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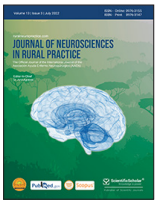

Brief Report

A retrospective study of helmet use and head injury in severe equestrian trauma

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ABSTRACT

Objectives: The aim of the study was to examine helmet use, incidence of injury, and patient outcomes in a rural cohort of equestrian accidents.

Material and Methods: EHR records of patients admitted to a Level II ACS trauma center in the North-west United States were reviewed for helmet use. Injuries were categorized according to International Classification of Diseases-9/10 code.

Results: Of 53 identified cases, helmets only reduced superficial injury (χ^2 (1) = 4.837, P = 0.028). Intracranial injury rates were not different between those with and without helmets ($P > 0.05$).

Conclusion: In equine related injury, helmets protect against superficial injury but not intracranial injury in Western riders. More investigation is needed to assess why this is the case and determine ways to decrease intracranial injury.

Keywords: Equestrian, Trauma, Helmet, Intracranial, Concussion

INTRODUCTION

Horses and equestrian sports are found across much of the globe and span diverse environments. Many still use horses as working animals. Despite being viewed as a relatively safe and bucolic pastime,[1] equestrian activities are among the most accident-prone, sustaining more injuries per hour than American Football, motorcycling, skiing, and car racing with a rate of approximately 0.49–0.6 hospital admissions per 1000 h.[2] Head injuries are among the most common injuries experienced in equestrian sports.[2] Concussion and traumatic brain injury (TBI) are frequently sustained by riders.[3-5] Children are particularly at risk of head injuries due to a greater head-to-body size ratio and are more likely to suffer from focal neurological deficits, epidural hematoma, and amnesia.[6]

Helmets are believed to reduce head injury frequency and severity. Helmets disperse the energy of an impact to the head. The previous work supports helmets as a means to reduce the likelihood of skull fractures;[7] however, there is still discussion surrounding their ability to prevent intracranial injuries. Helmets have traditionally been constructed to protect against linear impacts (impacts in which the energy vector is directed toward the center of mass of the head).[8] New evidence suggests, this offers inadequate protection in equine-related injuries which have rotational forces leading to intracranial injuries without skull fracture. Traditional helmet design will not mitigate these forces and may not protect against intracranial injury.[6,9]

Helmets are not well liked among ranchers and rodeo riders in the American West. Helmets are uncomfortable, reduce visibility, impair hearing, do not offer the sun or rain protection of a traditional cowboy hat, or are simply unconventional.[10] Regulations mandating helmets generally only apply to youth[11-13] or are optional for adults.[11,14-16] Absent from these guidelines is recommendations for helmet type and quality. As a result, many helmets used in rodeo are adapted from other sports such as hockey and use remains low in Western riding and it is unknown whether they improve health-care outcomes.

Horses are predominantly used in rural communities, making them the primary setting of injury. Pre-hospital times are high in rural areas, placing rural individuals at greater risk of a bad outcome relative to urban peers due to delayed care.[17-19] Therefore, it is important to understand the rate of helmet use in rural settings and assess effectiveness. This will enable

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individuals, clinicians, and policy makers to make informed choices concerning safety, prevention, and care.

In light of these issues, we conducted a retrospective analysis of equestrian trauma cases to examine helmet use, intracranial injury, and patient outcomes in a rural cohort from the North-west United States.

MATERIALS AND METHODS

This retrospective analysis examined patients with equine related injuries who presented at a Level II Trauma center in the North-west United States between 2011 and 2020. The sample was identified using the trauma registry. Cases were selected for inclusion if an injury occurred in an equine activity and helmet use or the lack thereof was recorded in the case notes. Demographic variables, International Classification of Diseases (ICD)-9/10 codes, Intensive care unit (ICU) length of stay, total length of stay, injury severity score (ISS), admission Glasgow Coma Scale (GCS), injury location, and rider activity were retrieved. Patients were coded through manual case review for rider experience. ICD-9 codes were converted to ICD-10 codes.[20] Injuries were classified by ICD-10 code as follows: Superficial injury (S00), open wound (S01), fracture of the skull and facial bones (S02), dislocation and sprain of the ligaments and joints of the head (S03), injury of cranial nerves (S04), injury of the eye and orbit (S05), intracranial injury (S06), crushing injury of the head (S07), avulsion and traumatic amputation of part of the head (S08), and other unspecified injuries of the head (S09). Concussions were also identified by ICD-10 code (S060).

Descriptive statistics were computed. Counts were used for categorical variables. Means and standard deviations were used to summarize continuous variables. Comparisons were made between groups through a Student's *t*-test for continuous variables or a Pearson's Chi-square analysis for categorical variables.

RESULTS

Fifty-two cases were identified. The sample was predominantly female (n = 33) and White (n = 48). Both groups were comparable in terms of age, gender, and body mass index, where their injury occurred, experience, and riding activity. Of those not wearing a helmet, most were riding as part of their work (43%) or recreation (33%). Most wearing helmets were riding for recreation (69%). When viewing those riding for work, only two (13%) wore a helmet. See [Table 1] for descriptive statistics.

Patient outcomes included: Incidence of injury, admission GCS, ISS, total hospital length of stay, and ICU length of stay. Differences between groups were present in the rate of superficial injuries to the head – nine individuals not wearing a helmet sustained superficial injuries, while none of those wearing a helmet sustained a superficial injury (χ^2 (1) = 4.837, P = 0.028). There were no differences between groups in all intracranial injuries (χ^2 (1) = 0.034, P = 0.85), concussions (χ^2 (1) = 0.076, P = 0.783), open wounds (χ^2 (1) = 0.068, P = 0.79), fractures of the skull and facial bones (χ^2 (1) = 0.018, P = 0.89), injury of the eye and orbit (χ^2 (1) = 0.45, P = 0.50), or other unspecified injuries (χ^2 (1) = 0.18, P = 0.67). There were no reported injuries in the following categories: Dislocation and sprain of the ligaments of the head, injury of the cranial nerves, crushing injury of the head, avulsion, and traumatic amputation. There was no difference in admission GCS, total length of stay, or ICU length of stay [Table 2].

DISCUSSION

This study builds on other studies examining the effectiveness of helmets in preventing injury in equestrian related trauma. Individuals in both groups were similar in terms of demographic characteristics, injuries, and outcomes. Helmets were found to prevent superficial injury; however, the rate of concussion, intracranial injury, open head wounds, skull fractures, injuries to the eye, orbit, and other unspecified injuries did not differ between groups. These findings partially contradict the prevailing narrative that helmets attenuate the rate of serious head injuries in equine accidents.

These findings are not without precedent. Recently, Clark *et al.*[9] found helmet testing standards do not match the stresses of equestrian accidents. Current testing involved

Table 1: Sample demographics.

	No Helmet	table	*P*-value
	n=36 (%)	*n*=16 (%)	
Age	39.2 (19.7)	34.8 (23.1)	0.507
Gender			0.143
Female	20 (55.6)	13 (81.2)	
Male	16 (44.4)	3 (18.8)	
Race			0.299
Caucasian/White	32 (88.9)	16 (100)	
Non-Caucasian	4 (11.1)	0 (0.00)	
BMI	30.5 (20.8)	24.9 (6.35)	0.163
RUCC of injury location:			0.664
3	19 (54.3)	7 (43.8)	
6	3 (8.57)	1 (6.25)	
7	7 (20.0)	4 (25.0)	
8	2 (5.71)	3 (18.8)	
9	4 (11.4)	1 (6.25)	
Riding activity			0.088
Recreation	10 (33.3)	9 (69.2)	
Rodeo	7 (23.3)	2 (15.4)	
Work	13 (43.3)	2 (15.4)	
Rider experience			0.133
Experienced	24 (85.7)	9 (64.3)	
Novice	4 (14.3)	5 (35.7)	

Table 2: Rider outcomes and injuries by ICD-9/10 code. Counts (percentage of group) are displayed for categorical variables while means (SD) are given for continuous variables.

	No Helmet	Helmet	OR	*P*-value
	n=36 (%)	*n*=16 (%)		
Concussion	12 (33.3)	4 (25)	0.68 (0.15;2.51)	0.783
Superficial Injury	9 (25.0)	0 (0.00)	-	0.028
Open Wound	3 (8.33)	1 (6.25)	0.80 (0.03;7.51)	1.000
Fracture of Skull and Facial Bones	5 (13.9)	2 (12.5)	0.92 (0.11;5.11)	1.000
Eye and Orbit	1 (2.78)	0 (0.00)	-	1.000
Intracranial Injury	19 (52.8)	8 (50.0)	0.90 (0.27;3.01)	1.000
Other/unspecified	0 (0.00)	1 (6.25)	-	0.308
Admission GCS	14.8 (0.38)	13.9 (2.91)		0.238
Injury Severity Score	8.97 (6.18)	8.81 (7.73)		0.942
Total LOS	3.11 (2.89)	2.44 (2.39)		0.386
Total ICU LOS	0.42 (0.84)	0.62 (0.96)		0.459

delivering linear blows to the top of a helmet mounted on a stationary anvil. After reviewing video evidence of 73 individual equestrian accidents, it was concluded that most impacts are oblique and were delivered to the sides, lower, and mid region of the back of the helmet. Therefore, traditional helmets are not designed to prevent concussions and other intracranial injuries. Connor *et al.*[7] came to similar conclusions in a recent study of 216 accidents. They found that head injuries occurred in 139 of the individuals. Of those, 126 included concussions.

The findings of this study contrast those of other investigations. Lemoine *et al.*[13] reported that helmet use was associated with decreased ISS, concussion and TBI, however, did so without a statistical comparison between groups by helmet use – the study examined only individuals who were not wearing a helmet and excluded those who did. Short *et al.*[21] aconducted a study of helmet use in pediatric cases and found differences in ISS, TBI, and ICU admission. Our findings differ, as we did not observe a difference between groups in terms of TBI or ISS-this may be due to differences in our cohort which was predominantly adult. Interestingly, our findings were similar, however, as neither detected differences in GCS scores or length of stay.

There are number of limitations to this study. Because this study was retrospective in nature and examined cases in the trauma registry, this study and its findings should only be applied to equestrian accidents that lead to hospitalization. Cases that did not require immediate medical attention or were not severe enough to require critical care services are not included in the trauma registry and not captured in this data. As a result, the study cohort represents a distinct subset of accidents. Less severe cases are also less likely to involve an oblique impact to the head; therefore, conventional helmets are likely well suited to protect riders in these cases, further preventing them from entering our cohort.

The retrospective nature of the study also reduces our ability to adequately capture helmet use rates accurately. Helmet use was only recorded for 18% of potential cases. Clinicians are not required to ask about helmet use; therefore, it is possible that some individuals were excluded who did wear a helmet and simply failed to report it. Incidentally, head injury of some kind was recorded for all 53 of the cases for whom helmet use was known. It is possible clinicians only asked about helmet use when a head injury was suspected or apparent. This would bias the results of the study to make helmets appear less effective, again by excluding cases in which helmets might have worked.

Sample size was also a limiting factor but unavoidable as the catchment region is highly rural and sparsely populated. This influenced the choice to categorize injury by ICD-10 code rather than more specific injury designations (e.g., subdural hematoma). This coarse method may have influenced the sensitivity of the analysis. A larger sample would have enabled a more detailed analysis of injury frequency, type, severity, and effect of helmet use. A follow-up study, with a larger sample size, will be necessary to confirm whether our observations are accurate.

Finally, the type and condition of the helmets are unknown. This study spanned 10 years of retrospective data. Helmet technology and testing standards have changed during that time. Multi-directional impact system technology was incorporated in some equestrian helmets as early as 2007.[22] However, helmets using the technology are costly, which has likely slowed adoption. In addition, helmet materials degrade over time, reducing their effectiveness, which is the primary reason why they all have an expiration date. It is possible that many of the helmets worn by this cohort were simply too old to effectively protect the rider, which would have contributed to increased incidence of skull fractures in the helmeted group and the lack of difference between those with and without helmets.

CONCLUSION

The findings of this retrospective analysis are that helmets do not prevent intracranial trauma in severe equine-related accidents, while somewhat counterintuitive and unsettling, this is not surprising in the context of prior work. This does not, however, mean that helmets do not provide protection to the user and do not change the outcome of an equine related accidents (in fact this study demonstrates a reduction in superficial injuries), rather it highlights the importance of developing better helmet technology and educating riders so they choose to utilize and maintain proper safety equipment.

Ethical clearance

Ethical approval for this study was given by the Privacy and Exemption Committee of Billings Clinic. This study also followed the guidelines set forth in the Declaration of Helsinki.

Declaration of patient consent

Patients' consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

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