

RESEARCH ARTICLE

Self-reported acute injury and chronic pain in American equestrian athletes

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Abstract

The use of trauma databases for epidemiological study of equestrian injuries is well established. However, such databases fail to capture minor injuries or injuries when medical attention is not sought. Additionally, concerns about chronic pain in equestrians have only been explored in small samples. The current study is the first nationwide survey of American equestrians 12 years and older participating in all equestrian disciplines. This study aimed to evaluate the patterns of self-reported acute injuries, behaviours of seeking medical attention for acute injuries, and chronic pain. A convenience sample of 2,573 American equestrians completed an anonymous online survey with questions on acute injury anatomical region, type, and if they sought medical attention. Additional questions identified frequency and location of chronic pain. In total, 2,049 survey responses were complete, with 96% female and representation from all regions of the United States. Participation status (PS) was categorised as professionals (19%), amateurs (43%), and recreational (38%). PS was associated with acute injury and chronic pain frequency. Only 3.9% had never experienced an acute injury from equestrian activity. Of all injuries, foot injuries were most reported (13% of all injuries; 52% of participants) with only 39% seeking medical attention. Professionals had higher odds of experiencing acute injuries in most anatomical regions. 42% indicated they had encountered a concussion; of those, 71% sought medical assistance due to a suspected concussion. Chronic back pain frequency was reported at 27.5%. This study is the first to evaluate self-reported injury in a large convenience sample of American equestrians. The current study found a higher rate of lower extremity injuries in equestrians than previously captured in trauma databases. Prior concussion and acute injury increased the odds of individuals experiencing regional chronic pain, suggesting that future studies and interventions should focus on improving preventative and rehabilitative care.

Keywords

sport injury – horseback riding – sport – injury reporting

1 Introduction

Equestrian-related injuries (e.g. individuals injured from interacting with horses) have been explored primarily within epidemiological databases focused on severe trauma. Heinrich's Triangle Theory is the first to high-

light a relationship between near-misses, minor, and serious accidents to focus policy changes around safety (Figure 1). The theory assumes that the near-misses at the bottom of the triangle and minor events in the middle will significantly outweigh the number of severe events at the point of the triangle (Heinrich, 1941).

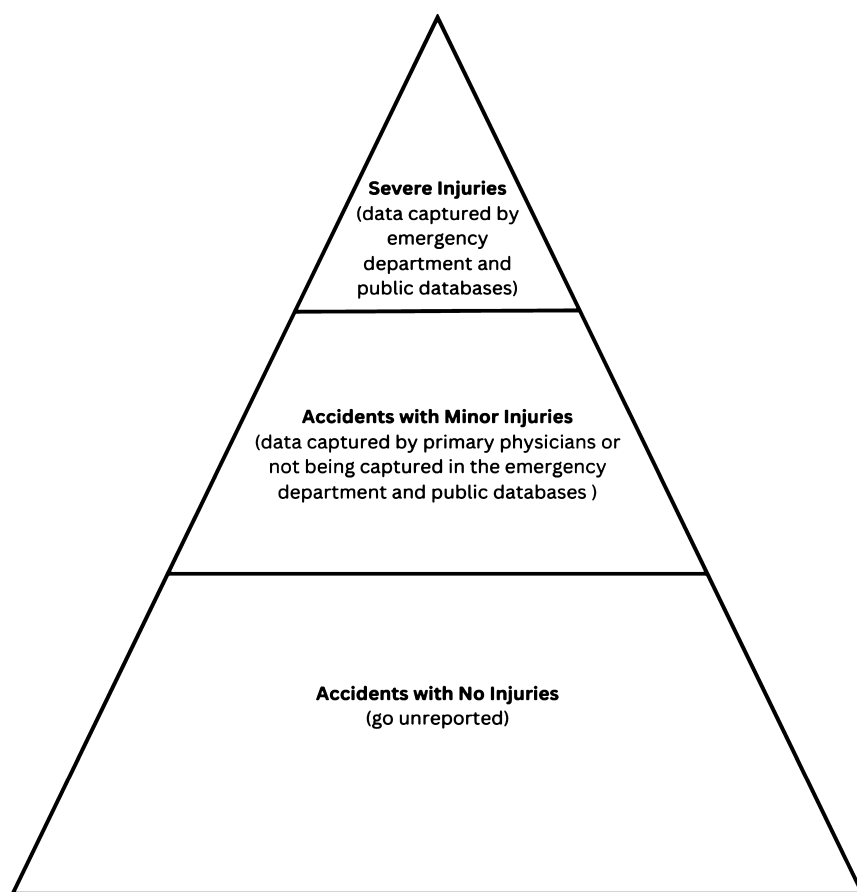


FIGURE 1 Heinrich's Triangle Theory adapted to fit equestrian sport.

Lindahl and colleagues' application of Heinrich's triangle theory to equestrian work sectors supports further investigation into equestrian-related injury beyond severe traumas (Lindahl *et al.*, 2022).

Equestrian activities offer a diverse range of disciplines (e.g. dressage, eventing, carriage driving, vaulting, barrel racing,) and vast opportunities for individuals to engage in physical activity across their lifespan, but equestrian activities come with an inherent risk (Keener *et al.*, 2023; Loder, 2008). Epidemiological studies evaluating emergency department (ED) and public health databases have highlighted that these activities have higher hospital admission rates compared to participation in rugby or football, skiing, or riding motorcycles (Ball *et al.*, 2007; Buckley *et al.*, 1993; Ekberg *et al.*, 2011; Sorli, 2000; Thompson *et al.*, 2015; Zuckerman *et al.*, 2015). However, these studies are limited in scope. Injuries are missed when individuals seek medical care from primary physicians, urgent care, or continue to ride while injured (Lindahl *et al.*, 2022; Loder, 2008; O'Brien, 2016). Like Heinrich's Triangle Theory, ED databases capture the serious injuries equestrians' experience, representing the number at the top of the triangle. Further anecdotal evidence indicates a signif-

icantly higher number of minor injuries in equestrian activities go unreported and uncaptured in ED or other epidemiological studies.

Organisational culture often dictates how individuals interact and communicate (Wreathall, 1995). Equestrian culture places higher importance on the horse's health and safety than the rider's (Kuhl *et al.*, 2014; Thompson *et al.*, 2015). Equestrians are often encouraged to get back in the saddle immediately after a fall unless severely hurt or impaired (Broshek, 2001; Kuhl *et al.*, 2014). Employees in equestrian occupations have generally accepted and normalised that working with horses will result in minor injuries, leading them to not report such injuries and events to their workplace (Lindahl *et al.*, 2022). As a result, underreported injuries make it difficult for organisations to adequately assess policy around injuries, pain, and missed work.

Acute pain, whether from reported or unreported events, often morphs into chronic pain. Over half of the equestrians hospitalised from an equine-related event report chronic physical symptoms, including chronic pain post-discharge (Ball *et al.*, 2009; Lavand'homme, 2011). In addition to a high rate of equestrians experiencing chronic pain after an acute injury, equestrians

are at a high risk of concussion. A recent study reporting 53.2% of equestrians have experienced a concussion during their riding career (Stanfill *et al.*, 2021). Concussions put individuals at a greater risk of experiencing mental, emotional, and physical health concerns, including an increased risk of experiencing chronic pain (Irvine and Clark, 2017). Considering the high risk of concussion and acute injury, a broad range of equestrians might experience long-lasting pain.

Chronic pain is joint in athletic and occupational populations and can stem from overuse (Dahlhamer *et al.*, 2018; Franco *et al.*, 2021). Like runners experiencing chronic knee pain from force attenuation across the joint, equestrians are at a high risk of back pain from repeated impact to the spine while sitting in the saddle (Keener *et al.*, 2021; Kraft *et al.*, 2007). Chronic low back pain estimates in equestrians are as high as 88% in dressage riders (Kraft *et al.*, 2009). Rates of chronic back pain in equestrians are pointedly higher than the general American population, estimated to be 20.4% (Dahlhamer *et al.*, 2018). In addition to chronic low back pain, chronic knee and hip pain are common complaints in equestrians (Ekberg *et al.*, 2011; Lewis and Baldwin, 2018; Lewis *et al.*, 2018; Lewis and Kennerley, 2017; Voscopoulos and Lema, 2010).

Chronic pain is a critical public health concern, with associated costs of \$560-635 billion per year in medical bills and lost productivity in the United States (Cohen *et al.*, 2021; Steglitz *et al.*, 2012). Chronic pain can lead to decreased quality of life and an increased likelihood of isolation, drug dependency, and mental health problems (Cohen *et al.*, 2021; Dahlhamer *et al.*, 2018; Yong *et al.*, 2022). Chronic pain in equestrians could manifest from an acute injury, a concussion, or overuse, making it critical to understand the frequency of chronic pain in a larger, more diverse equestrian sample than previously identified. Understanding health risks the equestrian population experiences helps shape future protocols and policy changes to improve equestrians' health and wellness.

Overall, this study has three aims. The first aim assessed the frequency of self-reported acute injury by anatomical region and associations with equestrian activity participation status (professional, amateur, or recreational). The second aim described the rate of American equestrians seeking medical attention for an acute injury by anatomical location. The third aim evaluated self-reported chronic pain by anatomical region associated with participation status, and self-reported acute injury by anatomical region.

2 Materials and methods

The University of Kentucky's Institutional Review Board (IRB) approved a survey distributed through email, social media, and QR codes to collect data from equestrians in the United States. IRB approval included individuals as young as age 12 years old without additional parental consent, as no identifiable information was collected, and no questions were considered worrisome or dangerous. The survey was voluntarily accessed from September 2020 to May 2022 and was protected with a CAPTCHA to ensure human participation only. The cover letter provided details of the survey, possible risks of participation, and contact information for the principal investigator and the university's IRB. The comprehensive survey included up to 162 fields; data from 107 fields were used in the current study. The survey used branching logic for adaptive questioning and collected data in a minimum of 34 fields for each participant. Prior data from the same survey was reported previously (Keener *et al.*, 2023).

To capture and manage the survey data, the research team used REDCap, an electronic data tool hosted by the university (Harris *et al.*, 2009, 2019). The survey did not capture personal information such as IP address, name, contact information, specific age, or state of residency (except for Hawaii and Alaska). No incentives were provided for survey completion.

Survey development

The survey was developed to capture acute injuries, chronic pain, and medical attention-seeking in equestrian athletes. It underwent review and revisions by a diverse group of equestrian athletes for applicability and ease of use. The research team then tested the adaptive branching and presentation of the survey questions on various devices. The sections and questions were presented in the same order for all participants.

Inclusion and exclusion criteria

Participants had to answer three questions about their current residence, age range, and equestrian participation status for inclusion in the study. Those who did not meet the inclusion criteria or failed to answer the questions were thanked for their interest, and the survey was stopped immediately. Inclusion criteria included being 12 years or older, living in the United States, and current participation in horse-related activities.

Demographics

Demographics questions included region of residence, sex, ethnicity, age, height, and weight, with categorical options to maintain anonymity. A 'prefer not to answer' option was provided for each question. Participants reported their involvement length and participation status (PS), with options like previous studies (Williams, 2017): professional (receiving payment), amateur (competitive without compensation), recreational (non-competitive), or other, with an opportunity to explain. Participants indicated their equestrian disciplines from a list of 23, with room for additional explanations. Finally, participants reported their weekly consistency of participation in the past six months, with options for frequency (e.g. daily, 5-6 days a week, 3-4 days a week, 1-2 days a week).

Injury history and reporting

Individuals were asked to reflect on their history of participation in all equestrian activities and indicate all the regions of their bodies where they had experienced an injury. Response options were head (concussion), head/face (other than concussion), neck, chest, back, breasts, abdomen, arms, hands, pelvis, genitals, upper leg, lower leg, foot, prefer not to answer, and 'I have not experienced any injuries from horses.' Once an individual responded, adaptive questioning would ask them to identify the type of injury or injuries they experienced in each region. The response options for each region were the following: bite, cut/abrasion, broken/fracture, strain/sprain, stepped on/kicked, torn ligament/tendons/muscles, and other. There was not an option for them to clarify other. In addition to the type of injury for each region, individuals reported if they sought out or received medical care for the anatomical region with the options of yes, no, and prefer not to answer.

Chronic pain

Participants were asked if they were currently experiencing chronic pain. Individuals that responded 'no' or 'prefer not to answer' were sent to the end of the survey. Individuals who responded 'yes' were asked to identify the regions they experience chronic pain, with the anatomical regions being the same as acute, with the head/neck region as a single option rather than split between 'concussion' versus 'other than concussion,' like in the acute injury options. For each region they selected, adaptive questioning asked participants to identify when they experienced chronic pain with

options of while riding, while not riding, all of the time, or in certain temperatures/weather conditions.

Data cleaning

Data from REDCap was migrated into SAS Analytics Software & Solutions (SAS Institute, Cary, NC, USA) for data cleaning and analyses. All observations that did not complete the first two-thirds of the survey were not included, ensuring respondents completed the survey to the start of the chronic pain section. There were no duplicate responses included. Responses marked 'other' for PS were hand-organised into the different disciplines based on their explanation and the PS definitions above. Individuals who did not explain their 'other' or did not report their PS were removed from the data set. Individuals who preferred not to answer their age, sex, and chronic pain were not included in the final analyses. Observations where the answer for 'length of involvement in equestrian.' was greater than the response to 'age' were deleted.

The twenty-three disciplines were further categorised into twelve disciplines. Definitions of these twelve-discipline categories are in Supplementary Table S1. The seven main categories for equestrian disciplines were trail, English flat, jumping, western, driving, and short burst. Individuals who selected 'other' were categorised into the seven main disciplines based on their explained responses ($n = 126$). An additional five disciplines were created for individuals who selected participation in more than one of the seven main disciplines.

Data analysis

Out of 2,573 participants who initiated the survey, the final dataset used for analysis contained 2,049 individual responses (Figure 2), with a completion rate of 83.8%. No response rate is available as it was a voluntary convenience sample. Descriptive statistics were used to report frequencies and percentages for all aims, while chi-square tests and logistic regression were used for aims one and three. Age and years of participation were excluded from the analysis, and odds ratios for significant models were reported. The final acute pain models included only PS, while the final chronic pain models included PS, concussion history, and an acute injury to the same region.

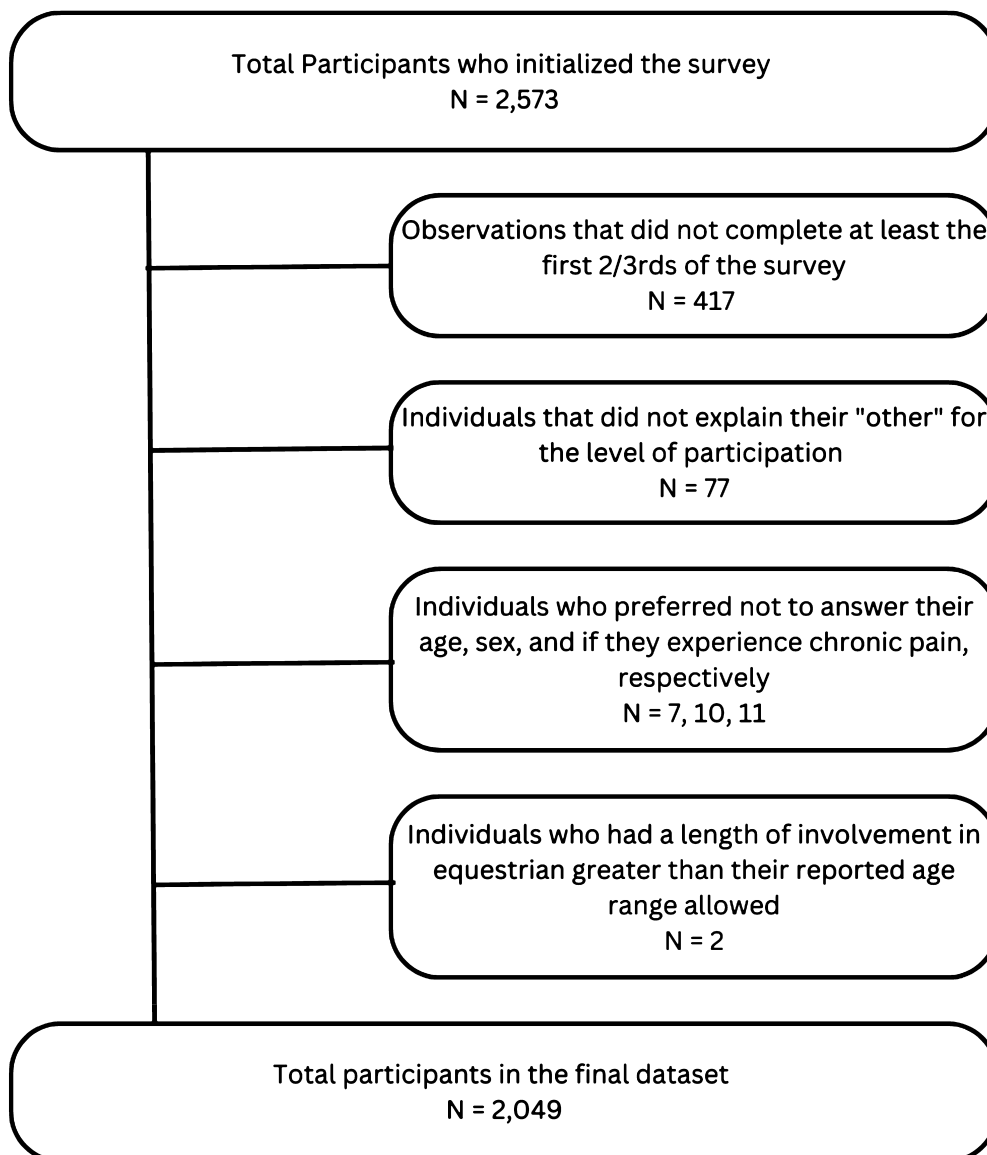


FIGURE 2 Summary graphic of inclusion criteria of participants.

3 Results

Demographics

The sample included 2,049 individuals, predominately females (96.0%). Details of participants' demographics and equestrian involvement are in Table 1. The most popular disciplines were English flat, jumping, and trail, while short burst, general, and driving had the fewest participants. Most had over five years of experience (96.8%) and consistently rode 1-2 days each week (83.3%) in the past six months.

Injury history and seeking medical attention

On average, equestrian participants reported 7.1 injuries, with only 4.8% reporting never experiencing an acute injury. Injuries to the lower extremities (29.0%) and

upper extremities (20.6%) were the most commonly reported. 13.1% of injuries were to the head, face, and neck, with concussions accounting for 11.2% of all reported injuries. Medical attention was sought for 47.8% of all injured regions, with 70.4% of individuals seeking attention for a concussion. Axial injuries resulted in more medical attention-seeking than appendicular injuries. Professionals reported 24.8% of injuries, amateurs 42.9%, and recreational equestrians 32.3%.

Logistic regressions examined acute injury by region and participation status. The odds ratios for these models are in Table 2. Professional equestrians had higher odds of acute injury in all regions than recreational equestrians. They also had higher odds of injury to all anatomical regions than amateurs, except for the chest and arms, and never experienced injury from horseback

TABLE 1 Self-reported demographics of sex, region, age and equestrian demographics of discipline, years of experience, and weekly commitment by participation status and percent of the total sample^a

	Professional n (%)	Amateur n (%)	Recreational n (%)	Total n (%)
Total	393 (19.2)	877 (42.8)	779 (38.0)	2,049 (100)
Sex				
Female	365 (17.8)	843 (41.1)	760 (37.1)	1,968 (96.0)
Male	28 (1.4)	34 (1.7)	19 (0.9)	81 (4.0)
Region ^b				
Alaska	15 (0.7)	30 (1.5)	44 (2.2)	89 (4.4)
Hawaii	14 (0.7)	13 (0.6)	29 (1.4)	56 (2.7)
Northeast	47 (2.3)	129 (6.3)	126 (6.1)	302 (14.7)
South	83 (4.1)	173 (8.4)	145 (7.1)	401 (19.6)
Central	68 (3.3)	199 (9.7)	130 (6.3)	397 (19.3)
North Central	64 (3.1)	158 (7.7)	125 (6.1)	347 (16.9)
Rocky Mountain	42 (2.1)	45 (2.2)	46 (2.2)	133 (6.5)
West Coast	60 (2.9)	129 (6.3)	132 (6.4)	321 (15.7)
Age (years)				
12-17	6 (0.3)	81 (4.0)	19 (0.9)	106 (5.2)
18-24	70 (3.4)	158 (7.7)	52 (2.5)	280 (13.7)
25-34	132 (6.4)	157 (7.7)	147 (7.2)	436 (21.3)
35-44	79 (3.9)	156 (7.6)	130 (6.3)	365 (17.8)
45-54	53 (2.6)	103 (5.0)	111 (5.4)	267 (13.0)
55-64	33 (1.6)	133 (6.5)	170 (8.3)	336 (16.4)
65+	20 (1.0)	89 (4.3)	150 (7.3)	259 (12.6)
Discipline				
Trail	15 (0.7)	74 (3.6)	194 (9.5)	283 (13.8)
English – flat	68 (3.3)	127 (6.2)	111 (5.4)	306 (14.9)
Jumping	65 (3.2)	207 (10.1)	62 (3.0)	334 (16.3)
Western	30 (1.5)	110 (5.4)	50 (2.4)	190 (9.3)
General	11 (0.5)	28 (1.4)	15 (0.7)	54 (2.6)
Driving	15 (0.7)	5 (0.2)	42 (2.1)	62 (3.1)
Short burst	25 (1.2)	17 (0.8)	2 (0.1)	44 (2.2)
English plus	30 (1.5)	106 (5.2)	59 (2.9)	195 (9.5)
Western plus	14 (0.7)	35 (1.7)	46 (2.2)	95 (4.6)
Other plus	19 (0.9)	46 (2.2)	36 (1.8)	101 (4.9)
Three disciplines	51 (2.5)	75 (3.7)	105 (5.1)	231 (11.3)
All around	50 (2.4)	47 (2.3)	57 (2.8)	154 (7.5)
Years of experience				
4 or less	3 (0.2)	27 (1.3)	36 (1.8)	66 (3.2)
5-9	17 (0.8)	90 (4.4)	69 (3.4)	176 (8.6)
10-19	96 (4.7)	241 (11.8)	163 (8.0)	500 (24.4)
20-29	124 (6.4)	191 (9.8)	150 (7.7)	465 (22.7)
30-39	78 (3.8)	146 (7.1)	116 (5.7)	340 (16.6)
40-49	31 (1.5)	72 (3.5)	98 (4.8)	201 (9.8)
50 or more	44 (2.2)	110 (5.4)	147 (7.2)	301 (14.7)
Weekly commitment ^c				
Daily	82 (4.0)	38 (1.9)	9 (0.4)	129 (6.4)

TABLE 1 (Continued)

	Professional n (%)	Amateur n (%)	Recreational n (%)	Total n (%)
5-6 days	127 (6.3)	251 (12.4)	78 (3.8)	456 (22.5)
3-4 days	111 (5.5)	363 (17.9)	253 (12.5)	727 (35.8)
1-2 days	33 (1.6)	146 (7.2)	200 (9.8)	379 (18.6)
Inconsistent	35 (1.7)	73 (3.6)	231 (11.4)	339 (16.7)

a The northeast region includes Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, Delaware, and Maryland. The south region includes Virginia, North Carolina, Alabama, South Carolina, Georgia, Florida, Mississippi, Arkansas, Louisiana, Texas, and Oklahoma. The central region includes Missouri, Illinois, Indiana, Ohio, Kentucky, West Virginia, and Tennessee. The north central region includes Minnesota, Wisconsin, Michigan, Iowa, North Dakota, South Dakota, Nebraska, and Kansas. The rocky mountain region includes Wyoming, Montana, Colorado, Utah, and Idaho. The west coast region includes Washington, Oregon, California, Arizona, New Mexico, and Nevada.

b The individuals did not answer this question.

c Eighteen individuals did not answer this question; % are of the entire sample.

riding. Injury to each region by discipline is in Supplementary Table S2.

Chronic pain

Over half (56.1%) of the sample reported experiencing chronic pain, with back pain being the main contributor. Logistic regressions were used to evaluate the risk of chronic pain by participation status, concussion history, and injury history to a region (Table 3). Professional equestrians had significantly higher odds of experiencing chronic general and chronic back pain than recreational and amateur equestrians. Prior acute injury to a region was the strongest predictor for chronic pain in the same region. Of those experiencing chronic pain, 47% reported they experience it at all times, while 53% only experience it during specific conditions or while riding. The division of when chronic pain was experienced by anatomical region is in Supplementary Figure S1. Individuals who had not experienced an acute injury had 3.5 times greater odds of not experiencing any chronic pain than those who had experienced at least one acute injury.

4 Discussion

The overall purpose of this study was to evaluate the patterns of self-reported acute injuries, behaviours of seeking medical attention for acute injuries, and frequency of chronic pain in experienced American equestrians. The study provides valuable information on equestrian-related acute injuries, medical attention-seeking behaviour, and chronic pain. Previous studies have focused on equestrian injuries found in trauma

and epidemiological databases or on injury databases from equestrian organisations, making this study the first nationwide equestrian-specific survey on this topic.

The sample was predominantly female and had the highest percentage of participants in the 25-44 year age range, consistent with previous studies, and representative of the American equestrian population (Council, 2018; Haines *et al.*, 2022; Kilby, 2007; Stanfill *et al.*, 2021). The study observed responses from all regions, with no prior studies to compare regional frequencies. However, the Rocky Mountain region sample may be lower than it should be as it has the highest horse-to-human ratio (Kilby, 2007).

Acute injury and seeking medical attention

The first aim of this study was to assess the frequency of self-reported acute injuries in equestrians based on their PS. The study found that 96.1% of equestrians have experienced at least one acute injury during their career, higher than the 89.8% reported in stadium jumpers in a previous study (Meyer *et al.*, 2022). However, 96.1% is a realistic estimate given the depth and breadth of the type of equestrian activity covered in this study. Self-reported injury data and medical records are reliable within a year (Schuh-Renner *et al.*, 2019). The current study focused on broader questions to avoid recall bias for injuries that occurred over a year ago. Prior research suggests that even asking broad questions about accidents, injuries, or pain could result in an underreporting of injury history, as individuals may not remember all of the times they experienced minor injuries (Gabbe, 2003; Schuh-Renner *et al.*, 2019). Considering this study asked participants to recall their entire career as an equestrian, and over 60% of the sample had 20 years

TABLE 2 Percent (%) of individuals per participation status who reported experiencing an acute injury by anatomical region, percent of individuals seeking medical attention, and total injuries of each anatomical region, and odds ratios^a

	Professional (n = 393)		Amateur (n = 877)		Recreational (n = 779)		Total participants (n = 2,049)		Sought medical attention %	Total injuries %	Amateur vs recreational OR (95% CI)		Professional vs recreational OR (95% CI)		Professional vs amateur OR (95% CI)	
	n	%	n	%	n	%	n	%								
Concussion	237	60.3	436	49.7	327	70.4	1000	42	70.8	11.20%	1.4 (1.2, 1.8) ^b	1.4 (1.2, 1.8) ^b	2.1 (1.6, 2.8) ^b	2.1 (1.6, 2.8) ^b	1.5 (1.9, 2.0) ^b	1.5 (1.9, 2.0) ^b
Head/face	159	40.5	275	31.4	220	44	654	28.2	44	7.30%	1.2 (0.9, 1.5)	1.2 (0.9, 1.5)	1.7 (1.3, 2.2) ^b	1.7 (1.3, 2.2) ^b	1.4 (1.1, 1.9) ^b	1.4 (1.1, 1.9) ^b
Neck	132	33.6	224	25.5	160	65.5	516	20.5	65.4	5.80%	1.3 (1.0, 1.6) ^b	1.3 (1.0, 1.6) ^b	1.8 (1.4, 2.4) ^b	1.8 (1.4, 2.4) ^b	1.5 (1.1, 1.9) ^b	1.5 (1.1, 1.9) ^b
Chest	91	23.2	178	20.3	140	66.4	409	18	65.7	4.60%	1.2 (1.0, 1.7) ^b	1.2 (1.0, 1.7) ^b	1.6 (1.2, 2.2) ^b	1.6 (1.2, 2.2) ^b	1.1 (0.8, 1.4)	1.1 (0.8, 1.4)
Back	243	61.8	474	54.1	371	63.2	1,088	47.6	62.8	12.20%	1.2 (1.0, 1.5) ^b	1.2 (1.0, 1.5) ^b	1.6 (1.2, 2.1) ^b	1.6 (1.2, 2.1) ^b	1.3 (1.0, 1.7) ^b	1.3 (1.0, 1.7) ^b
Breasts	17	4.3	35	4	31	25	83	4	22.9	0.90%	-	-	-	-	-	-
Abdomen	77	19.6	104	11.9	72	44.6	253	9.2	43.6	2.80%	1.2 (0.8, 1.6)	1.2 (0.8, 1.6)	2.0 (1.4, 2.9) ^b	2.0 (1.4, 2.9) ^b	1.8 (1.3, 2.6) ^b	1.8 (1.3, 2.6) ^b
Arms	209	53.2	411	46.9	314	54.1	934	40.3	54.4	10.50%	1.3 (1.0, 1.6) ^b	1.3 (1.0, 1.6) ^b	1.6 (1.2, 2.1) ^b	1.6 (1.2, 2.1) ^b	1.3 (0.9, 1.6)	1.3 (0.9, 1.6)
Hands	221	56.2	382	43.6	295	39.6	898	37.9	39.8	10.10%	1.3 (1.0, 1.6) ^b	1.3 (1.0, 1.6) ^b	2.0 (1.5, 2.6) ^b	2.0 (1.5, 2.6) ^b	1.7 (1.3, 2.1) ^b	1.7 (1.3, 2.1) ^b
Pelvis	113	28.8	168	19.2	146	63	427	18.7	63.3	4.80%	1.0 (0.8, 1.3)	1.0 (0.8, 1.3)	1.6 (1.2, 2.2) ^b	1.6 (1.2, 2.2) ^b	1.7 (1.3, 2.2) ^b	1.7 (1.3, 2.2) ^b
Genitals	20	5.1	32	3.7	16	15.4	68	2.1	13	0.80%	-	-	-	-	-	-
Upper leg	140	35.6	257	29.3	194	32.5	591	24.9	32.4	6.60%	1.1 (0.9, 1.5)	1.1 (0.9, 1.5)	1.5 (1.1, 1.9) ^b	1.5 (1.1, 1.9) ^b	1.3 (1.0, 1.7) ^b	1.3 (1.0, 1.7) ^b
Lower leg	184	46.8	352	40.1	271	55.7	807	34.8	55.2	9.10%	1.2 (1.0, 1.5) ^b	1.2 (1.0, 1.5) ^b	1.6 (1.2, 2.0) ^b	1.6 (1.2, 2.0) ^b	1.3 (1.0, 1.7) ^b	1.3 (1.0, 1.7) ^b
Foot	257	65.4	505	57.6	422	39.4	1184	54.2	39.3	13.30%	1.1 (0.9, 1.3)	1.1 (0.9, 1.3)	1.4 (1.1, 1.8) ^b	1.4 (1.1, 1.8) ^b	1.4 (1.1, 1.8) ^b	1.4 (1.1, 1.8) ^b
None	9	2.3	34	3.9	5.9	46	89	0.04	-	-	1.2 (0.9, 1.4)	1.2 (0.9, 1.4)	1.7 (1.3, 2.1) ^b	1.7 (1.3, 2.1) ^b	0.6 (0.3, 1.4)	0.6 (0.3, 1.4)

a OR (95%CI) = Odds Ratio (95% Confidence Interval) – 95%CI values below 1.0 were rounded down to 0.9 to show the 95%CI crossed 1, values above 1 were rounded as expected Logistic Regressions were not ran for breasts and genitals as they did not meet the assumptions for logistic regression. Reference for participation status in logistic regression was set to 'recreational' for columns labelled 'amateur vs recreational', 'professional vs recreational' and 'female vs male'. Reference for sex in logistic regression was set to 'males'. Reference for the column labelled 'professional vs amateur' was set to 'amateur' and 'male'.

b Indicates significance with an alpha value of 0.05.

TABLE 3 Frequency, percent of sample, and percent of total chronic pain reported, as well as odds ratios for chronic pain models including status of participation, history of concussion, and history of injury to the region where chronic pain is experienced

	n	% of sample	% of all chronic pain	Professional vs recreational		Amateur vs recreational		History of concussion		History of injury to region		Professional vs amateur	
				Odds Ratio (95% CI)		Odds Ratio (95% CI)		Odds Ratio (95% CI)		Odds Ratio (95% CI)		Odds Ratio (95% CI)	
General	1,149	56.1	-	1.5 (1.2, 1.9) ^a		1.0 (0.8, 1.2)		2.2 (1.8, 2.6)		-		1.5 (1.9, 2.7) ^a	
Head/face	37	1.8	2.3	0.6 (0.2, 1.6)		1.3 (0.6, 2.8)		4.9 (2.0, 12.0) ^a		2.3 (1.2, 4.5) ^a		0.4 (0.2, 1.2)	
Neck	182	8.9	11.2	1.1 (0.7, 1.7)		0.9 (0.6, 1.3)		1.8 (1.3, 2.6) ^a		5.6 (4.0, 7.7) ^a		1.3 (0.8, 1.9)	
Chest	23	1.1	1.4	1.8 (0.5, 7.0)		2.8 (0.9, 8.5)		1.8 (0.7, 4.7)		13.2 (4.8, 36.4) ^a		0.7 (0.2, 1.9)	
Back	549	26.8	33.7	1.4 (1.1, 1.9) ^a		1.1 (0.8, 1.3)		1.8 (1.4, 2.2) ^a		3.1 (2.5, 3.8) ^a		1.3 (1.0, 1.7) ^a	
Breasts	8	0.4	0.5	-		-		-		-		-	
Abdomen	29	1.4	1.8	1.2 (0.4, 3.5)		1.6 (0.7, 3.7)		1.3 (0.6, 2.7)		3.7 (1.7, 8.1) ^a		0.7 (0.3, 2.0)	
Arms	85	4.2	5.2	1.1 (0.6, 2.0)		1.0 (0.6, 1.7)		1.1 (0.7, 1.7)		4.6 (2.7, 7.9) ^a		1.1 (0.6, 1.9)	
Hands	79	3.9	4.9	1.5 (0.8, 2.8)		1.0 (0.6, 1.8)		1.4 (0.9, 2.2)		4.2 (2.4, 7.2) ^a		1.5 (0.8, 2.6)	
Pelvis	206	10.1	12.7	1.3 (0.9, 1.9)		1.0 (0.7, 1.4)		2.3 (1.6, 3.2) ^a		5.3 (3.9, 7.2) ^a		1.4 (0.9, 2.0)	
Genitals	4	0.2	0.2	-		-		-		-		-	
Upper leg	144	7	8.9	1.0 (0.6, 1.5)		0.7 (0.5, 1.1)		1.5 (1.0, 2.1) ^a		4.0 (2.8, 5.6) ^a		1.4 (0.9, 2.2)	
Lower leg	179	8.7	11.0	1.4 (0.9, 2.2)		1.2 (0.8, 1.8)		1.4 (0.9, 1.9)		5.5 (3.8, 7.9) ^a		1.2 (0.8, 1.7)	
Foot	102	5	6.3	1.3 (0.8, 2.2)		1.0 (0.6, 1.6)		1.6 (1.1, 2.4) ^a		3.6 (2.1, 6.2) ^a		1.2 (0.7, 2.1)	

^a Denotes significance ($P < 0.05$). Not all percent's for when chronic pain are experienced will add up to 100% as individuals were not required to answer this question. Reference category for participation status was recreational for the first four columns of odds ratios, and amateur for the professional vs amateur column. For all logistic regressions, the concussion history references was having no history of concussion, and the reference for history of injury to the region were set to no history of injury.

or more of experience, likely, the reported average of 7.1 injuries per equestrian is still an underestimate of total injury.

The study also found that 42.0% of the sample had experienced a concussion. This prevalence is lower than a previous survey with similar responses, which reported a prevalence of 53.2% for head injuries (Stanfill *et al.*, 2021). Another study highlighted that although 80% of New Zealand equestrians could identify a concussion as an injury to the brain, their knowledge about concussion symptoms was limited, suggesting a lack of specific understanding (Theadom *et al.*, 2020). Similarly, recognition of concussion symptoms and subsequent injury identification in this sample may account for the lower prevalence.

When evaluating risk of concussion, the study found that professionals had 2.1 times greater odds of encountering a concussion than recreational equestrians, and 1.5 times greater odds than amateur equestrians. The frequency of concussions experienced by professionals in this study was significantly higher, with 60.3% reporting a concussion compared to 48% in a prior study (Kuhl *et al.*, 2014). The sample size in Kuhl *et al.*'s study was smaller ($n = 96$), they did not provide an average age (18-87 years old), and data collection occurred at a single location (Kuhl *et al.*, 2014). These differences in sample size, breadth of age, and experience could explain the discrepancies in injury reporting. The high frequency of concussions documented among professionals in this study, who spend more time engaging in equestrian and barn work activities, should be considered very seriously.

Professional equestrians had significantly higher odds of experiencing an injury in all regions than recreational equestrians. Additionally, professional equestrians had higher odds of experiencing an acute injury in all regions except chest and arms than amateur equestrians. These higher odds for professionals are reasonable, considering they are more likely to work with younger, inexperienced horses, which are more likely to react unexpectedly compared to older, experienced horses (Meyer *et al.*, 2022). Professionals frequently spend more time riding and handling horses as part of their occupation, thus increasing the opportunity for injury (Keener *et al.*, 2023). Twenty percent of the professionals reported riding horses daily compared to 4.3% of amateurs and 1.2% of recreational equestrians. With higher exposure to young and inexperienced horses, professionals are at a greater risk of injury, as reported previously (Caparrós *et al.*, 2016).

The current study evaluated injury and chronic pain among various regions of the body, making it easier to compare with prior studies on trauma and emergency department (ED) injury data. Head/neck injuries accounted for 24.3% of reported injuries, aligning with the range of 23-26% reported previously in a review (Havlik, 2010). Trunk and abdomen regions accounted for 26.1% of injuries when combining back, chest, breast, abdomen, pelvis, and genital injuries, which falls within the range of 18-31% reported previously. Previous studies reported upper extremity injuries occurring more frequently than lower extremity injuries (ranging from 17-47% for upper extremity and 10-23% for lower extremity injuries) (Ball *et al.*, 2007; Bilaniuk *et al.*, 2014; Havlik, 2010; Krüger *et al.*, 2018). However, the current study showed the opposite: lower extremity injuries accounted for 28.8% of injuries, while upper extremities accounted for 20.6%. The differences between prior and current studies could be due to individuals not seeking medical attention for minor injuries, such as foot injuries from being stepped on by a horse. These findings suggest that the severity of injury may impact medical-seeking behaviours.

The rate of American equestrians seeking medical attention for an acute injury was investigated based on the anatomical location of the injury. Injuries to the axial region (skull and torso) had a higher frequency of seeking medical attention (60.3%) compared to injuries to the appendicular regions (pelvis and limbs) (45.8%). Further research is needed to examine the frequency of reporting medical attention by specific regions. Foot injuries accounted for the most significant proportion of reported injuries, yet only 39.3% sought medical attention post-injury. Similarly, individuals reported seeking medical attention 55.2% of the time for lower leg injuries and 32.4% for upper leg injuries. The findings imply that minor injuries are more frequent in the lower extremities than major injuries.

Compared to the lower extremities, individuals sought medical attention less often for breast, genital, hand, or lower leg injuries. On the other hand, they were most likely to seek medical attention for concussion, neck, chest, back, and pelvis injuries. In addition, the study found that more individuals sought medical attention post-head injury (70.8%) than a previous study reported (58%) (O'Connor *et al.*, 2018; Stanfill *et al.*, 2021). However, further investigation is required to determine the underlying causes of these differences, as no associations were found between seeking medical attention and independent variables such as participa-

tion status, discipline, sex, commitment to riding, or experience.

Chronic pain

The final aim of this study was to evaluate self-reported chronic pain by anatomical region associations with equestrian discipline, PS, and self-reported acute injury as fixed variables. No significant links were found between chronic pain and disciplines. Over half the participants reported experiencing chronic pain in at least one anatomical region, significantly higher than in the general American adult population (e.g. 20.4% with chronic pain) (Cohen *et al.*, 2021; Dahlhamer *et al.*, 2018).

A total of 26.8% of equestrians experience back pain, with professionals having 1.4 greater odds of having back pain than recreational riders and 1.3 greater odds than amateur equestrians. These findings align with previous studies reporting chronic low back pain in equestrians to range from 20–88% (Cejudo *et al.*, 2020; Ekberg *et al.*, 2011; Kraft *et al.*, 2009; Kraft *et al.*, 2007; Lewis and Baldwin, 2018; Lewis *et al.*, 2018; Lewis and Kennerley, 2017). Prior work associates the extensive range depended on hours spent in the saddle, discipline, position, and saddle type (Kraft *et al.*, 2009; Kraft *et al.*, 2007; Lewis and Kennerley, 2017; Quinn and Bird, 1996).

43% of riders experience pain concerning a prior injury (Lewis and Kennerley, 2017). Additionally, Ball and colleagues reported that 55% of riders experienced chronic physical outcomes post equestrian-related injury, with 62% identifying chronic pain or headaches as a symptom (Ball *et al.*, 2009). The current study adds foundational evidence for the critical need for rehabilitation programs to help decrease chronic pain post-acute injury. Experiencing a prior concussion showed significantly higher odds ratios ranging from 1.5–4.9 for individuals' experiencing various regional pain. Having a prior acute injury to the same region resulted in significant odds ratios in all regions, meaning that injury predisposed riders to chronic pain within the same region. Specifically, individuals who experience a chest injury have 13.2 higher odds of experiencing chronic pain in the chest region than individuals who have not experienced a prior chest injury.

Limitations

The survey had limitations as it did not require individuals to pick a primary discipline, potentially affecting the representation of injuries and chronic pain across disciplines. The data collected was broad, focusing on primary injury regions, injury types, and medical atten-

tion sought. Recall bias may have impacted how injuries were reported. In future work, using detailed anatomical regions such as joints to facilitate comparison with prior studies and evaluate differences based on variables like participation status, sex, and discipline is recommended. Another limitation was a lack of a detailed definition of chronic pain, leaving respondents responsible for individually interpreting these questions. Nevertheless, the expansive data set obtained in this study significantly contributes to injury risk and prevention practices.

It is worth noting that the survey relied on a convenience sample, including diverse ages, disciplines, and regions. Future research should utilise reporting systems within equestrian organisations for a more comprehensive understanding of injury and pain in equestrians. Individual equestrian organisations have started implementing injury-reporting systems, such as the USEF and the United States Pony Club (USPC) (Haines *et al.*, 2022; Thompson *et al.*, 2015). The USPC is the only organisation publicising that they are tracking injuries at all meetings, lessons, rallies (shows), and other USPC-sanctioned events. The USPC's strong safety culture and education focused on proper horse management may account for the small number of injuries reported in the organisation (Thompson *et al.*, 2015). Tracking systems should include specific anatomical location, mechanism of injury (e.g. falling off a horse), and an initial pain score. Creating an accessible tracking system for all levels and organisations to use is critical in preventing injury in this population.

5 Conclusions

Further research and promotion of protective equipment, such as vests, appropriate footwear, gloves, and helmets for all equestrian disciplines is necessary. The highest acute injury rates were to the feet, back, and head (i.e. concussions). Minor injuries to the lower extremities, specifically the foot and upper leg, may go unreported in traditional ED research.

Participation status was significantly associated with acute injuries, with professionals experiencing higher odds of injuries than recreational and amateur equestrians. With only 3.9% of the current equestrian sample reporting not having experienced an acute injury and nearly half of the sample reporting experiencing some form of chronic pain, clinicians, researchers, and other stakeholders must seek ways to help decrease levels of acute injury and chronic pain in equestrians. Addition-

ally, supporting and encouraging equestrians to report injuries and seek medical attention as needed is vital. Furthermore, researchers and clinicians must collaborate with equestrian stakeholders to implement reporting systems, improve safety culture, and implement preventative and rehabilitative interventions for all equestrians.

Supplementary material

Supplementary material is available online at: <https://doi.org/10.6084/m9.figshare.24243394>.

Figure S1. Division of when individuals feel chronic pain by anatomical location.

Table S1. Equestrian discipline categories based on discipline selection.

Table S2. Frequency (n) and percent (%) of individuals who reported experiencing an acute injury by anatomical region by discipline.

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Authors' contribution

Conceptualisation, MMK and KIT; Methodology, MMK and KIT; REDCap, MMK; Distribution, MMK and KIT; Formal analysis, MMK; Writing – original draft preparation, MMK; Writing – review and editing, MMK and KIT; Visualisation, MMK; Supervision, KIT; Project administration, MMK. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors have no conflicts of interest to report.

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