Recognition and Management of Spinal Cord Injuries in Sports and Recreation

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In developed countries, sports and recreation often rank as the second most common cause of acute spinal cord injury (SCI), just behind motor vehicle crashes and ahead of injuries at work and falls at home. In some countries, sports-related SCI comprises 20% or more of the cases of SCI. It has been estimated that the frequency of SCI in sports and recreation in various countries ranges from 4.5 to 95 cases per 100,000 population. In some sports, such as football and hockey, there has been a decline in the incidence of spinal injuries because of specific prevention efforts, but in other sports, such as alpine skiing and snowboarding, there has been an increase in most countries. There are some differences in the pathophysiology and clinical management of SCI attributable to sports and recreation compared with the other causes of SCI. Most of the injuries occur acutely, but many athletes have chronic progressive syndromes, such as chronic cervical myelopathy, after prolonged participation or “overuse” in impact sports, such as tennis. Injury prevention is one of the most important considerations in SCI attributable to sports and recreation, given that virtually all these injuries are avoidable. Another important issue relates to the guidelines for return to play after SCI incurred in sports or recreation.

CLINICAL MANIFESTATIONS

General Features

Worldwide, diving is the most common cause of acute SCI in sports and recreation. The injuries in diving are almost always to the cervical spine, and there is a high incidence of complete SCI. These injuries occur most often in the setting of unsupervised recreation at the lakeside, the ocean, or in private pools, and less often in a supervised setting such as a pool at a school. Trained divers seldom sustain SCI.
With respect to organized sports, football in the United States and hockey in Canada are the team sports with the highest incidence of acute SCI.\textsuperscript{11,12} These sports also cause a high incidence of accelerated degenerative spinal changes that can lead to chronic myelopathy and radiculopathy. In the U.S. and in Canada, registries have been developed that provide systematic reporting of the incidence of SCI related to football\textsuperscript{13} and hockey.\textsuperscript{14} Major prevention programs have been developed to deal with some of the identified causes of these injuries, such as “clotheslining” and “spearing” in football and hitting from behind into the boards in hockey. Other organized sports with a high incidence of spinal injury or SCI are gymnastics (including the trampoline), wrestling, skiing, hang gliding, mountain climbing, rugby, and horseback riding.\textsuperscript{15–17} Bicycling and motor sports, including snowmobiles, all-terrain vehicles, dirt bikes, and motor cycle racing, also are responsible for large numbers of SCI in specific regions of many countries that have terrain and facilities suitable for these recreational activities.\textsuperscript{7}

In almost all types of sports and recreation, approximately 80\% of the SCIs are sustained by male participants, and this is true for organized and unorganized activities. Horseback riding is one of the major exceptions in North America, because female participants are affected more often than male participants, likely reflecting the higher numbers of female participants. In sports and recreation, the SCI victims are usually young, with children occasionally affected.\textsuperscript{18} Indeed, in such sports as hockey, football, and rugby, teenagers often sustain SCI. In general, children younger than 10 years of age have a lower incidence of SCI but are prone to ligamentous injuries, especially of the upper cervical spine. In contrast, older children have injuries in the middle and lower segments of the cervical spine similar to adults.\textsuperscript{19}

\textbf{Sideline Evaluation}

It is safe and best practice to assume that until proved otherwise, all unconscious athletes have an unstable cervical, or other spinal level, fracture or dislocation of the spine. This implies a “no movement” policy for the unconscious player with strict attention directed to immobilization of the neck and back. The one exception to this rule is that the patient may need to be moved to establish an adequate airway and breathing. The same precaution holds for concussed athletes who may not have lost consciousness because they may also have sustained a concomitant spinal injury. Caution is also required in removing the helmet of football or hockey players; in general, it is best to leave the helmet in place until adequate help is available. Once prepared, it is best to remove the helmet and shoulder pads together as a unit to avoid the tendency for extension of the neck if the helmet is removed while the shoulder pads remain in place.

\textbf{Level, Severity, and Type of Spinal Cord and Spinal Injuries}

In general, cervical SCI is much more common in sports and recreation than thoracic or thoracolumbar injury.\textsuperscript{10} In certain activities, such as diving, SCIs are almost exclusively cervical. Motor sports, such as those involving all-terrain vehicles and snowmobiles, and horseback riding cause a large number of thoracic and thoracolumbar injuries.\textsuperscript{20} Similar to the findings in nonathletic injuries, approximately 60\% of SCIs in sports and recreation are incomplete injuries, with American Spinal Injury Association (ASIA) grades of B, C, and D. In some sports, however, notably diving, complete spinal cord injuries occur more often than incomplete injury. SCIs without spinal fracture are frequent in sports and recreation, especially related to acute disc herniations, which can occur at any level of the spinal column.
Many of the sports and recreational injuries of the spine involve a combination of high speed and axial loading, and this is especially true in football and hockey, in which burst fractures and compression fractures frequently occur. The combination of flexion and axial loading, or extension and axial loading, can lead to fracture-dislocation with or without associated disc rupture. Bilateral locked facets in the cervical region with anterior dislocation or fracture-dislocation are common injuries sustained in diving, whereas young gymnasts have a propensity for fractures of the pars interarticularis in the lumbar region.\textsuperscript{18} In children, the mechanisms of injury reflect those in adults, although there are significant differences, such as a greater tendency for SCI without fracture or dislocation of the spine.\textsuperscript{18}

Overuse spinal injuries accelerate the onset and magnify the severity of such conditions as degenerative disc disease, cervical spondylosis, and spinal osteoarthritis.\textsuperscript{21,22} These conditions may occur at a much earlier age in athletes than in the general population because of repetitive loading of the spine, as in wrestling, weightlifting, and gymnastics. There are several risk factors that make the adolescent spine susceptible to stress fractures manifesting as spondylolysis. The neurologic sequelae of these spinal diseases present as radiculopathy or myelopathy. Activities in which these chronic spinal conditions frequently become significantly symptomatic include running/jogging, tennis, and squash.

Repetitive lifting of heavy weight can also worsen preexisting degenerative spinal conditions. Practitioners should caution participants approaching middle age that high-impact activities may have to be tailored back or abandoned for lower impact or nonimpact activities, such as fast walking or swimming. Similar advice should be given about limiting the amount of weight to be lifted.

\textbf{TREATMENT}

\textit{Acute Injuries}

It is important for physicians associated with sports teams or athletic or recreational events to have the necessary training and equipment to provide first aid safely and effectively. In general, the first aid and subsequent hospital management of the athlete with an acute SCI are identical to the management of other patients with these injuries. There should be preparation for the management of a catastrophic spinal injury,\textsuperscript{23} with special attention to airway, breathing, and circulation—the "ABC's" of resuscitative trauma management. The attending physician or trainer should quickly obtain a thorough history of the injury, inquiring specifically for spinal pain, muscle weakness, and sensory loss, followed by an examination of the nervous system, including assessment of power and sensation. The examiner should gently palpate the entire spine for detection of crepitus, tenderness, or deformity. It is essential to ensure absolute immobilization of the entire spine during examination, and before any required transfers and transport. Effective treatment includes the prevention of secondary injuries, such as pressure sores, and administration of appropriate resuscitative measures. These measures prevent worsening of neurologic deficits or the initiation of a neurologic deficit in persons without an initial deficit who have an unstable spinal injury. There should be complete documentation of any previous injuries, because this information is essential for inclusion in the deliberations regarding return to play.

Helmet removal of injured players requires specific attention in sports like football and hockey sports in which players are also wearing shoulder pads.\textsuperscript{5} In these cases, the helmet should not be removed first. If there is a problem with airway management, only the facemask should be removed, and this can be accomplished with heavy wire cutters. Removal of the helmet first in a player wearing shoulder pads may cause extension of the neck because of the thickness of the shoulder pads.
the shoulder pads and helmet should be removed simultaneously while maintaining
the neck in axial alignment with the trunk.\textsuperscript{24,25} Spinal injuries in athletes require
complete imaging, preferably by a combination of CT and MRI to detect evidence
of current and previous injury to the spine and spinal cord, including ligamentous
injury, and to detect spinal instability and intracanalicular space-occupying lesions,
such as with herniated vertebral discs. MRI is especially useful for the detection of
ligamentous injury, disc herniation, and presence of subtle signal changes in the
injured cord. The details of management and the choice of surgical versus nonsurgical
management are beyond the scope of this article, except that there is a greater
tendency toward recommendations for operative fusion in athletes because of the
high level of impact forces, especially in contact sports.

\textbf{Chronic Injuries}

The management of athletes with chronic injuries is no different from that of nonath-
letes with similar injuries, except for the importance of changing to lower impact or
nonimpact activities and avoidance of lifting heavy weights.

\textbf{RETURN-TO-PLAY GUIDELINES}

The issue of return to play presents a specific management challenge in athletes. In
general, the treatment team should use the same return-to-play guidelines for profes-
sional and amateur athletes, although professionals often treat themselves differently
from the general population. The practitioner should be prepared for resistance from
some relatives, coaches, trainers, league officials, and players’ agents and should be
prepared for a higher percentage of noncompliance from professional athletes.

Many factors need to be considered when advising athletes about return to play
after spinal injuries. Although there have been good attempts to develop return-to-
play guidelines for spinal injuries,\textsuperscript{26–29} there is still a great deal of uncertainty. The
decision about return to play depends primarily on the nature of the injury and the
nature of the activity in which the athlete is engaged (\textbf{Table 1}).

\textbf{The Nature of the Injury}

Athletes with neurologic and spinal column injuries pose special problems compared
with those with spinal column injuries alone. After a permanent SCI, it is best to advise
no return to contact sports. MRI findings of extensive T2 signal change or syrinx should
also preclude return to play. If the cord injury has been transient, however, or if the injury
involves only a root injury and there is no significant spinal column injury or MRI abnor-
mality, the athlete may be eligible to return to play. The nature of the spinal column in-
jury is the next most important variable. If the spinal column injury is stable, such as with
a spinous process or transverse process fracture, or a mild compression fracture, the
athlete can probably be allowed to return to play, with or without surgical treatment. In
the case of an unstable injury, the athlete should not be permitted to return to play un-
less stability can be restored by conservative or operative means. Athletes who have
had an operative fusion involving one spinal motion segment or who have undergone
a single corpectomy for burst fracture may be eligible for return to play in 6 to 12
months. Most athletes who have had a radiculopathy attributable to a herniated disc
can be allowed to return to play after successful conservative or operative treatment.
Instability should be assessed by flexion-extension views of the spine. Congenital or
acquired lesions, such as atlantoaxial dislocation or severe cervical spondylosis or
stenosis, should preclude return to play (see \textbf{Table 1}).
The Nature of the Sport or Recreational Activity

With contact sports, such as hockey, football, or rugby, the potential for recurrent injury may be much greater, and athletes with significant neurologic or spinal column injuries can seldom return to play. Caution must also extend to sports with potential for high-impact forces, such as skiing, horseback riding, and baseball. Less caution is required for noncontact sports, such as tennis.

Athletes who require surgery, such as cervical or lumbar fusion, are permitted to return to activity gradually, beginning with walking only in the first month and progressing to floor exercises and bicycling. In the second month, postoperative weight training can begin and swimming is encouraged. In the third month, treadmill workouts can be allowed, with return to aerobic exercise the fourth month. With respect to contact sports, athletes should not participate until the next season after a cervical or lumbar fusion or after disc removal (see Table 1).

In summary, players should not return to play if there is persisting neurologic deficit or spinal column instability. In patients developing neurologic deficit, return to play may be permitted only when there has been full neurologic recovery and a stable spinal column. In those without neurologic deficit, return to play may be permitted if

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Spinal injuries in sports: criteria and guidelines for return/nonreturn to play in contact and other high-risk sports and recreational activities</th>
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</thead>
<tbody>
<tr>
<td>Allow Return to Play</td>
<td>Advise Never to Return to Play</td>
</tr>
<tr>
<td><strong>Neurologic injury</strong></td>
<td>• No persisting neurologic symptoms or deficit attributable to cord injury</td>
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<tr>
<td></td>
<td>• Neurologic deficit that recovers to normal</td>
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<td></td>
<td>• Persisting neurologic deficit related to root injury only</td>
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<td></td>
<td>• Single transient SCI or spinal cord concussion</td>
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<td></td>
<td>• Residual neurologic deficit related to SCI</td>
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<td></td>
<td>• Repeated transient cord injury or spinal cord concussion</td>
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<td></td>
<td>• Chronic myelopathy</td>
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<td><strong>Spinal column injury</strong></td>
<td>• Stable spinal column</td>
</tr>
<tr>
<td></td>
<td>• Spinal column stability restored by conservative or operative treatment</td>
</tr>
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<td></td>
<td>• Minor fracture (eg, spinous process, single body compression fracture)</td>
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<td></td>
<td>• No instability in flexion-extension radiographs</td>
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<tr>
<td></td>
<td>• Unstable spinal column</td>
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<td></td>
<td>• Major fracture (eg, burst fracture with canal compromise)</td>
</tr>
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<td></td>
<td>• Instability present in flexion-extension radiographs</td>
</tr>
<tr>
<td><strong>Congenital lesions</strong></td>
<td>• Minor spinal stenosis</td>
</tr>
<tr>
<td></td>
<td>• Congenital or operative fusion of one motion segment</td>
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<td></td>
<td>• Major spinal stenosis</td>
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<td></td>
<td>• Atlantoaxial dislocation</td>
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<td></td>
<td>• Congenital or operative fusion of two or more motion segments</td>
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<td><strong>Acquired lesions</strong></td>
<td>• Mild cervical spondylosis or other arthropathy</td>
</tr>
<tr>
<td></td>
<td>• Severe cervical spondylosis or other arthropathy</td>
</tr>
<tr>
<td><strong>MRI findings</strong></td>
<td>• Normal cord signal</td>
</tr>
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<td></td>
<td>• T2 signal changes in cord</td>
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<td>• Syrinx</td>
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the spinal column is stable. All these possibilities are tempered by the nature of the activities involved, and the discretion of the attending physician is always critical.

INJURY PREVENTION

Unfortunately, screening of participants is of limited value in terms of prevention for SCI in sports and recreation. Routine radiologic examination of the spine in all athletes is not cost-effective, although there are specific exceptions to this rule. For example, atlantoaxial dislocation is a recognized complication in Down’s syndrome and in people with Klippel-Feil syndrome and other congenital anomalies; all such patients should have flexion-extension views before participation. Fortunately, the incidence of SCI in the Special Olympics is low. The issue of routine radiologic screening in high-risk sports, such as football and hockey, has not been settled. There is no definite evidence that certain presumed radiologic indicators for stenosis, such as the ratio of the diameter of the spinal canal to the vertebral body, other measures of spinal stenosis, or the features of the so-called “spear tackler’s spine,” are proved contraindications to play. Lumbar spondylolisthesis has been shown to be present in a high proportion of gymnasts, but it has not been shown that this is a proved contraindication to their participation, although the continuing pain associated with this condition may limit participation. The same is true of progressive degenerative spondyloarthropathies in sports like hockey and football. The pain and neurologic deficits associated with disc protrusions and osteophytes, which produce radiculopathy or myelopathy, may prevent return to play. There is a need for further study of the effectiveness of prevention strategies for spinal injuries in sports.

The education of players, coaches, trainers, referees, and the administrators of sports leagues and associations is an important aspect of injury prevention. There should be an emphasis on respect for the health and safety of all players, including opponents. Awareness of the specific risk factors inherent in individual sports is essential. Repeated safety messages can be given by means of coaching sessions, videotapes, posters, and specialized educational sessions. Players should be warned about highly dangerous maneuvers, such as tackling with the “head into the numbers” in football and checking from behind in hockey. There is mounting evidence that these prevention measures have helped to reduce the incidence of SCI in football and hockey. There should be screening of the participants in sports like rugby to exclude small-stature players from vulnerable positions. Proper conditioning also has value, especially neck muscle conditioning in young athletes with poorly developed neck muscles who play contact sports, such as hockey and football. Adherence to appropriate return-to-play guidelines as outlined in this article can also help to reduce the incidence of catastrophic spinal injury.

Prevention can also be promoted by attention to the structural and physical aspects of the sports venue and by the use of special equipment that has been developed to enhance sports safety. For example, breakaway goal posts in hockey and padded goal posts in football are strongly advocated, although absolute proof of their effectiveness is lacking. There is a need for improved helmet design in many sports. More research is required to determine the best shape and padding for energy deflection and energy absorption, respectively. It should be noted that there is no definite evidence that helmets have led to an increase in SCI in sports like hockey or that improved helmets can actually reduce the incidence of SCI. It may be true that “helmets can neither cause nor prevent serious neck injuries.” Nevertheless, it is the view of this author that proper helmet design and use can reduce the incidence and severity of SCI in certain sports, such as hockey.
SUMMARY

Spinal injuries and SCIs in sports and recreation represent frequent and important causes of injury and disability. These injuries are virtually all preventable through strict adherence to the codes of conduct of the rules and regulations for sports and recreation and through an attitude of respect for one’s own welfare and the welfare of the opponents or other participants. Adherence to guidelines for return to sport after injury can help to prevent worsening of deficits and the onset of new deficits.

REFERENCES