Spinal Cord (2009) 47, 857–860

www.nature.com/sc

ORIGINAL ARTICLE

Pattern of sports- and recreation-related spinal cord injuries in Beijing

C Ye[1,2], T Sun[1], J Li[3] and F Zhang[2]

[1]*Orthopaedic Department, The Beijing Army General Hospital, Beijing, China;* [2]*Department of Hygiene and Rehabilitation, The Capital Institute of Physical Education, Beijing, China and* [3]*The China Rehabilitation Research Centre, Beijing, China*

Study design: Retrospective study.
Objectives: To determine the characteristics of sports- and recreation-related (SR-related) spinal cord injuries (SCIs) in Beijing.
Setting: Beijing, China.
Methods: A review of the complete medical records of 57 consecutive SR-related SCI patients referred to four general hospitals and two rehabilitation institutions was carried out. Patients were injured between 1993 and 2006. The variables studied included demography, sports and recreation characteristics, diagnoses and outcome.
Results: There were 44 males and 13 females with a ratio of 3.3:1. The mean age was 24.49 ± 11.92 years. In 37 patients (64.9%), water sports was the single most commont cause. Of them, injury because of diving was seen in 34, which constituted 59.6% of the total. Other types of sports and recreation accounted for 35.1%. Level of cord lesion was cervical in 89.5% and thoracic in 10.5% of the injured. The lesion of C4 alone constituted 45.6% of the total. The ratio of complete to incomplete lesion was 1.2:1. In all, two patients died, and one with an injury at the C4 level recovered completely. Of the other 54 survivals, 48 (89%) remained tetraplegic and six remained paraplegic (11%). The main underlying cause was the lack of safety awareness, safety regulations and their implementation.
Conclusion: SR-related SCI was most commonly seen among young male adults, predominantly as a result of diving accidents. There was a significant increase in sports injuries, other than those caused by diving, in later years. Successful prevention programs of other countries are being adopted in Beijing in recent years, hence an improvement in safety is expected in the years to come.
Sponsorship: This work was sponsored by Funding Project for Academic Human Resources Development in Institutions of Higher Learning Under the Jurisdiction of Beijing Municipality (2007) and Funding Project for Science and Technology Development of Beijing Municipality-(km200710029003).
Spinal Cord (2009) **47**, 857–860; doi:10.1038/sc.2009.49; published online 12 May 2009

Keywords: spinal cord injury; sports and recreation; diving; cervical; education

Introduction

Sports- and recreation-related (SR-related) spinal cord injuries (SCIs), although accounting for only a small percentage of all injuries in China, can have a devastating effect on the health and social well-being of the people involved. These injuries predominately occur in young adults,[1–4] and contribute to a high incidence of long-term disability and high morbidity.[5–10] They also impose a heavy economic burden on the society.[5,11] An understanding of the pattern of SR-related SCIs is necessary to identify the risk groups in terms of age, gender, type of sports and recreation, and mechanism of injury to improve prevention. Numerous studies have shown the features of SR-related SCIs[2–4,6–8,11–15] and proposed measures for their prevention.[14–16] In China, however, SR-related SCIs did not receive sufficient attention.

A study of SR-related SCIs was undertaken to provide basic demographic and medical information, mechanism of injuries and neurological outcome. It is hoped that it might help in further research and prevention.

Methods

This retrospective study describes SR-related SCIs that were referred to six institutions (see below). The inclusion criteria are as follows: admission between 1st January 1993 and 31st

Correspondence: Professor T Sun, Orthopaedic Department, The Beijing Army General Hospital, Dong Cheng District nan men cang 5#, Beijing 100700, China.
E-mail: drsuntiansheng@hotmail.com
Received 3 November 2008; revised 23 March 2009; accepted 4 April 2009; published online 12 May 2009

December 2006, and injuries of the vertebral column with spinal-cord lesions resulting from sports and recreation. Types of sports and recreation included water sports, gymnastics, ball game, casual game, dancing, acrobatics, high jump, snow skiing and tug-of-war. The following data were retrieved from the medical records for analysis: age at the time of injury, gender, type of injury, predisposing factors, mechanism of injuries and outcome. Statistical analyses were carried out using Statistical Package for the Social Science, version 11.5. Fisher's exact probability test was used for analyzing statistical significance.

Results

In this study, 57 cases with SR-related SCIs were included from six main institutions that specialize in SCI treatment and rehabilitation in Beijing. Of the 57 cases, 26 were from the China Rehabilitation Research Centre, 21 from the Beijing Army General Hospital, 5 from the China PLA General Hospital, 3 from the China PLA 304 Hospital and 1 each from the Peking University Third Hospital and the Beijing Rehabilitation Centre. Of the 57 patients, 37 were involved in water sports accidents (64.9%) and 20 in other accidents (35.1%).

Age at injury
The age of patients ranged from 5 to 58 years, with a mean of 24.49. (s.d. 11.9) years. The youngest was injured in a dancing accident, whereas the oldest fell during snow skiing (Table 1).

Gender
In all, 44 (77.2%) males and 13 (22.8%) females were involved in the injuries.

Types of sports and recreation
In water sports (Table 2), injuries because of diving in a public swimming pool was as high as 34 (59.6%), injuries because of a collision between floatplanes and falling from the bank of the swimming pool, and as a result, hitting the wall of the pool occurred in one each.

Neurological deficit
The ASIA Impairment Scale (AIS) was as follows: A 32 (56.1%), B 19 (33.3%), C 5 (8.8%) and D 1 (1.8%). The ratio of complete to incomplete injuries was 1.2:1. The level of neurological lesion is presented in Table 3. Cervical cord was the main location of injury, accounting for 89.5% of the series, whereas C4 was the most common level (45.6%). Thoracic cord injury was seen in 6 (10.5%) patients.

Sports type against level of Neurological lesion
Of the 34 diving injuries, 33 (89.2%) occurred at the C4–C7 level. Gymnastics and acrobatics also tend to cause cervical cord injuries. By contrast, dancing was associated with T9–12 cord injuries (Table 3).

Table 1 Sports- and recreation-related spinal cord injuries by age

Age (years)	*Number*	*%*
5–11	4	7.0
12–29	36	63.2
30–39	11	19.3
40–49	4	7.0
50–58	2	3.5
Total	57	100.0

Table 2 Sports- and recreation-related spinal cord injuries by cause (types of sports/recreation) and gender

Sports/recreation	*Number of patients*	*%*	*Gender*			
			Male	*%*	*Female*	*%*
Water sports	37	64.90	31	54.40	6	10.50
Gymnastics	5	8.80	3	5.30	2	3.50
Ball game	4	7.00	4	7.00	0	0
Casual play	3	5.30	3	5.30	0	0
Dancing	3	5.30	0	0	3	5.30
Acrobatics	2	3.50	2	3.50	0	0
High jump	1	1.75	0	0	1	1.75
Snow skiing	1	1.75	0	0	1	1.75
Tug-of-war	1	1.75	1	1.75	0	1.75
Total	57	100	44	77.20	13	22.80

Table 3 Types of sports/ recreation versus level of neurological lesion

Sports/ recreation	*Neurological level total*												*Total*
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*T8*	*T9*	*T10*	*T12*	
Water sports		1	2	19	7	5	2	1					37
Gymnastics				1	1	1	2						5
Ball game	1			2							1		4
Casual play				1	1				1				3
Dancing										1	1	1	3
Acrobatics				2									2
High jump						1							1
Snow skiing				1									1
Tug-of-war											1		1
Total	1	1	2	26	9	7	4	1	1	1	3	1	57

Table 4 Sports- and recreation-related spinal cord injuries by year

Year	*Number*
1993	0
1994	2
1995	7
1996	0
1997	2
1998	6
1999	9
2000	8
2001	5
2002	1
2003	5
2004	4
2005	3
2006	5
Total	57

Change of causes and quantity with time
Table 4 presents the annual number of SR-related SCIs. There was an overall increase of 8.8% from 26 cases in 1993–1999 to 31 cases in 2000–2006. It is worth noting that injuries because of sports other than water sports increased from 3 in 1993–1999 to 17 in 2000–2006, whereas those from water sports decreased from 23 to 14. In water sports, diving decreased from 22 to 12. This difference has high statistical significance (Fisher's exact probability test, $P \leqslant 0.001$). Such a change was to a large extent attributed to the increase in injuries due to dancing, acrobatics, snow skiing, casual play, high jump and tug-of-war from 0 in 1993–1999 to 11 in 2000–2006. However, there is no statistical difference in the numbers of males and females between 1993–1999 and 2000–2006.

Neurological outcome during hospitalization
Two patients (3.5%) with AIS A died in the emergency department, of whom one was a female with an injury at the C2 level resulting from a collision between floatplanes and the other was a young man with an injury at the C3 level, who fell head down from a high horizontal bar during dismount. In all, 2 out of the 19 patients with AIS B improved to AIS C, 2 out of 5 improved from AIS C to AIS D and only 1 improved from AIS D to AIS E. No deterioration was observed among the survivors. Of the 54 survivors who remained paralysed, 48 (89%) patients were tetraplegic and 6 (11%) were paraplegic.

The mechanism of injury varied with the type of sports and recreation. Almost all of them related to a lack of safety awareness, safety regulations and their implementation.

Diving head down into the shallow water of a public pool with depth markers was the most common mechanism in swimming accidents. Of the 36 swimming injuries, 34 (94%) dived into shallow water and the head struck the bottom of the pool. No one had taken drugs, although five had consumed alcohol before diving.

Falling head down from a high horizontal bar and vault was the main cause for gymnastics accidents, and an unfamiliar technique and lack of concentration were the contributory factors. In the five gymnastics accidents, four of the patients were students in secondary school and the fifth was a professional athlete. Of these five patients, two were males and three were females. A male gymnast was injured because of an unfamiliar technique, and another from a lack of concentration soon after a nap. He fell head down from a high horizontal bar during dismount. Of the three females who fell from a vault during jumping, two were injured because of their poor techniques. Another professional athlete was injured because of distraction caused by shouting during jumping.

Of the four ball-game injuries, two basketball injuries were caused by a collision between two players using inappropriate techniques, both football and volleyball injuries were caused because of ruck and maul.

Ruck and maul was the main mechanism of casual play. For the three casual players, two fell from other players' shoulders, resulting in tetraplegia of C4 (one complete, another incomplete), whereas the third resulted in paraplegia of T8 from maul.

Two patients, while engaged in acrobatics, fell from the air and developed complete tetraplegia of C4. In accidents caused due to dancing, all three children were injured during spine extension and rotation, resulting in complete paraplegia of T9, T10 and T12, respectively. All three were spinal cord injuries without radiographic abnormality (SCIWORA).

Discussion

In Beijing, the annual incidence of SR-related SCI is low. According to a survey, it was 0.6 per million people and constituted only 1.1% of all spinal cord injuries in 2002.[18] The majority of SR-related SCIs were seen among young male adults. Cervical spinal cord was the main anatomical location of neurological deficit. Complete injuries were slightly more than incomplete ones. These characteristics were consistent with those reported in the literature.[2,3,7,12,19] The pattern of aetiology varies among countries. In the United States, 7.3% of spinal cord injuries are caused by sports accidents, of which football is the most common.[5] In Germany, of 1016 reported traumatic spinal cord injuries, 147 (14.5%) resulted from sports accidents, of which 78 (7.7%) were from diving accidents.[12] In Japan, the majority of SR-related SCIs result from diving and gymnastics accidents,[6] and diving was the most common cause of spinal cord injury (21.6%) in a nationwide epidemiological survey.[7] This resembles the pattern of SR-related SCIs in this report. In Israel, air sport accidents are the main cause of SCI, probably because of intensive and extensive military activities in the region.[8] In Australia[10] and South Africa,[9] most of the spinal cord injuries result from the popular sports of the two countries, namely, Australian football and rugby. In Beijing, water sports were the most common cause of SR-related SCIs, followed by gymnastics and ball games. We failed to locate any case of casual play, dancing and acrobatics in other similar reports. Our observations of eight cases on these causes are too limited to draw any solid conclusion. These results may reflect the expansion of sports activities into unfamiliar territories in recent years in Beijing.

Diving has been widely studied, and its frequency is high among water sports.[1,2,6,7] According to Barss[1] and Reid,[2] diving off a beach or pier, or diving head first into shallow areas at private swimming or public pools and striking the bottom was the most common mechanism of injury. An absence of depth indicators and a *NO DIVING* sign contributed to 74 and 89%, respectively, of reasons for SCI in diving accidents.[1] Apart from these two factors, alcohol abuse, an unfamiliar private pool, first-time diving, inadequate or lack of lighting were considered to be other important contributing factors. DeVivo's study of teen diving injuries showed that 49% of cases of severe spinal injuries had consumed alcohol, 44% took place on a first visit to a pool, 28% happened on the first dive into the pool and that there were no depth markers at 87% of the private pools where the accidents took place.[14] In sharp contrast to

Barss[1] and *De Vivo*'s[14] report, 94% of the swimming injuries in our study were inflicted at the shallow areas of public pools despite the existence of depth markers. It was impossible to accurately trace back whether there was a *NO DIVING* sign or sufficient lifeguard's attention in the pool complex, particularly in cases during the early years of the study. As there were clear depth markers in most of the pools in our study, we can only assume that the high incidence of diving accidents was probably because of a lack of these two factors. Education programs of safety remain sketchy in the Beijing region. It is of paramount importance to promote such programs and enforce safety regulations.

As was true in other reports,[12,19] gymnastics injury also shows a similar profile, which occurred mainly in children and teenagers and led to cervical spinal cord injury. However, gymnastics accounted for relatively few cases in our study. It indicates that good training for beginners and awareness among participants are important preventive measures.

SCI from competitive contact sports is low in our survey. In South Africa, Australia and the United States of America, football, rugby and ice hockey pose the highest risk for SCI,[9,10,15–17] but they were rare in China. In line with other reports, tackle, scrum, ruck and maul were the most common causes of injury in ball games.[15–17]

Casual play, dancing and acrobatics also led to SCI, but they were less frequent. In contrast to the characteristics of water sports, gymnastics and acrobatics injuries, accidents caused by dancing mainly lead to thoracic cord injuries in little girls. The possible mechanism was thoracic spinal cord extension and rotation.

SR-related SCI is devastating and costly. Numerous preventive programs, such as warning signs, TV commercials, posters,[12] Think First Campaign[20] and rule changes to eliminate spearing, facing tackling and scrum,[15,16] have been designed and practiced to reduce the incidence of SR-related SCI with some positive results.[15,16,20] The recommended preventive measures include promoting public educational program of awareness of safety, improving equipment standards, teaching fundamental techniques, training inexperienced beginners, enforcing existing rules and encouraging coordination between players in team sports.

In summary, SR-related SCI was most commonly seen among young male adults, predominantly as a result of diving accidents. Sports activities have expanded into other less-familiar territories in the period of 2000–2006 because of the development of economy and a change in lifestyle. This has caused the number of other sports accidents to increase. During the same period, swimming accidents decreased, probably because of improved safety awareness. In recent years, successful prevention programs of other countries are being adopted in Beijing, hence an improvement in safety is expected in the years to come.

References

1 Barss P, Djerrari H, Leduc BE, Lepage Y, Dionne CE. Risk factors and prevention for spinal cord injury from diving in swimming pools and natural sites in Quebec, Canada: a 44-year study. *Accid Anal Prev* 2008; **40**: 787–797.
2 Reid DC, Saboe L. Spinal trauma in sports and recreation. *Clin J Sport Med* 1991; **1**: 75–80.
3 Caine D, Caine C, Maffulli N. Incidence and distribution of pediatric sport-related injuries. *Clin J Sport Med* 2006; **16**: 500–513.
4 Shelly MJ, Butler JS, Timlin M, Walsh MG, Poynton AR, O'Byrne JM. Spinal injuries in Irish rugby. *J Bone Joint Surg [Br]* 2006; **88-B**: 771–775.
5 DeVivo MJ. Causes and costs of spinal cord injury in the United States. *Spinal Cord* 1997; **35**: 809–813.
6 Noguchi T. A survey of spinal cord injuries resulting from sport. *Paraplegia* 1994; **32**: 170–173.
7 Katoh S, Shingu H, Ikata T, Iwatsubo E. Sports-related spinal cord injury in Japan (from the nationwide spinal cord injury registry between 1990 and 1992). *Spinal Cord* 1996; **34**: 416–421.
8 Ohry A, Rozin R. Spinal cord injuries resulting from sport. The Israeli experience. *Paraplegia* 1982; **20**: 334–338.
9 Hart C, Williams E. Epidemiology of spinal cord injuries: a reflection of changes in South African society. *Paraplegia* 1994; **32**: 709–714.
10 Yeo JD. Prevention of spinal cord injuries in an Australian study (New South Wales). *Paraplegia* 1993; **31**: 759–763.
11 Cantella D. Sports-related spinal cord injuries. *Crit Care Nurs Q* 1999; **22**: 14–19.
12 Schmitt H, Gerner HJ. Paralysis from sport and diving accidents. *Clin J Sport Med* 2001; **11**: 17–22.
13 Blanksby BA, Wearne FK, Elliott BC, Blitvich JD. etiology and occurrence of diving injuries. A review of diving safety. *Sports Med* 1997; **23**: 228–246.
14 DeVivo MJ, Sekar P. Prevention of spinal cord injuries that occur in swimming pools. *Spinal Cord* 1997; **35**: 509–515.
15 Quarrie KL, Gianotti SM, Hopkins WG, Hume PA. Effect of nationwide injury prevention programme on serious spinal injuries in New Zealand rugby union: ecological study. *BMJ* 2007; **334**: 1150–1153.
16 Cantu RC, Mueller F. Catastrophic spine injuries in American football. 1977–2001. *Neurosurgery* 2003; **53**: 358–363.
17 Carmody DJ, Taylor TK, Parker DA, Coolican MR, Cumming RG. Spinal cord injuries in Australian footballers 1997–2002. *Med J Aust* 2005; **182**: 561–564.
18 Jianjun Li, Investigation Group of 2002 Beijing SCI Epidemiology. Spinal cord injuries in Beijing: a municipal epidemiological survey in 2002. *Presented at the 42nd Annual Scientific Meeting of the International Spinal Cord Society; Beijing; 15–18 October* 2003.
19 Mueller FO, Cantu RC. Catastrophic injuries and fatalities in high school and college sports, fall 1982-spring 1988. *Med Sci Sports Exerc* 1990; **22**: 737–741.
20 Mueller F, Cantu R. *National Center for Catastrophic Sports Injury Research-Fifteenth Annual Report 1982–1997*. NCCSI: Chapel Hill, NC, 1997, 1–81.