency department records were reviewed and those who sustained injuries from motocross competition fitting the inclusion criteria were included.

Demographic data were recorded, including age, sex, and mode of arrival. When available, injury mechanism was noted. The electronic record was abstracted and reviewed by the principal investigator to determine type and severity of injuries sustained, medical and surgical management, need for and duration of higher level of care, total length of hospital stay, and operative and nonoperative procedures (eg, closed reduction under conscious sedation) during hospitalization. Two other investigators reviewed the data for consistency and validity. Publicly available records were reviewed online to determine the number of race competitors each year. These records did not specify age and thus the total number of competitors in each year of competition (including adults) was calculated. Descriptive statistics were used to summarize patient demographics. Documented injuries were used to calculate injury severity scores (ISS)⁹ for each study subject.

Normative comparison data for this study were obtained from a report by Comstock et al⁷ with data obtained from the National High School Sports-related Injury Surveillance System from the 2012 to 2013 school year. Injury was defined as requiring medical attention and leading to a 1 or more day loss of participation in sport and was reported by staff present at practice and games.

RESULTS

Over a 4-year period, 51 pediatric competitors sustained 75 injuries at the annual motocross competitions. Injured riders were 14.2 ± 2.5 years (range, 8 to 17 y) old and 92% (47/51) were males. The mechanism of rider injury varied and is presented in Table 1. Ambulance

TABLE 1. Mechanism of Injury in 51 Injured Riders

Injury Mechanism	No. Injured Riders	Percentage of Injured Riders
Bad landing	19	37
Collision on ground	9	18
Fall from bike	9	18
Struck while off bike	7	14
Unknown/unwitnessed	4	8
Collision in air	3	6

TABLE 2. Injury Frequency in 51 Injured Riders

No. Injuries	No. Injured Riders	Percentage of Injured Riders
1	34	67
2	11	22
3	4	8
4	1	2
5	1	2

transport was necessary in 30 patients (59%). Forty patients (78%) sustained at least 1 orthopaedic injury and 17 patients (33%) suffered polytrauma (Table 2).

Region of Injury

Twenty-seven (36%) of the 75 injuries were upper extremity trauma, the most common being forearm fracture (Fig. 1). The next most frequent anatomic regions of injury were lower extremity (16 patients, 21%) and thoracic (11 patients, 15%). The distribution and management of musculoskeletal injuries is detailed in Table 3. The most common nonorthopaedic injuries were concussion (8 patients) and pneumothorax (6 patients). No injuries were sustained to the face or neck (not including cervical spine).

Injury Prevalence and Severity

An average of 12.8 riders was injured in each year of competition (range, 4 to 25), sustaining 18.8 injuries per year (range, 8 to 35). Twenty-four patients (47%) required a procedure, 15 (21%) of which were operative. Thirty-nine patients (76%) necessitated pediatric surgical specialist care, most commonly orthopaedic and pediatric general surgery evaluation and management. Twenty patients (39%) required hospital admission for an average length of stay of 2.45 ± 1.7 days. Three patients required

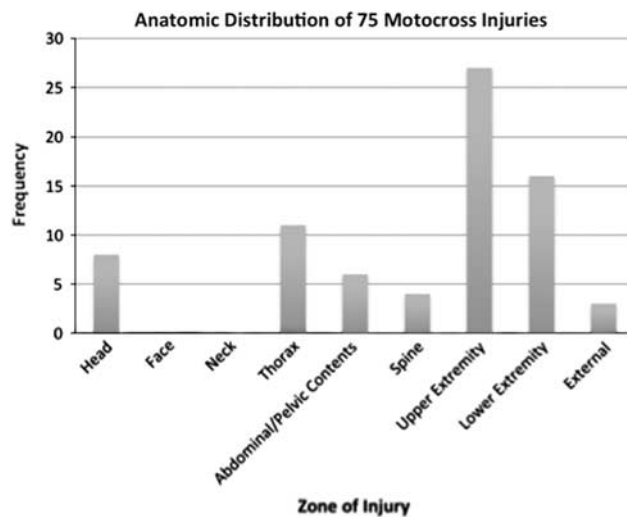


FIGURE 1. Anatomic distribution of motocross injuries. Anatomic distribution of 75 motocross injuries sustained during the (blinded event) from 2009 to 2012.

TABLE 3. Distribution and Required Management of Musculoskeletal Injuries Seen Among Injured Motocross Competitors

Region of Injury	Frequency	Most Common Injury	Procedural Intervention Required	Operative Intervention Required
Shoulder, upper Arm and elbow	6	Clavicle fracture (4)	1	0
Forearm, wrist and hand	21	Both bone forearm fracture (8)	14	5
Cervical spine	2	NA	0	0
Thoracic spine	2	NA	0	1
Lumbar spine	2	Back sprain (2)	0	0
Pelvis and acetabulum	5	NA	0	5
Hip and upper leg	3	Subtrochanteric femur fracture (2)	0	2
Knee and lower leg	4	Tibial shaft fracture (2)	0	3
Foot and ankle	5	Talus fracture (2)	0	1

NA indicates not available.

intermediate or intensive level care for 3.3 ± 1.5 days. The average ISS was 6.5 (range, 1 to 75). The distribution of ISS is demonstrated in Figure 2.

Complex Injury Case Examples

In our 51 patient case series, we identified 2 riders sustaining injuries far exceeding the norm of severity. Although rare, these cases represent the morbidity and mortality that can occur from motocross participation and we have thus included a brief summary of their presentation, management, and outcome.

Subject 625 (Fig. 3)—a 13-year-old male was brought in by Emergency Medical Services after being run over by 2 other bikes after losing control and falling off his bike on a jump. The patient was found to have multiple injuries including a left acetabulum fracture, a left sacroiliac joint dislocation, a right acetabulum fracture, intraabdominal and intrapelvic bleed, and a concussion. ISS was 33. The patient was taken immediately to the operating room for application of skeletal traction and endovascular embolization. Three days later he un-

derwent left acetabulum and sacroiliac joint open reduction internal fixation. He spent 10 days in the hospital, 5 of which were spent in the intensive care unit (ICU). On discharge, the patient returned home and did not return to our center for follow-up. He obtained follow-up with a local orthopaedic surgeon in his home state. He was without problems or immediate complication 3 weeks after discharge; however, no further follow-up is available for this patient.

Subject 844 (Fig. 4)—a 16-year-old male was brought in by Emergency Medical Services after a mid-air collision with another rider. The patient was found to have a left anterior shoulder dislocation reduced on arrival and a C2-C3 fracture with listhesis and severe spinal cord injury with near transection. ISS was 75 based on the spinal cord injury. After extensive discussion between the child's parents and the ICU staff regarding prognosis, a decision was made to withdraw care. The patient died after 3 days in the ICU.

DISCUSSION

Despite the popularity of motocross in the pediatric population, the existing literature on injuries sustained as a direct result of competition is sparse. To our knowledge, no prior study has evaluated injury prevalence and severity of injuries seen specifically in a cohort of pediatric motocross event competitors. In this study, we identified a high rate of injury and notable injury severity in pediatric motocross competitors as a result of participation in a local, annual event.

Sport injuries occurring in pediatric-aged participants are common. Comstock et al⁷ reviewed over 1.3 million injuries occurring in high school sports, the majority of which took place during competition. The overall rate of injury found was 4.3 injuries per 1000 athletic exposures (including practice and competition), with football injuries sustained during competition carrying the highest rate of any sport, 12.3 per 1000 athletic exposures). The majority of injuries seen were self-limited (eg, sprains and strains) and rarely required surgical intervention (8%). Although catastrophic injuries do occur,

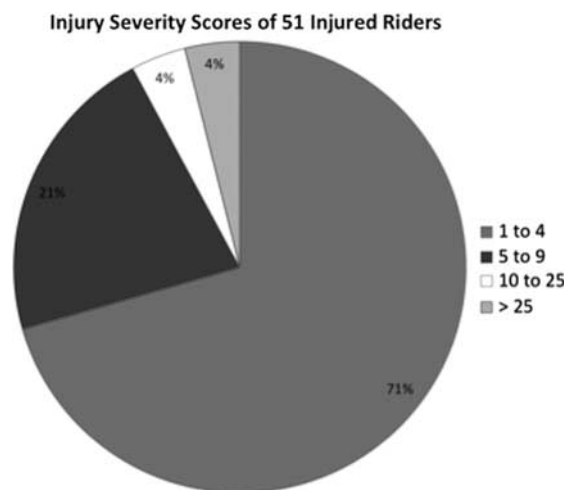


FIGURE 2. Injury severity score distribution. Distribution of injury severity scores of 51 injured riders during the (blinded event) from 2009 to 2012.

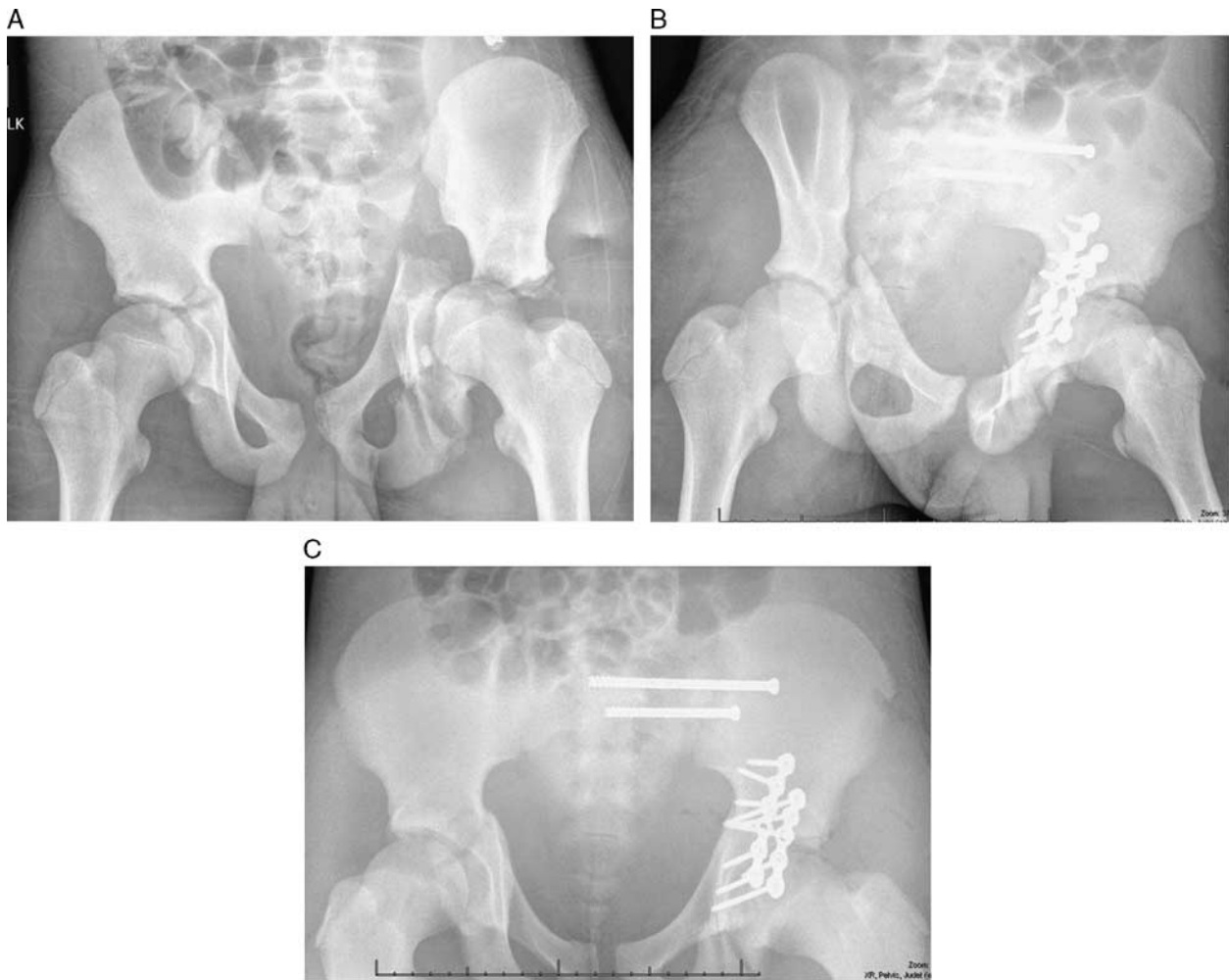


FIGURE 3. Subject 625—complex pelvic/acetabular injury. A, AP pelvic radiograph demonstrating bilateral acetabular fractures and left sacroiliac joint dislocation in a 13-year-old motocross participant. B and C, AP and iliac oblique radiograph after open reduction and internal fixation of the left acetabulum and sacroiliac joint.

they are infrequent and most commonly occur during participation in football.¹⁰

Previous studies examining motocross competitors of all ages report a prevalence of injury ranging from 3% at a small, single day event⁵ to as high as 10% in an annual off-road motorcycle endurance race.¹¹ Abdelgawad and colleagues examined a smaller cohort of 24 admissions over a 10-year period of recreational pediatric dirt bike injuries. They found a similar rate of polytrauma (38%), average ISS (8.5), and need for surgical/procedural intervention (33%). One patient death occurred in their cohort.

In the largest pediatric-only series, Larson et al⁶ evaluated the type, severity, and mechanism of motocross injuries occurring over an 8-year period at their tertiary care center. Two hundred ninety-nine injury episodes occurred. Similarities with our study were seen in the most common injury (forearm fracture), the high proportion of patients requiring hospitalization (47%), the length of hospital stay (2.9 d), and the need for surgery (30%). However, in contrast to our study, no patient

fatalities or severe permanent disabilities were identified as a result of injuries sustained in their series. It is also important to note that the Larson and colleagues' series reviewed injuries sustained both recreationally and during competition. Thus, many of these injuries likely occurred among inexperienced riders, on unapproved tracks or without standard safety equipment (< 50% of the riders were documented to have been wearing safety equipment). The present study reviewed injuries occurring in a more controlled setting, yet a remarkable rate and severity of injury was still observed. Our findings thus support the existing, yet limited, literature regarding the impact of pediatric motocross injuries and provide new insight into injury sustained during competition.

Injury Severity

In addition to occurring at higher rates than other competitive sports, motocross injuries also tend to be more severe. The need for hospitalization after motocross injury has been consistently documented in the literature,

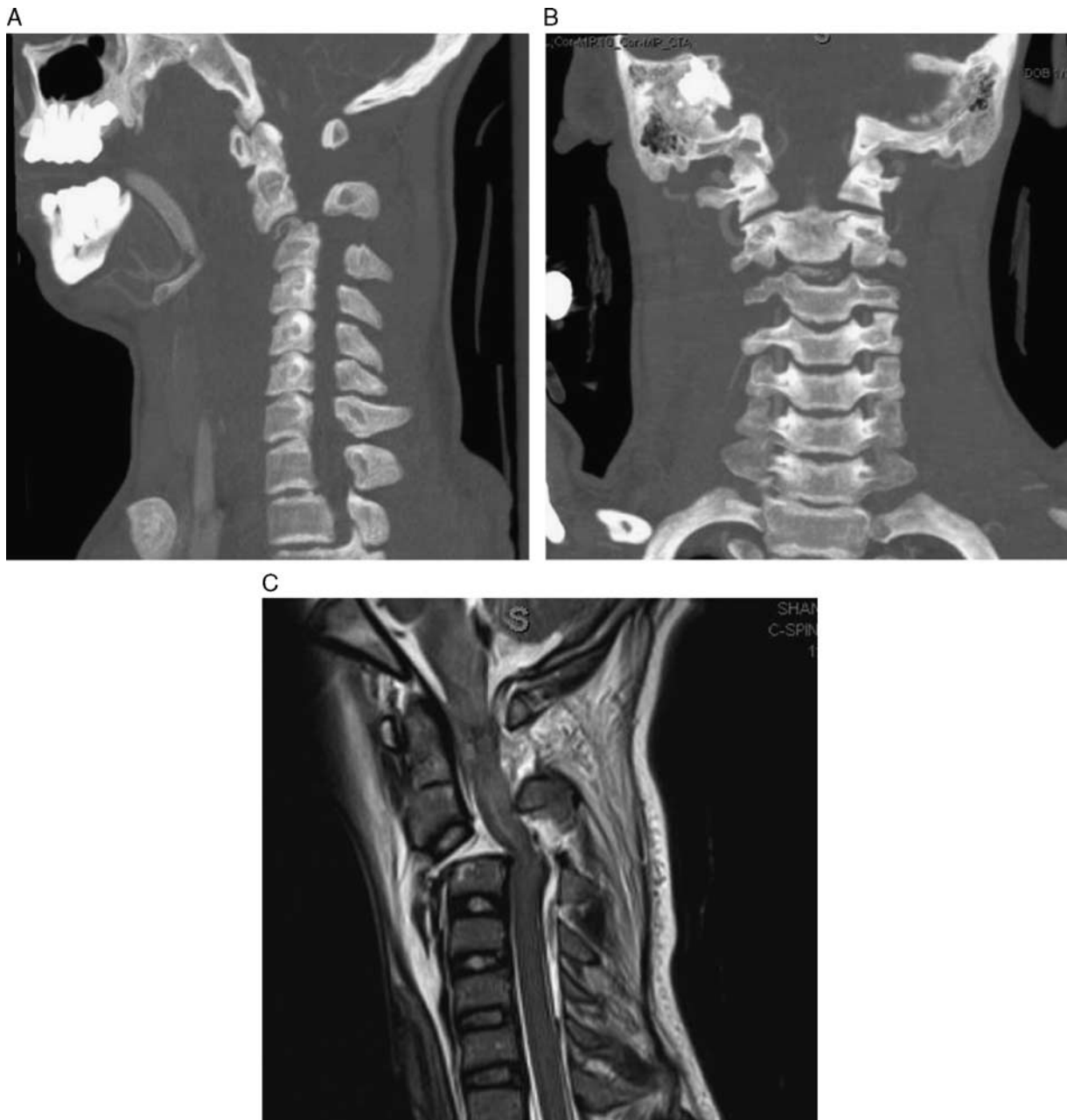


FIGURE 4. Subject 844—spinal cord injury. A and B, AP and lateral cervical spine radiographs of a C2-C3 fracture with listhesis and canal narrowing in a 16-year-old motocross rider. C, Sagittal MR demonstrating C2-C3 listhesis with canal narrowing and substantial cord edema.

with rates as high as 50% to 78%^{1,5,6} and the need for surgery in 21% to 50%.³⁻⁶ Our study demonstrated similar findings. Nearly half of patients (47%) required a procedure (21% operative) and 39% of patients required a hospital stay of 1 or more nights. In comparing these figures with injuries seen in other high school sports competition, the differences in severity become more apparent. Although the most common injuries in both are similar (concussions and extremity injuries), the severity of the extremity injuries is markedly different. The ma-

jority of extremity injuries seen in high school sports are sprains and strains (39%). Surgical intervention is rarely required (< 10%) and a return to sport is rapid.⁷ Conversely, the extremity injuries seen in our and other motocross cohorts were more frequently long bone fractures and the need for surgical or procedural intervention is 2- and 5-times higher than other high school sports.^{3,5,6} High school sport injuries required specialist management half as frequently as the patients in our cohort (39% vs. 76%). Finally, although ISS are not distinctly reported in

the Comstock et al⁷ report, estimation based on the injuries occurring most often would suggest values substantially lower than the average ISS of 6.5 seen in our study and 8.5 demonstrated by Abdelgawad et al.³

Limitations

This study is limited in its retrospective design with a historical comparison group that differed somewhat in demographic distributions (age and sex). Chart review can lead to missed injuries if not appropriately documented. In addition, many riders were presumably triaged at the racetrack and did not warrant immediate medical attention (eg, ankle sprains, concussions) or were effectively managed at other lower level of care facilities. These injuries would be missed by our study methods, but are included in the comparative study by Comstock and colleagues used for normative values. Finally, the age of individual race participants was not available in public records. As a result, the calculated injury rate used a denominator based on the total number participants (includes both youth and adult riders) and thus represents a minimum estimate of the injury rate among pediatric competitors. Therefore, the true rate of injury in this population is necessarily higher than the reported value.

Future Directions

There exists a need for prospective studies to determine a true rate of injury in competitive motocross with onsite evaluation of injured participants at the race track. The injury rate seen in this analysis is likely a significant underestimate due to the limitations discussed. Findings may be more striking with a prospective, age-controlled study design. In addition to overall injury rates, the prevalence of less severe injuries not prompting immediate emergent care requires further attention. Concussions in particular are likely underdocumented in this study, despite accounting for over 10% of documented injuries. Numerous factors likely contribute to decreased recognition in these athletes at the point of care.^{12,13} A substantially higher rate of traumatic head or brain injury (20%) was seen in another series of injured motocross riders¹⁴; however, these injuries did not all occur in the controlled setting of competition where safety equipment like helmets are required. Nevertheless, concussions remain a hot topic in youth sports with growing concerns about the long-term effects of multiple concussions and those sustained at an early age.¹⁵ With greater injury prevalence and severity than football, motocross riders and caregivers should have similar concerns. Recent work has begun to explore the neurological impact of concussions in pediatric riders in the short term,¹² but longitudinal studies examining cumulative impact of motocross competition as well as competitor and caregiver experiences would provide valuable information to the safety discourse.

CONCLUSIONS

Injuries were found to occur frequently among pediatric competitors at the studied annual motocross event.

As participation in this sport increases in youth populations, pediatric orthopaedic surgeons will encounter a growing number of aspiring riders and competition-related injuries. Knowledge of the risks associated with racing motocross in this age group will be important for appropriate counseling and patient advocacy. Prevalence of injury and injury severity exceed those seen in other competitive sports in this age group. The majority of identified riders in this cohort sustained at least 1 orthopaedic injury and nearly all required pediatric surgical specialist care. Polytrauma was common. There is significant morbidity associated with motocross injuries and mortality has been demonstrated in this population. Motocross participants should be educated on the injury risks of training and competition. Event organizers should seek to arrange competitions near facilities with an adequate offering of pediatric surgical specialty services. This study highlights the prevalence of serious injury in pediatric motocross riders. It identifies the features of concern in motocross competition for young participants, in particular.

REFERENCES

- Gorski TF, Gorski YC, McLeod G, et al. Patterns of injury and outcomes associated with motocross accidents. *Am Surg*. 2003;69:895–898.
- Postl BD, Moffatt ME, Black GB, et al. Injuries and deaths associated with off-road recreational vehicles among children in Manitoba. *CMAJ*. 1987;137:297–300.
- Abdelgawad AA, Maxfield D, Tran S, et al. Dirt bikes injuries in children. *Musculoskelet Surg*. 2013;97:211–215.
- Kennedy RD, Potter DD, Osborn JB, et al. Childhood motocross truncal injuries: high-velocity, focal force to the chest and abdomen. *BMJ Open*. 2012;2:1–5.
- Dick CG, White S, Bopf D. A review of the number and severity of injuries sustained following a single motocross event. *J Orthop*. 2014;11:23–27.
- Larson AN, Stans AA, Shaughnessy WJ, et al. Motocross morbidity: economic cost and injury distribution in children. *J Pediatr Orthop*. 2009;29:847–850.
- Comstock RD, Collins CL, Currie DW. National High School Sports-related Injury Surveillance Study. 2013 School Year. Center for Injury Research and Policy; 2013. Available at: <http://www.ucdenver.edu/academics/colleges/PublicHealth/research/ResearchProjects/piper/projects/RIO/Documents/2012-13.pdf>.
- Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: prevention initiatives. *J Athl Train*. 2007;42:311–319.
- Baker SP, O'Neill B, Haddon W, et al. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma*. 1974;14:187–196.
- Mueller FO. Catastrophic head injuries in high school and collegiate sports. *J Athl Train*. 2001;36:312–315.
- Colburn NT, Meyer RD. Sports injury or trauma? Injuries of the competition off-road motorcycle. *Injury*. 2003;34:207–214.
- Luo TD, Clarke MJ, Zimmerman AK, et al. Concussion symptoms in youth motocross riders: a prospective, observational study. *J Neurosurg Pediatr*. 2015;15:255–260.
- Guskiewicz KM, Clarke MJ, Puffer R. Pediatric sports-related concussion. *PM R*. 2011;3:353–364.
- Daniels DJ, Clarke MJ, Puffer R, et al. High occurrence of head and spine injuries in the pediatric population following motocross accidents. *J Neurosurg Pediatr*. 2015;15:261–265.
- Stamm JM, Bourlas AP, Baugh CM, et al. Age of first exposure to football and later-life cognitive impairment in former NFL players. *Neurology*. 2015;85:1007.