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Systematic Review of Spinal Cord Injuries in Equestrian Athletes: Incidence, Risk Factors, and Outcomes

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Abstract

Objective

The goal of this systematic review is to identify common themes amongst acute spinal cord injuries (SCI) in equestrian athletes.

Design

A systematic review was performed using PubMed, CINAHL Plus with Full Text (EBSCO), Cochrane Library, and Scopus with pre-determined MESH terms. The initial search returned 354 studies. Following PRISMA guidelines, 13 articles were included. Exclusion criteria included injuries to the horse only, non-English language, cauda equina, and case reports. Data extraction was completed, and common findings were evaluated narratively due to heterogeneity of data.

Results

Seven manuscripts listed specific horse-related activities that caused SCI, with fall from horse as the highest percentage of injury. Nine articles identified the injury region, with large variations and no clear dominant area of injury. Five articles identified the length of hospital stay with ranges from 1 to 82 days. Four articles looked at the association of professional vs non-professional riders. Only two articles evaluated helmet use at time of injury, with one article showing 81% of those with SCI used helmets, and the other showing only 35.6% utilized this safety measure.

Conclusion

SCI in equestrian athletes can have a wide presentation, with large variation on location of injury, length of stay, and other factors. However, non-professional riders are at greater risk of SCI and individuals are more likely to sustain injury from a fall from a horse rather than a kick or another modality of injury. Future study can elicit presenting symptoms, types of surgical intervention used, and long-term outcomes and recovery.

Introduction

Horseback riding is a popular recreational and competitive activity worldwide and

it is often associated with a range of physical and psychological benefits[1]. As of March of 2024, the International Federation for Equestrian Sports (FEI), the worldwide governing body of equestrian activities, concluded that approximately 27 million individuals ride horses annually, more than the total number of people playing tennis or golf[2]. However, it is also a sport with inherent risks, particularly due to the unpredictability of horses, as well as the physical demands placed on riders[3]. Among the various injuries sustained in horseback riding, spinal cord injuries (SCIs) account for one of the most severe and life-altering outcomes[3]. These injuries can result in significant morbidity, including but not limited to paralysis, chronic pain, and a profound impact on one's quality of life.

The injury associated with the highest rate of mortality in the sport of horseback riding has historically been traumatic brain injuries[3]. Thankfully, over the past 30 years, the number of TBIs has significantly decreased due to the improvements in helmet quality along with the requirement of helmets in multiple competitive disciplines[4]. Unfortunately, helmets have little to no effect on the risk of sustaining an SCI following a fall from a horse[4]. Without adequate protection like the skull has with a helmet, the spinal cord is left vulnerable to injury during falls. In North America, the rate of serious injury requiring hospitalization is approximately 1 in 350-1000 hours of riding[3]. SCI's, while less common than head injuries, represent one of the most devastating outcomes of equestrian accidents. The annual incidence of SCI among equestrian athletes has been reported to range from 2% to 10% of all riding-related hospital admissions, with cervical injuries accounting for the majority of cases[3, 4]. These injuries frequently result in long-term neurologic deficits, with nearly half leading to partial or complete paralysis[4]. In a previous study, 22% of riders who sustained an SCI were unable to return to their profession following the injury[3]. Around the same time as helmets, protective vests were introduced into horseback riding to reduce the risk and severity of injuries from falls[5]. They work by absorbing and distributing impact energy through layers of foam, gel, or air-filled compartments, which compress on contact so that force is spread across a wider surface area. This design helps protect the chest, ribs, spine, and abdomen[5]. Due to the limitations and potential change in neck dynamics, these vests may increase the likelihood of whiplash injuries in riders; however, no current studies have been conducted regarding this mechanism.

The mechanism of injury to the spinal cord in horseback riding can vary widely, but is most often due to falls, being thrown from, or crushed by the horse. These actions involve direct trauma or indirect forces leading to spinal cord compression, contusion, or transection[3]. Falling from any height can lead to different mechanisms of injury, including axial loading, where force is transmitted along the length of the spine; hyperflexion or hyperextension, leading to excessive bending of the spine; and direct impact, where forces applied lead to direct damage to the spinal cord[4]. Other mechanisms of injury that are less apparent than a fall include a whiplash injury from sudden deceleration and crush injuries from a horse landing on a rider. The severity of spinal cord injuries in horseback riding depends on several factors, such as the height of the fall, the speed at which the accident occurs, the surface onto which the riders falls, and the immediate response to the injury[4]. Despite the severe consequences that may result from horseback riding injuries, the incidence, risk factors, and outcomes associated with equestrian related spinal cord injuries are not comprehensively understood.

While the prevalence and mechanisms of SCIs have been thoroughly studied in sports such as football and other disciplines like motorcycling, little research has been conducted on these injuries, specifically in equestrian athletes. The unpredictable nature of horses, combined with the speed and height involved with this sport, places horseback riders at an increased risk for catastrophic SCI[3]. The current

literature on SCIs in equestrian athletes is fragmented, with variations in study populations, injury classifications, mechanism of injury, and outcomes reported across studies. Many reviews primarily examine injuries resulting from falls from horse-drawn carriages, highlighting a significant gap in literature, as modern equestrian activities are predominantly sport-related rather than transportation-based[6]. This lack of consolidation and current prospective impedes a comprehensive understanding of the scope, risk factors, and effective prevention strategies for these injuries.

This systematic review aims to synthesize the current evidence on horseback riding-related spinal cord injuries, focusing on the epidemiology, mechanisms of injury, and clinical outcomes. By consolidating the findings from studies worldwide, this review seeks to provide a clearer understanding of the factors leading up to, during, and after a spinal cord injury from an equestrian accident, ultimately guiding better safety practices and interventions to reduce the occurrence and severity of these injuries.

Methods

A qualitative systematic review was performed using PubMed, CINAHL Plus with Full Text (EBSCO), Cochrane Library, and Scopus with MESH terms. This database search was limited to only peer-reviewed journal articles up until 2023. In collaboration with a medical librarian the following was established as the MESH terms utilized within the search: horses, spinal cord injuries, spinal cord, spinal injuries, spinal fractures, sports, athletic injuries. The initial search returned 354 studies. After de-duplication of 108 documents, 246 articles were screened by assessing the title and abstract. 2 reviewers reviewed each of these articles and when in disagreement, a third reviewer assessed for a final decision. 42 relevant studies were sought for retrieval to be included for a full readthrough after assessment. Of those, 3 were not able to be retrieved. 39 papers were then reviewed in full by each of the 3 reviewers. After thorough review and discussion amongst all 3 reviewers, 13 papers were left and accepted for final inclusion.

To determine inclusion the authors independently reviewed articles with established inclusion and exclusion criteria. The inclusion criteria included: (1) acute spinal cord injury, (2) accepted papers published in peer reviewed journals, (3) injury involving horseback riding activities unless otherwise listed. Exclusion criteria included (1) injuries to the horse instead of the rider, (2) non-English language, (3) papers regarding cauda equina, (4) injury via cart and buggy, (5) non-spinal cord injuries, and (6) case reports.

Data extraction was then completed by 1 team member and analyzed the following variables and outcomes: (1) author, (2) title, (3) overall population size, (4) population gender, (5) average age, (6) injuries analyzed, (7) percentage of injuries to the spinal cord, (8) percentage of spinal injury caused by equestrian events, (9) causes of spinal injury, (10) injury region, (11) recovery/outcome, (12) surgical intervention required, (13) average length of hospital stay, (14) average follow up time, (15) percentage of non-professional riders, (16) admission rate to the hospital, (17) use of helmet at time of injury, and (18) spine injury by age group. The PRISMA diagram associated with the identification of studies across the databases is included in Figure 1. Common findings were evaluated narratively due to heterogeneity of data. Zotero was utilized throughout the screening process and manuscript preparation as both an article management tool and reference organizer[7]. ROBVIS was used to create the traffic light plot for risk of bias judgement[8].

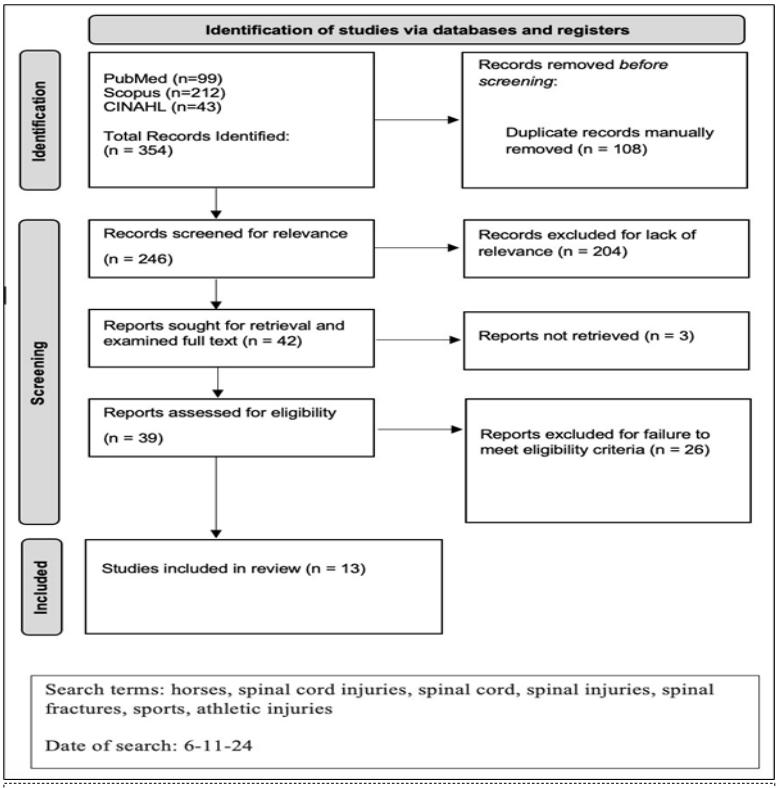

Figure 1. PRISMA diagram, the detailed inclusion procedure in a systematic review of literature

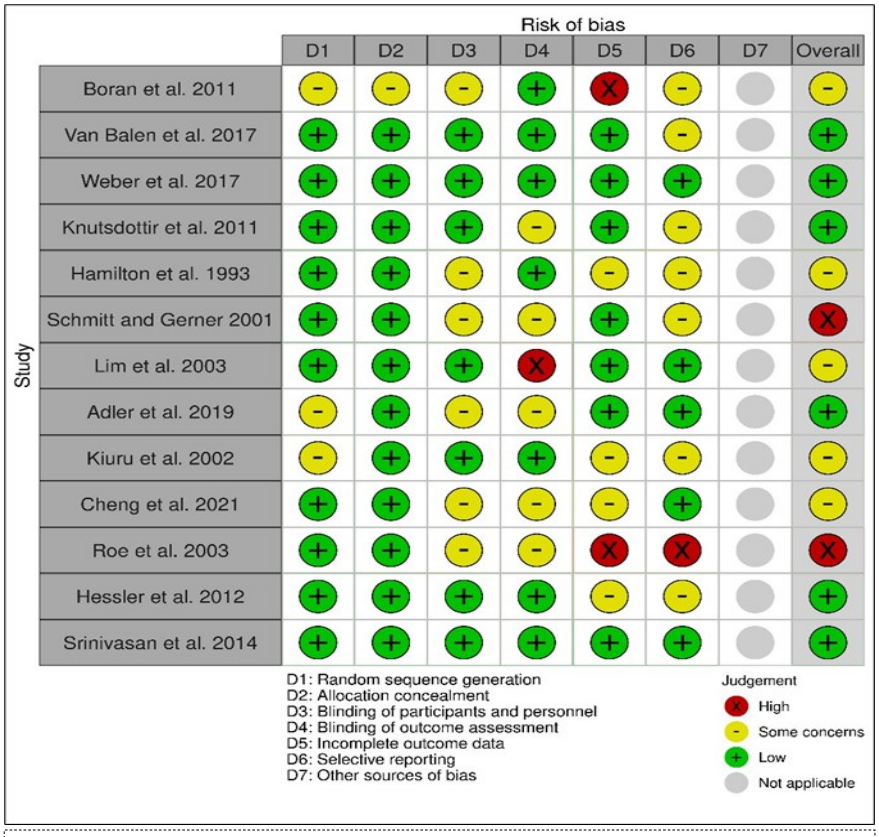

Figure 2. Summary of risk of bias judgement for included case-control and cohort studies using the ROBINS-I tool (traffic light plots generated using ROBVIS)

Results

The risk of bias for each included study was assessed using the ROBINS-I tool and visualized using the ROBVIS traffic light plot (Figure 2). Overall, six of the thirteen studies were judged to have low risk of bias across most domains. A few studies were rated as having some concerns in specific domains, most commonly due to concerns about incomplete outcome data, blinding, and selective reporting. Only two studies were judged to have a high risk of bias, primarily due to undefined blinding and ambiguous methods. A few of the articles did not include complete descriptions of their methods, limiting the ability to assess the bias of the article, leading readers to have to make assumptions and interpretations on their own. These patterns are visually reflected in the traffic light plot, where green predominates, with occasional yellow cells and a single red cell indicating high risk. The results suggest that while the overt methodological quality of the included studies was robust and well-reported, caution is warranted when interpreting findings from the studies collectively.

Of the 246 articles screened, a total of 13 articles met the inclusion criteria. 4 of these articles analyzed spinal injuries from all sports, 4 analyzed any type of injury caused by equestrian events, and 5 analyzed spinal injuries caused by equestrian events. The total population was 4496 individuals (25.8% male) with a frequency weight average age of 24.3 years. More specific information on the demographics of patients included in this study can be found in Table 1.

Table 1. Patient demographics from articles included in this systemic review.

Author (Year)	Title	Overall Population	Injuries analyzed	Population Gender	Average Age
Boran (2011)	A 10-year review of sports-related spinal injuries	196	Spinal injuries from all sports	42 males, 40 females	35 years (range 15-72)
Van Beilen (2017)	Beware of the force of the horse: mechanisms and severity of equestrian-related injuries	951	All equestrian injuries	178 males, 767 females	20.0 for mounted injuries, 45.0 for unmounted injuries
Weber (2017)	Blunt injuries related to equestrian sports: results from an international prospective trauma database	679	All equestrian injuries	188 males (27.9%), 491 females (72.1%)	35.1 years
Knutsdottir (2011)	Epidemiology of traumatic spinal cord injuries in Iceland from 1975 to 2009	39	Spinal injuries from all sports	26 males (67%), 13 females (33%)	
Hamilton (1993)	Nervous System Injuries in Horseback-Riding Accidents	156	Spine injuries in equestrians	77 males, 79 females	25.4 years (range 1–72)
Schmitt (2001)	Paralysis from Sport and Diving Accidents	1016	Spinal injuries from all sports	46 males (67%), 23 females (33%)	26.8 years (range 9–52)
Lim (2003)	PATTERN OF EQUESTRIAN INJURIES PRESENTING TO A SYDNEY TEACHING HOSPITAL	429	Spine injuries in equestrians	168 males, 221 females	25.5 years
Adler (2019)	Retrospective analysis of equestrian-related injuries presenting to a level 1 trauma center	281	Spine injuries in equestrians	61 males, 161 females	38.5 years (range 4–79)

Kiuru (2002)	Serious horse-riding accidents: imaging findings and evaluation with multi-slice CT	46	All equestrian injuries	3 males, 43 females	30 years (range 16–55)
Cheng (2021)	Sex- and Sports-Specific Epidemiology of Traumatic Lumbar Spine Injuries	497	Spinal injuries from all sports	292 males (59%), 205 females (41%)	
Roe (2003)	SPINAL AND SPINAL CORD INJURIES IN HORSE RIDING: THE NEW SOUTH WALES EXPERIENCE 1976–1996	59	Spine injuries in equestrians	21 males, 13 females	range 22–80 years
Hessler (2012)	Localisation and pattern of spine fractures caused by horse riddening accidents	47	Spine injuries in equestrians	5 males (11.1%), 40 females (88.9%)	38 years (range 15–74)
Srinivasan (2014)	Straight from the horse's mouth: neurological injury in equestrian sports	80	All equestrian injuries	37 males (46%), 43 females (54%)	37 years (range 2–79)

In papers discussing spinal injuries from all sports[9,10,11,12], 1748 patients were assessed, with 312 (17.91%) obtaining their spinal injury from an equestrian event. The reported distribution of injury regions varied considerably between studies, likely due to differences in study populations, classification systems, and reporting methods. Boran et al.[9] described an even distribution of injury along the spine (cervical 25%, thoracic 22%, lumbar 21%, multiple regions 32%), whereas Knutsdottir et al.[12] found that cervical spine injuries (57%) predominated over thoracic and lumbar injuries (43% collectively). Schmitt et al.[10] did not specify the anatomic location of injury, limiting direct comparison, while Cheng et al.[11] reported 100% of equestrian-related spinal injuries occurring in the lumbar region, a stark contrast to the other studies. This discrepancy likely reflects differences in inclusion criteria—such as whether isolated vertebral fractures versus spinal cord injuries were analyzed—and may also relate to regional or discipline-specific riding practices. Regarding treatment patterns, Boran et al.[9] was the only paper to report surgical intervention data, with 29% of cases requiring surgery and an average hospital stay of 9.5 days (range 1–82). Both Boran et al.[9] and Schmitt et al.[10] identified a predominance of non-professional riders among those injured (92% and 60%, respectively), underscoring that less experienced or recreational equestrians represent the population most vulnerable to serious spinal trauma.

Another group of studies examined injuries to any part of the body sustained during equestrian activities, with spinal injuries reported as a subset of total injuries[13–16]. Collectively, these four articles documented 1,756 total injuries, 342 (19.5%) of which involved the spinal cord. Despite similar overall sample sizes, the proportion and severity of spinal injuries varied across studies, again suggesting methodological heterogeneity. Van Balen et al.[13] reported that 14.6% of 951 equestrian injuries involved the spinal cord, with 29.1% of those cases requiring surgical intervention and an average hospital stay of only one day when all injury types were considered. This relatively short hospitalization contrasts with the findings of Boran et al.[9], suggesting that inclusion of less severe injuries or broader hospital admission criteria may account for the difference. Van Balen et al.[13] also differentiated mounted from unmounted riders, observing that mounted riders represented the majority of injuries (68.4%) and had a higher hospital admission rate (23.5% vs. 14.3%), consistent with previous studies indicating that falls from height are the predominant mechanism of serious spinal injury.

Table 2. Mechanism of spinal cord injury reported in articles analyzing all equestrian injuries.

Author (Year)	Title	Causes of Spinal Injury		
		Fall from Horse	Kicked by Horse	Crush Injury
Van Balen (2017)	Beware of the force of the horse: mechanisms and severity of equestrian-related injuries	-	-	-
Weber (2017)	Blunt injuries related to equestrian sports: results from an international prospective trauma database	25.5%	2.7%	16.7%
Kiuru (2002)	Serious horse-riding accidents: imaging findings and evaluation with multi-slice CT	72%	11%	13%
Srinivasan (2014)	Straight from the horse's mouth: neurological injury in equestrian sports	28%	49%	21%

Weber et al.[14] reported 679 equestrian-related injuries, with 25.5% involving the spinal cord—broken down by location as 46 lumbar, 38 cervical, and 38 thoracic spine injuries—showing a more balanced anatomic distribution than Knutsdottir et al.[12]. Similarly, Kiuru et al.[15] found that 28.6% of 46 injuries involved the spinal column, primarily burst and compression fractures, while Srinivasan et al.[16] identified spinal involvement in 21% of 80 injuries, with 17.5% requiring surgical intervention. When comparing across studies, the proportion of spinal involvement ranged from 14% to 29%, and the percentage requiring surgery varied from 17% to 29%, suggesting that although relatively infrequent, equestrian-related spinal injuries often carry significant clinical consequences. Weber[14], Kiuru[15], and Srinivasan[16] all described specific mechanisms of spinal injury—most commonly falls from mounted position, horse kicks, or being crushed during a fall, which are summarized in **Table 2.** Collectively, these findings reinforce that while the exact distribution and severity vary across reports, equestrian activities consistently represent one of the leading causes of sport-related spinal trauma, particularly among non-professional riders.

The final category of articles included in this review are those that specifically analyzed spinal cord injury due to equestrian events. Five papers were included in this category for a total of 972 spinal cord injuries[17–21]. No significant differences were noted in the injury region between articles. Several authors specified the frequency of injury mechanisms with similar frequencies to those listed in Table 2. Fall from a horse is the most common injury mechanism across all papers. Lim[18] and Roe[20] both reported the percentage of injuries that occurred in non-professional riders to be 27.27% and 88.14%, respectively. Despite the low proportion of amateur riders reported by Lim[18], the authors did note that the amateur riders had higher rates of severe head/spine injury compared to their professional counterparts. Lim et al.[18] also analyzed the frequency of helmet use at the time of injury (81%) and the admission rate to hospital for helmeted and non-helmeted riders (27% vs. 55%, respectively). In contrast, another study demonstrated markedly lower helmet use, with only 35.6% of riders wearing a helmet at the time of injury[19]. This discrepancy likely reflects variations in study demographics, including differences in competitive level, geographic region, discipline of horse riding, and cultural attitudes toward helmet use. Additionally, Lim et al.'s[18] study population may have included a greater proportion of competitive or organized riders, in whom helmet compliance is generally higher due to formal regulations[4]. Conversely, studies capturing recreational riders or those in disciplines without mandatory helmet requirements, such as western or pleasure riding, tend to report

significantly lower rates of helmet use. Temporal differences between studies may also contributes, as awareness campaigns and improved safety regulations in recent years have led to increased adoption of protective headgear[4].

Discussion

This systematic review aimed to synthesize the current data on SCI in equestrian athletes in regard to athlete demographics, mechanism of injury, and body region in which injury occurred. In summary, the evidence revealed that the majority of athletes injured were young adult females, with the highest risk factor for SCI being the act of mounting the horse, rather than handling the horse on the ground. Another significant risk factor for hospital admission was the failure to wear a helmet. Additionally, being a non-professional rider was identified as a risk factor for SCI, likely due to confounding conditions such as limited riding experience, instability in the saddle, a lack of awareness of safe versus unsafe situations, and slower decision-making while riding. Some articles found that the region of the spinal cord injury incidence injury was evenly distributed from cervical to sacral[9], but others found a significantly higher incidence of injury in the cervical region[12]. When comparing overall injury outcomes in equestrian sports, SCIs were not the most common injury resulting from falls while mounted, but they were among the most severe, often leading to devastating consequences.[13]. While these conclusions are supported by multiple articles in this review, more thorough research needs to be conducted in order to truly capture the impact of helmets and body protectors on the incidence and outcomes of SCI in mounted riders. Currently, very few manuscripts outline the specific differences between injured and uninjured riders, and no reviews are available in which children are included in the parameters.

One of the strengths of this review is its comprehensive assessment of available literature, integrating data from multiple disciplines, including sports medicine, neurology, and biomechanics. By synthesizing findings from various study designs across decades of research, this review provides a holistic understanding of the issue. However, several limitations should be acknowledged; first, the variability of study designs, injury classification, and reporting creates inconsistencies when comparing the studies, making it challenging to establish precise incidence rates of certain injuries and identify definitive risk factors. Second, many studies relied on retrospective data, which may introduce recall bias or underreporting of minor SCIs. Lastly, there is a lack of high-quality, prospective research examining long-term outcomes for equestrian athletes with SCIs, which remains an area requiring further exploration.

Horseback riding is a high-risk sport that attracts hundreds of thousands of people to participate in[2]. Due to the inherent interaction between horse and rider, and the unpredictability of this connection, riders are in a unique position regarding the possibility of SCI. Previous studies on head injury and helmet design have significantly reduced the number of TBIs sustained by riders in the past decade[22]. Similar research surrounding the nature of life-altering SCIs specifically in this sport could inform further changes in helmet and body protector designs to better suit the riders and reduce the risk of SCI. These studies can also contribute to improved response strategies, earlier interventions, and enhanced rehabilitation techniques to promote better outcomes and lessen the potential for long-term disability.

Future research should focus on prospective cohort designs to establish clearer causative links between risk factors and SCIs. Research should also explore the biomechanical effectiveness of current and emerging protective equipment, such as airbag vests, in reducing SCI risk in different equestrian disciplines. Additionally, developing equestrian-specific injury prevention programs and evaluating their effectiveness in both recreational and competitive settings would be a valuable next step in reducing injury burden to these riders.

Statements & Declarations

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All authors contributed to the study conception and design. Kayleigh Crane retrieved the articles from databases and managed the inclusion/exclusion database. All authors conducted the initial literature review. All authors independently took part in the abstract review. All authors divided the remaining articles and conducted full review and extraction independently. Kayleigh Crane managed the extraction database. Emily Heinrich managed the reference database. All authors supervised the writing of this manuscript. All authors contributed to the development and writing of this manuscript. Emily Heinrich prepared this manuscript for publication. All authors have approved this manuscript.

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