Characteristics of Rodeo Injuries and Suggestions for Injury Prevention

A Systematic Review

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Background: Rodeo is a globally popular sport, with its athletes prone to various types of injuries. There is no systematic review discussing rodeo injuries across all age groups.

Purpose: To (1) review the published literature on incidence, types of injuries, and factors leading to injuries in rodeo athletes; (2) provide prevention recommendations for health care providers; and (3) identify gaps in the research.

Study Design: Systematic review; Level of evidence, 4.

Methods: A comprehensive search of available literature was electronically performed through MEDLINE, Embase, and SPORTDiscus databases using the key terms ''rodeo'' and ''injury'' or ''trauma'' between 1995 and 2021. A systematic review was performed using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, which identified 116 eligible studies. Outcome data included frequency of injuries, risk factors for injury, and types of injury.

Results: A total of 23 studies met the inclusion criteria (N = 2105 athletes), of which 13 were retrospective studies. In the included studies, the injury rate per competition exposure (CE) ranged from 4.2 to 19.1 injuries per 1000 CE. Sprains and strains accounted for the highest percentage of injury types, ranging from 15% to 34%. The knee was the most common location of injury, making up 11.1% to 17% of injuries. Concussions occurred in up to 15.3% of injuries for all events and up to 77% of injuries in roughstock events. Of all rodeo events reported, bull riding caused the highest percentage of injuries, making up 19.4% to 58.4% of injuries, and bareback had the second highest at 15.3% to 28.8% of injuries.

Conclusion: There was a high prevalence of various injury types and mechanisms in rodeo. Improved injury surveillance and the introduction of a comprehensive standardized injury reporting system would be helpful in the future prevention, diagnosis, and treatment of rodeo injuries.

Keywords: bareback; bull riding; concussion prevention; rodeo; rodeo injuries

The sport of rodeo involves a unique combination of large, unruly animals and very focused, goal-oriented individuals.[42] For the athletes involved, rodeo is more than a sport; it is an integral part of their work and lifestyle.[53] A part of American culture and history, as well as many cultures worldwide,[51] rodeo focuses on high-intensity bursts of human versus livestock action, which gives the sport an intense nature, a sense of danger, and an increased risk of injury that is not seen in traditional sports.[3] The sport of rodeo is broken up into 2 event types: (1) *roughstock* (untamed livestock likely to buck when ridden) and (2) timed events. The roughstock events include bull riding, saddle bronc, and bareback riding. The timed events include team roping, tie-down roping, barrel racing, and steer wrestling. Male-only events include all roughstock events, plus steer wrestling and tie-down roping. Events for female athletes include barrel racing, team roping, breakaway roping, and pole bending.

Roughstock events in rodeo have a higher rate of injury than timed events.[6,30,61] Bull riding is the most dangerous roughstock event.[3,6,61] While injury rates are high and fatalities have been reported in rodeo, there is still a concern for underreporting.[7] One reason for this is the personality of rodeo athletes, which leads them to "shake off" their injuries and provide their own treatment.[65] Rodeo athletes display an increase in resilience to pain and

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injury.[40,53,57,63] This aspect, combined with many extroverted, self-sufficient, and tough personalities, can lead rodeo athletes to suppress injuries and delay medical care.[20,42,38,63] In the rodeo sport, not competing because of an injury means not getting paid, incentivizing athletes to continue competing despite injuries.[6,9,18,61] In addition, rodeo provides many unique barriers to medical care access that are not seen in other sports. Many Professional Rodeo Cowboys Association (PRCA) rodeos and most non-PRCA rodeos do not have formal or sufficient medical coverage.[61] Rodeos held in geographically remote and distant locations frequently result in a lack of consistent access to health care providers and continuity of medical care.[8,36] The lack of adequate medical insurance for most rodeo athletes and the high volume of travel the athlete must endure independently without any coaching or medical support staff also contribute to low overall medical care.[8,65]

A review covering pediatric and adolescent injuries in rodeo was published in 2018 by Stoneback et al.[64] However, no systematic review has discussed rodeo injuries across all age groups. This study aimed to (1) comprehensively review the published literature on the incidence, types of injuries, and factors leading to injuries in rodeo athletes; (2) provide prevention recommendations for health care providers; and (3) identify gaps in the research. We hypothesized that roughstock events are the most common causes of injury in rodeo athletes, that interactions between the animal and athlete are the most common mechanism of injury, and that head contact, strains and sprains, and concussions, are the most common types of injury that these athletes endure.

METHODS

Literature Search

A comprehensive search of available literature was electronically performed through MEDLINE, Embase, and SPORTDiscus databases using the key terms "rodeo" and "injury" or "trauma" between 1995 and 2021, which were included in the initial review. Search results yielded 42 articles in PubMed/MEDLINE, 30 in Embase, and 44 in SPORTDiscus databases. Two reviewers (M.W.B., F.W.) independently analyzed the studies, and both reviewers verified duplicates. A third reviewer (C.B.P.) reconciled any disagreements on study selection. The exclusion criteria for the initial assessment were cases or case series with <5 athletes, studies that included injuries not sustained during a rodeo event, and studies that did not specify which rodeo events injuries occurred. Figure 1 demonstrates the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart of the study inclusion process.

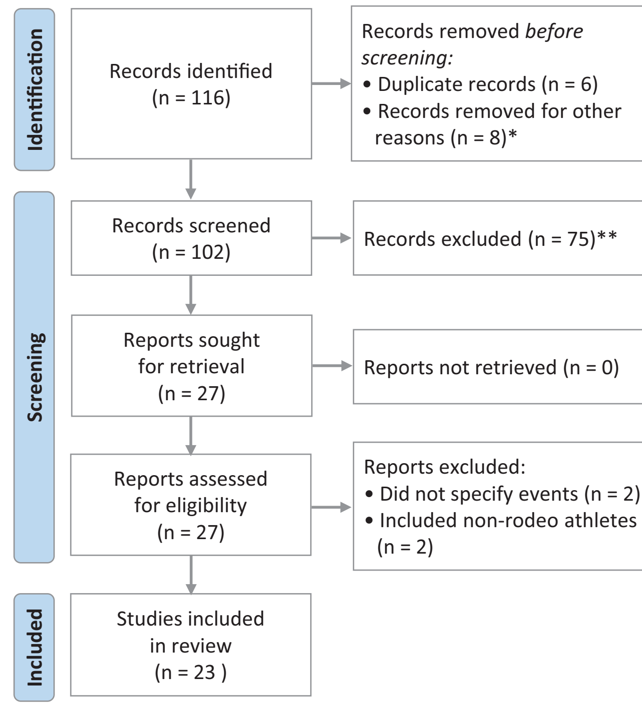

Figure 1. A PRISMA flow diagram describing the inclusion process for studies in the systematic review. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.
*Articles related only to animal injuries outside of rodeo or other sports.
**Articles that did not meet the minimum number of athletes (n = 5).

Definitions of Terms

According to MeSH (Medical Subject Headings), an *injury* is defined as "damage inflicted on the body as the direct or indirect result of an external force, with or without disruption of structural continuity." Because of the variety of literature review designs and the already low injury reporting rates for most rodeo athletes, it was difficult to have a standardized definition of injury or its severity that would capture most injuries. For this review, injury characteristics reported by health care professionals were

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grouped and compared when the classification was consistent. Reporting the injury rate as the number of injuries per 1000 competition exposures (CE) is the most useful way to compare rodeo injury rates to other sports, and it takes into account the risk of injury exposure. Most studies have used these measures.[6,8,9,11,60-63] Injuries classified in a unique way that could not be compared are reported separately. Crichlow et al[14] used injuries per rodeo, and Butterwick et al[7] reported injuries per participant. Four studies used voluntary assessments from rodeo participants.[6,8,9,11,45] Three studies[7,14,52] used surveys.

We referred to the explanation by Butterwick and Meeuwisse[8] to define an *experienced athlete* in this review: "a competitor at least 18 years old or was in the top 10 of the final standings in a recognized amateur rodeo association." Athletes who did not meet these criteria were considered to be inexperienced.

RESULTS

Table 1 presents the characteristics of the 23 studies[§] that met the inclusion criteria. Two of the 13 retrospective studies by Butterwick and Meeuwisse[8,9] were subanalyses of the 1995-1999 Canadian Professional Rodeo Association (CPRA) cohort in a study by Butterwick et al.[6] However, both subanalyses presented new data and thus were included in this review. Butterwick et al[11] reported injuries from the 1994 CPRA season. Two studies[21,60] focused only on adolescent rodeo athletes.

Injury Frequency

Table 2 presents the overall frequency of injuries reported for all rodeo events as well as the most frequently reported individual events. The overall injury rate in the reviewed studies was 14.7 to 25.2 injuries per 1000 CE.[6,8,61] Sinclair and Smidt[60] reported 8.20 injuries per 1000 CE in high school athletes, and Watts et al[66] reported a rate of 4.2 injuries per 1000 CE total in collegiate athletes. Bull riding accounted for 19.4% to 58.4% of injuries, and bareback riding had the second-highest injury rate[8,21,60,61] at 15.3% to 28.8%. Bull riding had an injury rate of 28.5 to 48.2 per 1000 CE, or a risk probability of 5.06% of injury, making bull riding over twice as dangerous per CE compared with all other rodeo events.[9,60,61] Of the timed events, steer wrestling had the highest injury rate, at 7.6 to 9.87 injuries per 1000 CE.[6,11,60,61] The lowest injury rate was reported as either ladies' barrel racing (1.5-5 injuries per 1000 CE) or team roping (0.5-0.6 injuries per 1000 CE).[60,61] Butterwick et al[7] reported a catastrophic injury rate of 9.45 to 19.81 per 100,000 participants and a fatality rate of 4.05 to 7.29 per 100,000 participants.

The study by Watts et al[66] was the only study to report time loss from injuries with respect to practice and competition. Injuries resulting in time lost from competition occurred at a rate of 6.82 per 1000 CE, and those resulting in time lost from practice occurred at a rate of 1.72 per 1000 CE; however, practice injuries accounted for 62.2% of all injuries. Miller et al[45] reported that 27% of competition injuries required an athlete to miss $\geq$1 rodeo events. A survey of athletes with a median competition duration of 9 years showed that 47% of athletes reported a history of injury, 33% of whom had an injury in the past 10 rodeos, with a rate of 14 injuries per 100 rodeos.[14]

Injury Types

Table 3 summarizes the most common injury types reported. As classified by Butterwick et al,[6] serious injuries accounted for 22.8% to 52% of injuries.[9,21,60] Livingston et al[36] reported fractures to make up 63% of injuries in athletes who required hospital admittance. The location of fractures was dispersed evenly between the face and extremities. Concussion frequency ranged from 5% to 15.3% of injuries for all events.[9,21,60,61,66] Concussions made up the highest proportion of head injuries, followed by lacerations.[6,60] Roughstock events had a concussion frequency of 12.8% to 77% of all injuries from roughstock events.[6,61] When evaluating self-reported injury history, 13% to 61% of rodeo athletes had sustained a concussion or head injury, and 17% had a fracture, sprain, or laceration.[14,54] Reinjuries only accounted for 5% of injuries.[9] Multiple injuries comprised 17% of injuries for all events and were more likely to occur during roughstock events.[6,9,45] When comparing injury type and livestock, bull riding resulted in higher proportions of contusions, while horse events involved more sprains and strains.[25]

Injury Location

Table 4 presents the percentage of total injuries in the most common locations. The knee was the most reported[6,11,61,66] injured area (11.1%-17%).The knee was also the most common injury location that required surgical intervention.[66] The next most common injury locations were the head (7.7%-14.4%) and the shoulder[61,66] (11%-12.2%). When examining orthopaedic injuries in bull riding athletes, 75% of dislocations and subluxations/labral tears occurred at the glenohumeral joint, while 62% of complete ligament tears were in the knee.[8] Head injuries accounted for 27% of injuries or 8.7 per 1000 CE in bull riding athletes but were reported[8,61] as low as 7.7%. Most of the injuries to the central nervous system (CNS), as reported by Brandenburg and Archer,[2] occurred between the ages of 15 and 19 years. Moneim et al[46] reported that 3 of 5 injuries in athletes <18 years were due to CNS trauma. Limb injuries were the most common cause of hospital admittance (52%), followed by the chest (15%) and the head[36] (12%). Butterwick et al[7] and Ketai et al[30] reported trauma to the thorax, chest, and abdomen as the primary location of catastrophic or traumatic rodeo injuries.

[§]References 2, 4, 6-9, 11, 12, 14, 20, 21, 30, 34, 36, 43, 45, 46, 54, 60-63, 66

TABLE 1
Included Studies and Representation of Athletes Evaluated[a]

Study	Study Type	Athletes, n	Mean Age, Years (Range)	Rodeo Events Recorded, n	Female Athletes	Data Collection Method	Dates of Injuries	Location	Level of Rodeo
Brandenburg and Archer[2]	Retrosp	81	20 (7-52)	1	No	Survey	Jun 5, 1995, to Jul 19, 1999	Oklahoma, USA	Pro, nonpro
Brandenburg et al[4]	Retrosp	34	Median, 18 (9-33)	1	No	Chart review	1992-1996	Oklahoma, USA	NR
Butterwick et al[6]	Prosp	323	NR	6	No	Voluntary assessment	1995-1999	Canada	Pro
Butterwick et al[7]	Retrosp, prosp	49	22 (9-49)	10	Yes	Chart review, survey	1989-2009	Canada and USA	NR
Butterwick and Meeuwisse[8]	Prosp	NR	18-28	1	Yes	Voluntary assessment	1995-1999	Canada	Pro
Butterwick and Meeuwisse[9]	Prosp	NR	NR	6	Yes	Voluntary assessment	1995-1999	Canada	Pro
Butterwick et al[11]	Prosp	NR	NR	5	No	Voluntary assessment	1994-1995	Canada	Pro
CDC[12b]	Retrosp	5	28, 14, 26, 15, 17	1	No	Chart review	1994-1995	Louisiana, USA	NR
Crichlow et al[14]	Retrosp	169	25 (17-59)	8	Yes	On-site survey	2004	California, USA	Pro
Figueiredo et al[20]	Retrosp	13	23.2 ± 4.4 (18-31)	1	No	Chart review	Apr 2010-Feb 2012	Brazil	NR
Forrester[21]	Retrosp	408	13-19	NR	Yes (15.3%)	Chart review	2000-2019	USA	Adolesc
Ketai et al[30]	Retrosp	39	27 ± 8.4	NR	Yes	Chart review	1990-1005	New Mexico, USA	NR
Lau et al[34]	Retrosp	9	35 ± 7 (30-51)	1	No	Chart review	1992-2008	Canada	NR
Livingston et al[36]	Retrosp	38	21.3 ± 6.13 (12-47)	1	NR	Chart review	Nov 2004-Nov 2010	Australia	NR
Meyers et al[43]	Retrosp	25	21 ± 1.4	2	No	Voluntary assessment	NR	USA	College
Miller et al[45]	Prosp	19	NR	6	Yes	Online survey	NR	USA	NR
Moneim et al[46]	Retrosp	19	30 (11-50)	1	Yes (26.3%)	Chart review	1983-2002	New Mexico, USA	NR
Ross et al[54]	Retrosp	189	18-36	3	No	Mailed survey	Jan 2004-Jun 2006	USA	Pro, college
Sinclair and Smidt[60]	Retrosp	334	NR	11	Yes	On-site injury surveillance	1996-2005	USA, Canada, Australia	High school
Sinclair Elder et al[61]	Retrosp	NR	NR	6	No	Chart review	2011-2014	USA, Canada, Brazil, Australia	Pro
Sinclair Elder and Tincknell[62]	Retrosp	82	NR	6	No	Chart review	2011-2014	USA, Canada, Brazil, Australia	Pro
Slawski and West[63]	Retrosp	5	23 (18-32)	1	No	Chart review	1995-1996	Missouri, USA	NR
Watts et al[66]	Retrosp	264	NR	9	Yes	Chart review	2016-2017	USA	College

[a]adolesc, adolescent; nonpro, nonprofessional; NR, not reported; Pro, professional; Prosp, prospective; Retrosp, retrospective.
[b]CDC, Centers for Disease Control and Prevention.

TABLE 2
Frequency and Breakdown of the Most Frequently Reported Injuries in the Evaluated Studies[a]

Study	No. of Injuries Reported	No. of CE	Injuries per CE	Injury Rate, Injuries per 1000 CE: Overall Injuries	Bull Riding Injuries	Bareback Injuries	Steer Wrestling Injuries
Butterwick and Meeuwisse[8]	141	4375	0.0322	32.2	NR	NR	NR
Butterwick and Meeuwisse[9]	275/53[b]	10,912/2782[b]	0.0252/0.0191[b]	25.2/19.1[b]	32.2/16.7[b]	24.5/25.3[b]	NR
Butterwick et al[6]	451	30,564	0.0147	14.7	32.2	24.5	9.3
Butterwick et al[11]	94	3882	0.0242	24.2	36.1	46.6	9.87
Sinclair and Smidt[60]	354	43,168	0.0082	8.20	28.5	31.9	7.6
Sinclair Elder et al[61]	2305	139,098	0.0166	16.6	48.2	41.2	8.1
Sinclair Elder and Tincknell[62]	84	76,146	0.0011	1.10	1.80	1.30	0.257
Watts et al[66]	98	23,122	0.0042	4.24	NR	NR	NR

[a]CE, competition exposures; NR, not reported.
[b]Data are shown as experienced athletes/inexperienced athletes.

Hip injuries were reported to occur in 6% to 10% of injuries and at a rate of 0.41 injuries per 1000 CE.[6,45,61] Roughstock events accounted for 83.3% of hip injuries.[62] The most common type of hip injury was contusions (45.2%) due to contact with objects or animals 65.8% of the time. Fractures and dislocations made up 6% of hip injuries.[62] Of hip impingement symptoms, 53.8% occurred while in the chute and most commonly in bareback riding and tie-down roping. Age and experience were shown to affect injury location. Inexperienced athletes had higher hand, wrist, and forearm injuries but lower rates of knee, thigh, elbow, and shoulder injuries at 0.5 to 1.5 injuries per 1000

TABLE 3
The Most Common Injury Types Reported in the Evaluated Studies[a]

Study	No. of Injury Types Reported	No. of Injuries Reported	Injury Type, %			
			Sprains and Strains	Contusions	Concussions	Fractures
Butterwick et al[6]	9	451	35.3	22	8.65	11.1
Butterwick and Meeuwisse[8]	15	141	28.4	19.2	10.6	12.8
Butterwick and Meeuwisse[9]	9	275/53	34.7/28.4	20.5/22.5	11.3/9.12	12.5/9.19
Forrester[21]	11	408	15	29.5	8	22.8
Sinclair and Smidt[60]	11	354	35	27.4	15.3	10.5
Sinclair Elder et al[61]	14	2305	24.9	23.1	11.6	7.16
Watts et al[66]	6	98	34	14	5	7

[a]Data are shown as experienced athletes/inexperienced athletes unless otherwise indicated.

TABLE 4
The Most Common Injury Locations Reported in the Evaluated Studies[a]

Study	No. of Injuries Reported	No. of Locations	Injury Location, %						
			Knee	Head	Shoulder	Elbow	Hand and Wrist	Hip	Ankle
Butterwick et al[6]	451	19	16.9	5.76	9.31	3.77	9.53	3.99	5.10
Sinclair and Smidt[60]	354	24	8.76	17.8	11.3	1.41	7.06	1.13	8.47
Sinclair Elder et al[61]	2,305	23	11.1	7.72	11	3.73	9.93	5.94	4.12
Watts et al[66]	98	NR	14.3	NR	12.2	NR	NR	NR	NR

[a]NR, not reported.

CE.[9] The head and neck were most commonly affected in adolescents (17.8%-26.9%), followed by the shoulder (10.2%-11.35%) and the knee[21,60] (8.4%-9%).

Meyers et al[43] retrospectively analyzed radiographs of the upper extremity of college rodeo athletes and reported approximately 3.28 abnormalities per athlete. The hand/wrist comprised 52% of abnormalities, 52.6% of which were fractures and 32% of degenerative joint disease. Elbows comprised 26% of anomalies, the majority being degenerative joint disease.

Slawski and West[63] reported 5 cases of syndesmotic ankle injuries. Four cases were surgically repaired, and all athletes returned to competition within 7 to 10 weeks. The non–surgically treated patient reported continuous moderate pain after returning to competition. Figueiredo et al[20] reported on 13 bull riders with anterior glenohumeral instability, all in the athletes' free arm. [20] All patients underwent open bone block procedures for repair and returned to competition within 2 to 10 months, with axillary neuropraxia being the primary complication. Lau et al[34] reported 9 cases of complete pectoralis major tendon ruptures in steer wrestlers. Eight of the 9 athletes returned to competition after surgical repair. Moneim et al[46] reported on 19 team ropers with thumb avulsions or crushes that required microvascular repair for reattachment. Of the 19 athletes, 63% had complete amputations, and only 33% had successful replantation.

Catastrophic Injuries and Fatalities

Roughstock events had the highest frequency of nonfatal injuries and fatalities.[7] Bull riding caused most of the roughstock catastrophic injuries[7] (82.6%). Of 5 bull riding CNS trauma patients reported, 4 had severe cognitive and behavioral impairments, including quadriplegia and vegetative state.[12] However, in Butterwick et al,[8] there were no fatalities out of 4375 CE of bull riding. Although timed events are generally safer, 3 catastrophic injuries were reported, 2 of which were fatalities in ladies barrel racing due to head injury.[7] Thoracic compression fatalities accounted for 76.19% of fatalities[7] (16/21). Ketai et al[30] reported 1 fatality due to postinjury acute respiratory distress syndrome.[30] Competitors <17 years had an increased incidence of catastrophic injuries and fatalities, making up 29% of injuries and 33% of fatalities.[7] Most traumatic brain injuries occurred in adolescents.[2,7] Brandenburg et al[2] reported 1 fatality in an adolescent out of 34 traumatic CNS injuries. In high school athletes, 0.56% of injuries were life-threatening due to internal organ damage.[60]

Injury Mechanism

Table 5 presents the injury mechanism for all rodeo events. Impact with the ground was the most common cause of

TABLE 5
Most Common Mechanism of Injury Reported in Evaluated Studies

Study	Total Injuries Reported, n	Mechanism of Injury, %			
		Impact With Ground	Stepped on by Animal	Kicked by Animal	Other Animal Contact
Forrester[21]	408	41.4	22.4	5.9	7.4
Sinclair and Smidt[60]	354	25.2	15.7	7.91	5.37
Sinclair Elder et al[61]	2,305	26.6	15.4	2.73	20.9
Sinclair and Tincknell[62]	84	36.9	10.7	2.38	8.3

injury (25.2%-41.4%), but no fatalites.[21,60,61] In 15 cases of glenohumeral dislocation, all were caused by contact with the ground, causing arm abduction and external rotation.[20] Being stepped on by an animal was the next most common cause of injury.[12,27,28,63] This mechanism was also the cause of 5 of the cases of syndesmotic ankle injuries.[63] Athletes kicked by an animal was the most likely cause of multiple injuries.[4,57,60,61] Concussions and CNS injuries were most likely to be caused by contact of the athlete's head with the ground or the head of the animal.[2,4,6,8,12,21] The athlete-livestock contact accounted for 70% of catastrophic injuries and 75% of fatalities.[3,7,30] Hip injuries were primarily caused by collisions with the ground, animal, or arena infrastructure during dismount or while in the chute 65.5% of the time.[62] Pectoralis major tendon ruptures in steer wrestling were caused primarily by the throwing phase of the steer and secondarily by using the arm to break a fall, both due to unexpected behavior of the steer.[34] Finger or thumb avulsions or crushes occur almost exclusively in team roping when dallying the rope to the saddle horn, and the thumb or hand gets caught in a coil of the rope.[46]

Sinclair Elder et al[61] and Sinclair and Schmidt[60] evaluated the activity phase of the event in which injuries occurred. Injuries mainly occurred during or after the dismount and secondly while in the chute.[61] This pattern was the same when analyzing bull riders in isolation. This pattern was the opposite in saddle bronc and bareback. Timed event athletes were typically injured during the throwing or tying portions of their events.[61]

Protective Equipment and Injury

Several studies did not report the use of protective equipment by the athletes.[6,9,61] Only 11% to 40% of athletes reported wearing protective gear.[14,54] However, 0% of steer wrestlers reported wearing a protective vest.[14] While 21% of roughstock riders always wear a helmet, 96% always wear a vest.[54] Bull riders are 15 times more likely to wear a helmet than horseback riders and more likely to wear protective equipment overall.[54] The absence of protective headgear was present in all fatal head injuries.[7] In comparison, protective vests were worn in all but 1 thoracic fatality.[7] In a survey of bull riders, 74% of head injuries, including 2 cases of permanent brain damage, occurred without a helmet.[4] In injuries requiring inpatient admittance, 54% of bull riders wore a helmet, 100% wore a vest, and all head injuries occurred in riders wearing a helmet during the event.[36] Overall, wearing a helmet was most preventative of concussions and facial fractures caused by impact on the head of the animal.[4,54]

DISCUSSION

The major findings from this systematic review demonstrate a rodeo injury rate of 4.2 to 19.1 injuries per 1000 CE. Roughstock events, particularly bull riding, put athletes at the greatest risk of injury (19.4%-58.4%). This review also showed that the most common rodeo injuries are sprains and strains in many locations (15%-35.3%), specifically the knee (8.76%-16.9%). However, there is also a high rate of concussions (5%-15.3%). These injuries most commonly occur due to contact between the athlete and the ground (25.2%-41.4%), but the most dangerous injuries occur when there is contact between the athlete and the animal. This study also showed the high rate of lack of protective equipment use among rodeo athletes.

Of the studies included in this review, the injury rate per CE ranged from 4.2 to 19.1 injuries per 1000 CE for rodeo athletes in varying populations.[6,9,60,61,66] This is lower than reported in previous studies (43-197 injuries per 1000 CE).[24,41] However, recent studies support a lower injury rate (2.47-16.6 injuries per 1000 CE).[60,61,66]

Sprains and strains accounted for the highest percentage of injury types.[9,21,45,60,61,66] The most common location of injury ranged from the knee to neurologic injuries and head injuries.[6,61,66] Most injuries in rodeo athletes occur due to the impact on the ground after being thrown from an animal. However, the most dangerous mechanism of injury occurs when there is contact between the athlete and the livestock, such as being kicked or head-to-head contact.[3,4,57,60,61] While reinjury should still be considered in an injured rodeo athlete, reinjury is uncommon, and instead, most injuries are new injuries.[6] Novice riders were found to have a higher rate of contusions and subluxations/dislocations than the experienced athletes but a lower incidence of concussions, fractures, and sprains than experienced riders.[9] However, the frequency difference was reported to be only 1 to 2 injuries per 1000 CE, indicating that experience does not significantly impact the type of injury an athlete could experience.

Of all rodeo injuries reported, bull riding caused the highest percentage of injuries, making up 19.4% to 58.4%

of injuries, and bareback had the second highest at 15.3% to 28.8% of injuries.[9,21,60,61,66] Bull riding had the highest injury rate of any event, sustained the highest percentage of severe injuries, and is the most likely to cause multiple injuries in 1 CE. Bull riding and steer wrestling were most likely to cause injuries requiring surgery treatment.[66] Steer wrestling had the highest injury rate of the timed events. The lowest injury rate was reported as either ladies barrel racing with an injury rate of 1.5 to 5 per 1000 CE or team roping at 0.5 to 0.6 per 1000 CE.[60,61] However, barrel racing caused the only reported fatalities of timed events.[7] Timed event injuries appear to have fewer neurological injuries; however, knee and shoulder injuries occur at a similar rate.[61]

Much of the research published has focused primarily on the male-only roughstock events and timed events, with little reporting on female injury data. This leaves out a nonnegligible portion of rodeo athletes. More injury reporting needs to be done in this area to design injury prevention strategies that serve all rodeo athletes.

Injury Characteristics

Health care practitioners should be prepared to treat many types of orthopaedic injuries, specifically in the shoulder, knee, ankle, and elbow. Radiographic findings reflect the reports of other studies of increased incidence of upper extremity injuries.[43] The primary reasons for these orthopaedic limb injuries are high-impact short-fall bracing and frequent repetitive forces through the arm.[14] The forces that a rodeo athletes' gripping arm experiences are so great that they lead to bone hypertrophy causing a 42% increase in bone diameter.[17] Furthermore, the impact these forces can have is emphasized in reported steer wrestling injuries, including pectoralis major tears and latissimus dorsi ruptures.[10,20,26,34] In bull riding and saddle bronc, if the rider's hand gets "hung up" on dismounting the animal, hyperextension of the elbow can occur. Thus, athletes should have both free and gripping arms evaluated for injuries.[23] Although athletes might understand the safe ways to dismount their animals, it is challenging in practice. An athlete can try to alter how they hit the ground to avoid injury, such as tucking into a ball, but these strategies are not typically utilized.[36] Preventative measures such as shoulder and elbow braces have been suggested in the literature to decrease these forces.[16] However, their effectiveness in injury prevention should be studied.

While hip injuries are not the most common rodeo injuries, they can significantly impair an athlete's ability to perform. Athletes in roughstock events are most likely to incur hip contusions because of impact on the ground or arena structures.[62] Hip injuries were less likely to be fractures or dislocations than any other joints described in the literature. The deep location of the hip socket and its capability to exert and withstand a high load of force most likely contribute to this difference.

Trauma to the thorax, chest, and abdomen was the leading cause of catastrophic rodeo injuries.[7,30] Trauma to the chest was the most common cause of inpatient admittance of bull riders when limb injuries were excluded.[36] However, the abdomen was one of the least commonly injured areas, and there were no reported fatalities, with all riders wearing protective vests.[36] It cannot be determined whether this difference is due to convenience sampling or external factors. Interestingly, there was only 1 reported thoracic injury out of 30,564 CEs in a study by Butterwick and Meeuwisse.[9] However, thoracic injury was the most common cause of fatality.[6,7,21] Thoracic injuries are rare, but they can result in the most severe outcomes.

Roughstock events, specifically bull riding, were the most common cause of nonfatal injuries and fatalities. Severe CNS injuries were more common in adolescent rodeo athletes, and there was an increased catastrophic injury incidence in athletes <17 years.[2,4,7] Thus, increased care should be taken to prevent adolescent injuries. Although these are frightening statistics, most rodeo injuries are minor regardless of age, and inexperienced riders have a higher proportion of minor injuries to severe injuries.[9]

Livingston et al[36] reported that 64% of injuries recorded required surgical treatment. In a separate study of injuries that did require surgical intervention, the knee was the most common surgical site.[66] However, the usage of surgical treatment for specific injuries was not reported and would be a helpful measurement in future studies.

Unlike most rodeo events, team roping utilizes 2 athletes, a heeler and a header, who must attempt to halt a steer by roping the horns and heels.[27,31,47] Team roping can cause thumb or finger injuries, including avulsions.[27,31,46,47] Avulsions typically occur when the thumb is pointed down and gets caught in the dallying loops and the saddle horn. Avulsions can still occur when the thumb is pointed up, forming a second horn for the rope to constrict the thumb. If an athlete does not manage the unwinding of the rope coils in the opposite hand, digit injury can occur. Thumb injuries requiring replantation efforts have a 36% to 68.1% success rate depending on the injury mechanism, with avulsions having the worst prognosis.[13,15,22,50]

Moneim et al[46] reported that only one-third of team roping athletes had a successful replantation, with most replantation failures occurring due to avulsion. These results indicate that team ropers are more likely to sustain thumb injuries that do not successfully replant.

Overall, a standard of data collection methods, injury rate reporting, and injuries reported need to be established in the literature on rodeo injuries to allow for more generalizable conclusions on various factors and occurrences of rodeo injuries.

Head Injuries and Concussion Prevention

Concussions or head injuries are among the leading injuries in all rodeo athletes[9,21,60,61,66] (5%-15.3%). Concussion rates in roughstock events were even more significant[6,61] (12.8%-77%). Bull riding specifically is the leading cause of concussions in rodeo.[6] The protective gear available to rodeo athletes includes helmets, vests, and mouthpieces.[46] Recent innovations such as the Bull Tough Helmet have given rodeo athletes sport-specific headgear.[4,14] The use of helmets has been shown to decrease the likelihood of concussions and traumatic brain injuries in both rodeo and recreational equestrian and bull riding.[2,4,54,58] While there have been no direct studies of concussion prevention with mouthguards in rodeo athletes, studies in other sports have shown that mouthpieces reduce forces that cause orodental injuries and concussions[1,32,33] Most head traumas reported in this review occurred in athletes not wearing a helmet.[2,7,14] Despite this, only 21% of athletes always wear a helmet, mostly due to performance issues such as restricted vision and the fact that helmets are "not cowboy."[2,54] Helmets and mouthguards are mandated for athletes in high school and college rodeo, but these rules do not extend to local events.[48] Mandating helmet and mouthguard use in this population is essential, considering that adolescent athletes are at a higher risk of concussions and catastrophic head and CNS injuries.[2,4,7,12,21,60] Ketai et al[30] reported that only 13% of rodeo athletes reported head or neck trauma and suggested that helmet usage is not warranted in rodeo athletes. However, this study only included patients who presented to the emergency department or were admitted, possibly excluding many athletes who did not report to the hospital with concussions or other head injuries.

Although the more recent studies reported a higher rate of concussions, this could be due to higher quality of livestock used, increased awareness of concussions, or increased presence of medical staff.[6,60] It is still of concern that many concussions are being underreported. A survey of a small sample of rodeo athletes revealed that 32% hid concussion symptoms and continued to compete, while 63% who knew that they had a concussion did not seek medical care.[55] However, even these underreporting rates are probably much higher.

Current guidelines for concussion management by health care providers include preseason education, a multidisciplinary approach to management after acute diagnosis, and gradual postinjury exposure to the sport and cognitive activity.[37] The barriers mentioned previously put rodeo athletes in a nonideal situation for proper concussion management. Wicklund et al[67] adapted general sport concussion guidelines by McCrory et al[37] to apply to rodeo athletes. Implementing this routine at the youth level could lead to long-term improvements in concussion reporting and care. Clinicians should also attempt to educate rodeo athletes on the importance of helmets and concussion protocols when appropriate and implement rehabilitation measures that will be best followed.[64] Continued research into the concussion prevention strategies and concussion treatments in the rodeo athlete is still needed.

Physical Activity and Training

With most traditional sports, training occurs with sport-specific and traditional training measures, leading to improved performance and injury prevention.[19,49,59] In rodeo, many of the athletes get exercise from labor-intensive jobs or hobbies such as farming and do not utilize traditional gym-based exercise regimens. Sinclair and Ransone[59] reported that 69.4% of rodeo athletes lifted objects during ≥25% of their day. Despite their nontraditional training methods, the amount of physical activity and metabolic rate in rodeo athletes has not been shown to affect injury rates.[44] In college rodeo athletes, 88% of athletes implemented running or walking in their training but spent most of their time training for specific events.[45] It has also been reported that up to 43% of college rodeo athletes maintain no conditioning regimen.[25] These data indicate that sport-specific training may benefit the rodeo athlete and possibly prevent injury.

One of the main injury mechanisms in rodeo is when the athlete makes contact with the ground.[21,60,61] The athlete must withstand high volumes of eccentric load during contact with the ground. The more neuromuscular control a rodeo athlete has, the more likely the athlete can respond to the rapidly occurring high forces characteristic of the sport. Implementing eccentric resistance exercise has been shown to increase neuromuscular control and could be of value to the rodeo athlete.[35] Sinclair Elder and Tincknell[62] recommended implementing eccentric hip strength training in rodeo athletes to prevent the high occurrence of hip muscle strains. A training protocol utilizing traditional and sport-specific training for steer wrestling was reported by Harris et al.[25] These training modalities should be implemented outside of event-specific practice, as increased frequency of event practice may increase the risk of injury.[45,66] Further research is needed to determine the effectiveness of these interventions.

Warm-up and stretching have also been shown to help prevent injury and are commonly implemented in traditional sports.[39,68] No prospective studies have identified warm-up or stretching implementation on the occurrence of rodeo injuries. Implementing such protocols could help prevent muscular injuries due to unpredictable forces on the athlete.

Justin Sportsmedicine Team

While medical personnel staffing at rodeo events can be sparse, the Justin Sportsmedicine Team (JST) has worked to bridge this gap in the United States for over 40 years. The JST is composed of physicians, athletic trainers, and other health care providers who volunteer to cover over 125 rodeos and 600 performances every year.[28] Their website also provides instructional videos and articles on rehabilitation exercises, taping, and bracing that athletes can access and implement in their training.

Suggestions for Injury Prevention

Finding ways to decrease this risk of injury in rodeo athletes could compound into decreased medical costs to the athlete, prevent lost income, and increase quality of life as these injuries compile throughout an athlete's career. One suggestion for injury prevention is the development of vests that can withstand the penetrating and compressive forces of a bull's hoof.[30] Thoracic compression forces were the number 1 cause of rodeo fatalities, and all but 1 fatality was wearing a traditional vest.[7,30] The vests worn by rodeo athletes are flak-jacket vests made from various materials, such as leather. Bull riders tend to wear protective vests more than horseback riders.[54] While vests protect the abdomen and chest from penetrative forces, they do not protect from compressive forces. The mean surface area of a bull's front limb hooves is 0.0122 m^2, and the hind limb hooves[52] are 0.0102 m^2. Based on the forces reported by Savage et al,[56] the estimated pressure produced by a bull ranges from 2.29 to 2.58 MPa for the front hooves and 8.96 to 10.42 MPa for the back hooves. The tensile strength that Kevlar composites can withstand far exceeds this force.[29] Applying orthotic abdominal and chest plates could protect from compressive forces. Integrating these 2 components into rodeo equipment, similarly to military equipment, would provide protection while maintaining the utility and movement that athletes desire.

Helmets reduce the occurrence of head injuries. While national organizations have taken steps to implement guidelines for rodeo athletes, such as the First International Rodeo Research and Clinical Care Conference[5] in 2004, these guidelines do not extend to local and youth rodeo events. Implementing legislation requiring helmet usage at more rodeo events could help decrease preventable injuries. While a huge cultural barrier must be overcome for this suggestion to be implemented, proper education beginning at all levels of competition could change the culture to be more accepting of protective equipment use.

Many injuries could be avoided with proper injury prevention strategies, such as braces, taping, and proper strength and conditioning. One possible suggestion would be to educate athletic trainers who work at frequent smaller rodeos on these prevention strategies and provide them with resources to educate athletes, including the free resources that the JST offers on prehabilitation and rehabilitation. These strategies could help lower the rates of injuries that account for the highest percentage of injuries in rodeo. Implementing these prevention strategies is imperative for a rodeo athlete's continued health and longevity. As the public pays more attention to the long-term effects of injuries, such as head trauma in football, it is the hope that rodeo will garner equal attention for prevention and safety.

Limitations

One of the limitations of this study is the lack of epidemiological research within this field. Only 4 articles in this review looked at epidemiological factors in rodeo injuries.[6,9,59,60] Slawski and West[63] reported that rodeo athletes are prone to avoid medical treatment. Avoiding medical treatment could result in the underreporting of injuries in the studies evaluated. There are several possible causes of the variability in injury rates. A factor that should be considered is the tendency of rodeo athletes to underreport injuries.[53] Further epidemiological studies should be performed to understand the injury risk of rodeo athletes in events. When discussing the effects of experience on rodeo injuries, it must be noted that the inexperienced riders were most likely riding animals that are calmer and produce less force.[9]

CONCLUSION

This review presents the latest data on the characteristics of injuries in rodeo athletes. Rodeo injuries occur up to 25 times per 1000 CE, with strains, sprains, and contusions being the most common injury types. The knee and head are the most common locations for injuries, and contact with the ground is the most common cause of injury. Of all events, bull riding and bareback riding caused most of the injuries. Health care providers need to understand the risk of injury, risk factors for injuries, types of injuries, and potential preventative measures in rodeo athletes.

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