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ORIGINAL ARTICLE

A 10-year review of sports-related spinal injuries

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Abstract
Introduction The incidence of traumatic spinal cord injury varies in different countries from 2.5 to 57.8 per million per annum, with sport accounting for 8–12.7% of these injuries. Spinal injuries associated with recreational sport often result in long-term permanent disability in otherwise active individuals.
Materials and methods The aetiology, pattern and mechanism of the 196 sports-related spinal injuries treated in the National Spinal Injuries unit in Ireland from 1993 to 2003 is reviewed in this article.
Results Sports-related spinal injuries accounted for 11% of all spinal injury admissions. There were 145 (74%) males and 51 (26%) females, with an average age of 30.2 years (range 14–72 years). The most common sport responsible for a spinal injury was equestrian events (41.8%), rugby (16.3%), diving (15.3%), Gaelic football and hurling (9.6%), cycling (4.2%), and miscellaneous (12.7%). Injury distribution was cervical spine (118 patients, 60%), thoracic (41 patients, 21%), lumbar spine (37 patients, 19%). In 18 patients (9.25%) more than one region was affected. In 78 patients (40%) more than one vertebral level was affected. On admission 71 patients (36%) had a neurological deficit with 46 patients (65%) incomplete and 25 (35%) complete, of which 6 patients (23%) were paraplegic and 19 (77%) were tetraplegic.
Conclusion Sport is an important cause of spinal injury among young people in Ireland. This study contributes to our understanding of these injuries aetiology, pattern and mechanism of injury and allows constructive recommendations for injury prevention and management.

Keywords Spinal injury · Cord injury · Sports

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Introduction

With increasing emphasis on exercise and recreation, the number of people engaging in sporting activities both at an amateur and professional level is increasing [9]. Spinal injuries are among the most devastating and costly of all injuries in recreational sport, often giving rise to long-term permanent disability. The incidence of traumatic spinal cord injury varies in different countries from 2.5 to 57.8 per million per annum, with sport accounting for 8–12.7% of these injuries [18]. The estimated lifetime cost is one million dollars for each paraplegic casualty and five million dollars for a tetraplegic casualty [33]. Thus a heightened awareness of sport-related injury patterns is required. Careful study of the pathomechanics and epidemiology of sports-related spinal injuries brings to light many common features. The incidence has been shown to increase, as the sport becomes increasingly violent and aggressive [5]. While rules and regulations have been shown to have important safety ramifications in the reduction of incidence and severity of injuries [22, 30], the ever-present threat of spinal injury requires that health care professionals be responsible for a greater understanding of these injuries.

The aims of this study where to determine the aetiology of sports-related spinal injuries in Ireland, to investigate the patterns of injury for each sport, and to elucidate the mechanisms by which these injuries occur.

Materials and methods

The National Spinal Injuries Centre is the tertiary referral centre for major spinal injury management in Ireland. This prospective study examines all patients admitted to our unit with a sports-related spinal injury from 1993 to 2003 were collected from a prospective computerized spinal database, which details the initial presentation, mechanism of injury and the treatment instituted. Data collected included patient demographics, mechanism of injury, injury pattern, neurological status, hospital stay, and treatment. Data on those that died before reaching hospital is not included.

Results

Between 1993 and 2003 there were 196 sports-related spinal injuries admitted to our unit. Sports-related spinal injuries accounted for 11% of all spinal injury admissions. There were 145 (74%) males and 51 (26%) females, with an average age of 30.2 years (range 14–72 years). Figure 1 shows the number of admissions over the 10-year period, showing that July and August were the months were injuries were most likely to occur.

The most common sport responsible for a spinal injury was equestrian events (41.8%) followed by rugby (16.3%), diving (15.3%), Gaelic football (8.1%), cycling (4.2%), hurling (1.5%), and miscellaneous (12.7%). Injury distribution was cervical spine (118 patients, 60%), thoracic spine (41 patients, 21%), lumbar spine (37 patients, 19%). In 18 patients (9.25%) more than one region was affected. In 78 patients (40%) more than one vertebral level was affected.

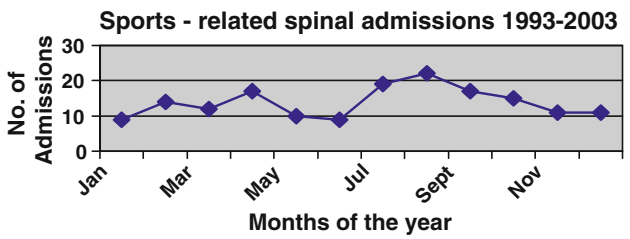

Fig. 1 Sports-related spinal admissions 1993–2003

On admission neurological deficit was seen in 71 patients (36%). Of those with a neurological deficit 46 patients (65%) were incomplete and 25 (35%) were complete, of which 6 patients (23%) were paraplegic and 19 (77%) were tetraplegic.

Surgical intervention was required in 68 patients (35%), with the remaining 128 patients (65%) managed conservatively. The average length of stay in hospital was 10.1 days (range 1–84 days), with the longest average length of stay associated with rock-climbing injuries (26.4 days). 55 patients (28%) required further treatment in an inpatient rehabilitation facility following their hospital stay.

Table 1 illustrates the demographic data, pattern and mechanism of injury, neurological deficit and treatment instituted for each sport.

Equestrian injuries (82 patients, 41.8%) accounted for the highest number of sports-related spinal injuries. The majority of riders (92%) were non-professionals.

Rugby accounted for 16.3% of sports-related spinal injuries. The majority of injuries occurred early in the season. After an average of 5.5 years of follow up only 36% of patients had returned to play.

Diving accounted for 15.3% of sport-related spinal injuries. The majority of these injuries occurred abroad and were repatriated home. There was a similar representation between injuries occurring between diving into the sea and swimming pool. Excess alcohol consumption was found to be a contributing factor in 64% of cases.

Gaelic football, which is one of our national sports, accounted for 8.1% (16 patients) of sports-related spinal injuries. It is a field game, often described as a mixture of soccer and rugby similar to Australian rules. Spinal injuries mainly occurred at the cervical level.

Hurling, which is another one of our national sports, accounted for 1.5% (3 patients) of sports-related spinal injuries. It is Europe's oldest and fastest field game and resembles hockey in that it is played with a small ball and a curved wooden stick.

Rock climbing accounted for 3% (5 patients) of all sports-related spinal injuries. There was a high incidence of associated injuries, especially pelvic fractures.

Sailing resulted in 3% (5 patients) of all sports-related spinal injuries. The mechanism of injury in all cases involved falling overboard.

Skiing accounted for 1.2% (2 patients) of all sports-related spinal injuries. Both accidents occurred abroad and patients were repatriated home for further treatment.

Surprisingly motor racing only accounted for 1.2% (2 patients) of all sports-related spinal injuries. The most common pattern of injury was damage to the thoracolumbar junction, following collision on the track.

Table 1 Demographic data, pattern and mechanism of injury, neurological deficit and treatment for each sport

Sport	No. (%)	Gender	Mean age (range)	Length of stay	Pattern of injury	Mechanism of injury	Neurology	Surgery (%)
Equestrian	82 (41.8)	42 males 40 females	35 (15–72) years	9.5 (1–82) days	29% thoracolumbar jxn 25% cervical 22% thoracic 21% lumbar 3% cervicothoracic	Fall/thrown from horse Jumping most common activity	23–17% complete	29
Rugby	32 (16.3)	32 male	21 (14–53) years	8.1 (3–29) days	C5/6 #-subluxation	Hyperflexion > hyperextension Loose play > scrums	50–56% complete	35
Diving	30 (15.3)	28 males 2 female	25 (16–40) years	9 (1–21) days	90% cervical spine (C6 most common level) 10% lumbar	Combined axial loading ± hyperflexion following diving/sliding head first into shallow water Lumbar # if dived feet first	60–39% complete	43
Gaelic football	16 (8.1)	16 males	25 (15–25) years	5 (1–13) days	Cervical spine (C5 most common level)	Hyperflexion > hyperextension following tackles + collisions on pitch	25–6% complete	6
Hurling	3 (1.5)	2 males 1 female	26 (16–34) years	8.3 (1–15) days	Cervical spine (C6/7)	Hyperflexion injury to following tackles + falls	66–50% complete	33
Rock climbing	5 (3)	4 males 1 female	28 (22–45) years	26.4 (5–84) days	Thoracolumbar junction 60% > 1 vertebral level affected	Fall from height	40–50% complete	80
Sailing	5 (3)	4 males 1 female	54 (32–71) years	13.4 (8–35) days	Cervical spine Lumbar spine	Fall overboard	60–100% incomplete	20
Skiing	2 (1.2)	1 male 1 female	36 (33–39) years	2.5 (2–3) days	100% Thoracic spine	Falls during ski jumping	50–100% complete	50
Cycling	8 (4.2)	6 males 2 females	35 (19–63) years	15 (1–70) days	75% cervical spine 25% thoracic spine 12.5% lumbar spine	Fall from bicycle	38–66% complete	50
Quad bike	4 (2.3)	4 males	26 (19–36) years	11 (3–25) days	75% thoracic spine	Falling backwards off quad bike	0%	25
Paragliding	2 (1.5)	2 males	36.5 (33–40) years	15.8 (8–23) days	100% lumbar spine	Axial compression following inappropriate landing technique	50–100% incomplete	50
Parachuting	4 (2.3)	3 males 1 female	31 (21–40) years	22.5 (10–29) days	50% lumbar spine 25% cervical spine 25% thoracic spine	Inappropriate landing technique	25–100% incomplete	75
Motor racing	2 (1.2)	2 males	25 (18–31) years	17.5 (2–33) days	Thoracolumbar jxn	Collisions on track	0%	50
Gymnastics	1 (0.6)	1 female	23 years	4 days	C3/4 subluxation	Hyperextension injury	0%	0
Jet ski	1 (0.6)	1 female	21 years	16 days	L4 #	Hyperextension injury	0%	0

Discussion

Sport is an important cause of spinal injury among young people in Ireland, with 60% of injuries occurring in those under 35 years of age. Males predominated in all sporting activities with equestrian sports accounting for the highest number of spinal injuries in females. The severity of these injuries is compounded by the risk of long-term neurological deficit. In our study, for those who sustained permanent complete paralysis 77% were tetraplegic.

Understanding the factors that contribute to spinal injuries is paramount in injury prevention. The injuries resulting from spinal trauma depend upon the magnitude and direction of the applied force, and the stability of the spine, which depends on the integrity of the intervertebral disc, joints and ligaments. The cervical spine is more susceptible to injury than the thoracic or lumbar spine. This study shows that the cervical spine is particularly susceptible to injury during contact field sports.

The articular processes of the cervical spine are small, flat, and almost horizontal. This configuration allows for maximum mobility but does not afford stability; dislocation can therefore occur relatively easily. The spine is particularly vulnerable to rotational forces. Manual rotation of the cervical spine is sufficient to tear the spinal ligaments and result in dislocation. If the neck is slightly flexed and a rotational force is applied, the posterior ligaments, joint capsule and posterior longitudinal ligaments will tear, making the cervical spine highly unstable. The fulcrum for maximum flexion and cervical movement in the adult spine is located at C5/6. The ribs, sternum and thoracic facet joint orientation confer more stability to the upper thoracic spine (T1–T10); however, the thoracolumbar junction acts as a fulcrum, allowing increased motion to occur, thereby giving rise to an increased risk of injury.

This study shows that in equestrian sports the main mechanism of injury involved a fall or been thrown from a horse, with the pattern of spinal injury being determined by how the rider landed. The head of the rider is approximately 3 m above the ground so; falls particularly at speed can be potentially very serious [1, 12]. Those that landed on their head were more likely to sustain a hyperflexion injury to the cervical spine; however, those that landed on their buttock were more likely to sustain an injury at the thoracolumbar junction. The use of proper riding helmets has dramatically reduced the number of severe and fatal head injuries [7, 13]. All riders in our series wore helmets. Only a minority wore body protectors; however, the protective role of body protectors has yet to be shown. The fact that the majority of injuries (92%) occurred in amateur riders stresses the importance of a good knowledge of horses and their behaviour and teaching riders safe falling techniques [19, 31].

The most common mechanism of injury seen in contact field sports in this study, namely rugby, Gaelic football and hurling was a flexion injury to the cervical spine, often associated with a rotational component. Loose play is inherently dangerous to the cervical spine from forced flexion of the ball carriers' neck. This can occur when several players fall on top of the kneeling ball carrier that is trying to escape from the ruck or alternatively from the progressive increase of force exerted on the neck of the player at the bottom of the heap as more players join in the ruck. Also the player who dives carelessly into a ruck with is head and neck flexed places his own neck at risk. Changes in rules have been shown to impact on incidence of spinal injuries. A rise in the number of ruck and maul injuries in England was attributed to rule changes that allowed the tackled player to retain control of the ball, thereby encouraging wrestling for the ball and the development of the ruck and maul [27]. Whereas in New Zealand injuries were reduced by rule changes that encouraged players to stay on their feet in the ruck and maul [4]. During a scrum, both packs may generate forces equivalent to 1.5 tons. The forces produced during the scrum exceed the force necessary to cause compression failure of the vertebral body (4,500 N) or ligamentous injury to the cervical spine (200 N) [20]. Injuries occurring due to engagement and collapse of scrums have shown to be reduced by using the following techniques. To control and slow engagement, props should use the crouch, touch, pause, engage technique so that the engagement will be more coordinated [2, 14]. The collapsing scrum can be prevented by techniques that reduce the preoccupation with power scrummaging by 'depowering' the scrum. This involves limiting its duration and by preventing it from moving more than 1.5 m or wheeling [4, 27].

The incidence of diving-related spinal cord injuries varies from 2.3% in a South African study [15] to a high of 21% in a study conducted in Poland [17]. Several studies confirm that spinal injuries occur in water depths <1.52 m, which is below the minimum required diving depth [3, 10, 21]. Velocities and angles of entry will determine the body's ability to decelerate upon entry. Entry angle is critical as the more vertical the angle the less the distance to the pool or sea bottom [32]. Angles >30° with straight body alignment can cause the diver to contact the pool bottom at potentially life threatening velocity [3, 8]. This is further exacerbated by the narrow diameter of the spinal cord, the minimum protection offered by bones and soft parts, and minimal flexibility of the actual spinal canal [3, 11, 29]. The risk of spinal injury during aquatic recreational activities is increased by alcohol consumption because preception, cognition, information processing, and awarness of external and internal cues are impaired and risk-taking behaviour is induced [23]. Hence, judgement of

distance, height, and depth is affected and reflexes are slowed, making diving extremely dangerous, especially in shallow water [25]. Teaching safe diving techniques are the most effective way to prevent diving injuries, since people have been found to take little notice of signs or regulations [3]. Studies of paragliding and parachuting injuries showed how improving pilot skills and use of back protection devices were the best prophylaxis for the pilot against pelvic and spinal injuries [26].

Excess speed, loss of control and subsequent falls landing directly onto the lower back and/or buttock have been shown to be the main contributing factors in skiing spinal injuries [24]. Despite knowledge of the most common patterns and mechanisms of injury associated with each sport it is important to evaluate the spine as a whole for associated injuries. In our study 9% had more than one region and 40% had more than one vertebral level affected.

Studies on the incidence of sports-related spinal injuries in other countries have identified the following risk factors; inexperience and poor knowledge of the inherent dangers of the sport, inadequate coaching and practice facilities, lack of supervision, protective equipment and strict refereeing [28]. Research has shown that the safest way to tackle and block is with the head up, to discourage it from being used as the initial point of contact [16]. Cantu and Mueller [6] reported how teaching the fundamental techniques of the game, equipment standards, and improved medical care both on and off the playing field led to an amazing 270% reduction in permanent spinal cord injury in American football from a peak of 20 per year during the period 1971 to 1975 to 7.2 per year from 1991 to 2001.

Accurate epidemiological data and analysis of the pathomechanics of these injuries helps in the design of rules and regulations to reduce the risk of these injuries; however, without rigorous enforcement of these rules their incidence will remain unchanged.

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