Spine Injuries

19

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19.1 Introduction

The head, the neck, and the spinal cord are the costliest and potentially morbid among sports injuries. Although the practice of sports usually results in well-being while it aggregates lots of health benefits, no sport is immune to the risk of a spine injury. The spine may be affected during professional and recreational sports practice, both in training and competitions [1].

The spine is very sensitive to asymmetric sports, which may contribute to the postural imbalance or increase of pre-existing asymmetries. For the same reason, athletes with posture deviations are more susceptible to these types of lesions. As an example, studies on the relationship between posture and sports injuries in footballers have shown that back injuries are associated with the poor symmetry of shoulders and back, as well as to scapulae abduction [1].

There are specific lesions that are more common in sports practices, and these can be divided into those due to direct trauma in a specific anatomical structure or those due to supraphysiological stress on the spine [2]. Stress lesions can take place both in the individual as in collective sports. Special attention must, therefore, be given during the training phase in order to avoid excessive workloads in terms of intensity and frequency. Appropriate timing must be observed taking into account the period needed for recovery and the adaptation of the muscle and tendon involved; this way, this type of lesion can be avoided, as well as the pain associated with inflammatory phenom-

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ena and anatomical injuries of spine structures [3]. Traumatic lesions usually occur in speed and contact sports, both individual and collective.

19.2 Anatomy of Spine Lesions (Table 19.1)

19.2.1 Bone Lesions

Many types of fractures occur in sports injuries. The most common and frequently reported vertebral bone lesion is spondylolysis, the vertebra area that connects the upper and lower zygapophyseal joints. These lesions are related to repeated extension movements which impact the isthmus on the superior facet joint of the inferior vertebra. The symptoms are back pain whether or not associated with radiculopathy [4]. Fractures of the vertebral body may occur due to compression forces in high-energy sports accidents [5].

19.2.2 Muscle Lesions

Muscular lesions are probably the most common ones related to sports. Direct contusions, stretches, and ruptures may be caused by diverse mechanisms. Reflex contractions of muscles are another cause of pain, and they are usually secondary to another skeletal lesion.

19.2.3 Ligament Lesions

This type of lesion on the spine is related to hyperextension or hyperflexion in repeated movements or a traumatic condition. Incomplete lesions occur due to stretches and are not associated with instability. On the other hand, complete lesions are unstable and commonly associated with neurological deficit [6].

Table 19.1 Anatomical lesions on the spine

Muscle	Contusion, stretch, total or partial rupture
Ligaments	Stretch, total or partial rupture
Disc	Disc rupture, protrusion, extrusion
Bone	Fractures (compression, traction, rotations, and avulsion)
Joints	Sprain and dislocation
Neurological	Nerve root and spinal cord (partial or complete)

19.2.4 Disc Lesions

This condition is related to sport intensity and its repeated movements, as well as to a previous degenerative disease that leads to its worsening and becoming more frequent. A disc herniation seldom occurs due to a traumatic event even though it has been reported [7]. Neurological deficits and pain may occur due to disc compression.

19.2.5 Joint Lesions

Low-energy traumas may cause a sprain, while high-energy traumas may cause joint dislocations. Chronic lesions with mild instability are associated with synovial cysts and possible radiculopathy.

19.2.6 Neurological Lesions

Neurological spine lesions are among the worst and most devastating lesions in sports. They affect the spinal cord and/or spinal nerve roots, with different presentations and levels of severity. Contact sports are among the riskiest for these lesions. Many publications report severe spine lesions in ice hockey, rugby, and football [8–12]. Degenerative disease and congenital stenosis reduce available space in the vertebral canal of the spinal cord; there are findings concerning the risk of developing neurological injury in the practice of sports.

> Contact sports present the highest rates of severe injuries.

19.3 Cervical Spine Lesions in Sport

Cervical spine injuries are common in sports. Most injuries result from low-energy trauma causing sprains, which, in turn, lead to complete rehabilitation without sequelae. Although rare, cervical spine injuries involving the spinal cord and nerve roots can lead to potentially serious sequelae such as tetraplegia. The severity and extent of the injury depend fundamentally on the kinetics of trauma and is related to the type of sport and the technical level of the athlete. Contact sports, especially rugby; high-speed sports, such as skiing; and motorized sports have a greater risk of developing serious injuries [8–11].

> In general, lumbar injuries are the most common, but the cervical spine is subject to the most severe lesions.

The presence of previous lesions, such as congenital or acquired spinal canal stenosis, increases the risk of neurological damage and should be considered and evaluated before sports practices that expose the cervical spine to risk. Trauma in hyperextension of the cervical spine can cause a medullary contusion with the possibility of transient or permanent symptoms.

Cervical neurological lesions in the athlete are classified in three categories [13]:

- Type I—Permanent spinal cord injury.
- Type II—Transient medullary or root neurological deficit, with regression in a few minutes or hours.
- Type III—Post-traumatic lesion with purely radiological findings, without clinical correspondence.

In addition to acute traumas, repetitive traumatic injuries can cause or accelerate degenerative processes leading to lesions that may have clinical presentations ranging from asymptomatic to chronic axial pain and neurological root or spinal deficits.

19.3.1 Cervical Peripheral Nerve Injuries

19.3.1.1 Burners

"Burners" (also known as "stingers") are temporary symptoms of burn, pain, or sensitive and/or motor loss that happens involving the upper limbs [14]. They usually occur after a trauma to the brachial plexus or the exiting nerve roots in the cervical spine [15]. They frequently happen in contact sports, such as football and rugby. A high number of football players, most commonly defensive players, present burner symptoms at least once during their careers [16].

Burners can be caused by compression, distraction, or direct blow mechanisms. If an asymmetrical axial trauma to the neck causes a compression in the neuroforamen, it can damage the peripheral nerve root. Also, if the player falls on the shoulder and his head is distracted from the upper limb, traction is applied to the nerve root and the brachial plexus. Finally, when the cervical spine receives a force in hyperextension, hyperflexion, or lateral flexion to the opposite side, the distance and the angle between the shoulder and neck are excessively increased, thus stretching the brachial plexus. Compression combined with extension is the most common mechanism [17].

Symptoms of burners are usually severe pain in the shoulder and arm, with a loss of the sense of touch and weakness of the arm. The deltoid (C5), biceps (C5,6), and spinatus muscles (C5,6) are most commonly involved, and the symptoms typically last only a few seconds or minutes. Shoulder abduction may cause less pain, and the doctor can ask the player to place a hand on the top of the head. The Spurling maneuver reproduces the mechanism of the injury, and burning or pain is reported by the player when this movement is performed [16, 18] The symptoms can be presented in different degrees of severity ranging from a transient nerve irritation without residual damage (most common) to a complete avulsion of the nerve root from the spinal cord with permanent deficit (very rare) [17].

To prevent burners the player needs to wear appropriate protection equipment and to learn the correct way to block and to tackle during the practice, using only the shoulder, and never the head while keeping the head down [17].

Initial treatment involves removing the player from the game and allowing him/her to rest; this is followed by strengthening exercises of the neck and restoration of the range of motion. These injuries are classified using the Seddon classification of neurapraxia. Athletes with more severe lesions may require a longer period for recovery lasting from a few hours to a few weeks when the athlete will be away from the game [19–26].

19.3.1.2 Cervical Stenosis

Congenital cervical stenosis is a risk factor for cervical spine injuries [27]. Burners are more common in players with spinal stenosis as defined by the Torg ratio, which is defined as the ratio of the spinal canal width to the width of the vertebral body at the same level; the narrowest is at C7. A Torg ratio of 0.7 to 0.8, or lower, is high risk. For players with cervical stenosis, the risk of burners and other neurological complications during sports practice is three times as high as players without stenosis, and this ratio is usually used as a screening for football and rugby players to prevent neurological complications in those sports [20–31].

19.3.1.3 Transient Spinal Cord Compression

Torg and colleagues [32] related the syndrome of transient quadriplegia, which represents a “neuropraxia of the cervical spinal cord.” The syndrome is characterized by bilateral upper and lower limbs’ neurological involvement without any fracture or dislocation associated; in most cases, the problem is solved in 36 hours. There is a strong association between transient quadriplegia and developmental spinal stenosis; according to the current literature, all patients who presented transient quadriparesis had a diagnosis of spinal stenosis. However, there is no evidence that the occurrence of transient quadriplegia predisposes to permanent neurological injury [17, 32].

19.4 Thoracolumbar Lesions in Sports

The thoracolumbar lesions are more frequent than the cervical ones, and they represent 10% of the injuries caused by sports. Likewise, there is a broad clinical presentation spectrum ranging from non-specific low back pain to paraplegia [33, 34].

The different types of sports and mechanisms of thoracolumbar injury are related to the clinical findings. The lesions that occur in extension expose the risk of fracture of the pars or facet joints, and gymnasts are among the most affected athletes [35]; torsional injuries affect discs and facets and occur more often in sports such as golf and tennis; compression/flexion lesions expose the intervertebral disc to greater risk of damage; injury by fall or secondary to an external agent can cause unexpected and potentially more serious damages depending on the intensity and energy of the trauma [36].

The way energy is applied to the trauma can lead to different lesions and in different tissues: for example, lesions occurring at high speed can affect the vertebrae and cause fractures by abrupt deceleration, while the application of progressive and repetitive energy favors disc and ligament degeneration.

19.4.1 Spondylolysis

Spondylolysis is a stress fracture of the pars interarticularis. It is generally considered to be a low-risk fracture that occurs most frequently at L5, followed by L4 and L3. The mean rate of spondylolysis is 5–6% in the general population, [37] and, in general, it is asymptomatic. Repetitive stress generally produces fatigue fracture. These fractures may consolidate but develop fibrous nonunion or heal in an elongated state [38].

The incidence of pars defects is greater in athletes than in the nonathletic population, and it is a clinical problem for these patients [39]. Sports that require hyperextension associated with rotational movements such as gymnastics, wrestling, and weightlifting are associated with a stress fracture of the pars interarticularis. Some specific sports, such as diving, weightlifting, wrestling, and gymnastics, have extraordinarily high rates of this injury [40]. Many studies suggest that a variety of sports, such as soccer, volleyball, and baseball, increase the risk of spondylolysis [41].

Spondylolysis is a bone injury that, in most cases, does not produce neurological symptoms. Any nerve root signs would suggest an alternative diagnostic [37].

19.4.2 Spondylolisthesis

Spondylolisthesis occurs when there is a bilateral lesion in the pars interarticularis, and the vertebral body slips forward over the lower vertebra. The incidence of spondylolisthesis in athletes is the same as in the general population [37].

In the current literature, there are no criteria available for predicting which cases of spondylolysis will progressively slip, resulting in spondylolisthesis. Most cases of spondylolisthesis are low grade and unlikely to progress. With mild spondylolisthesis, there is no reason to forbid the athlete from participating in sports [37].

Isthmic spondylolisthesis is the most common type found in young athletes. Bilateral stress fractures of the pars are the distinguishing pathology of spondylolisthesis. The main risk factor, other than a familial predisposition for this injury, is hyperextension mechanism [37].

Symptoms of spondylolisthesis are low back pain worsened during activity, especially those that involve hyperextension and rotation. Sports with rotation and extension under load repeated a lot of times during practice such as gymnastics, football, wrestling, hockey, pole vaulting, diving, and throwing sports are related as causal factors in many reports [42, 43]. Typically for mechanical-type pain, rest tends to alleviate the pain [37].

During the investigation, it was found that, if radiculopathy is present, the L5 root is most commonly involved [44, 45]. Cases with neurological symptoms must be differentiated from disc herniation.

The lateral X-ray of the lumbar spine confirms the diagnostic, and the degree of the slip is graded according to the Meyerding classification. There is a consensus that kyphosis is a more important sign of severity measure of the deformity than displacement [45].

19.4.3 Apophyseal Ring Fracture

This injury is characterized by bone fragments at the posterior vertebral endplate and is also known as limbus fracture or fracture of the vertebral rim, ring, or endplate [46]. This lesion is exclusive of adolescents [47] and was reported by Skobowytsh-Okolot in 1962 [48, 49]. There is an overall prevalence of only 0.07%; there is also an 85% predominance in males; 66% have an association with a traumatic event, such as weightlifting or sports injury [46–49]. This is, also, associated with Scheuermann disease [50] and lumbar disc herniations [51].

Both hyperextension of the lumbar spine [52] and acute flexion associated with axial compression to the lumbar spine, such as it occurs with weightlifting, are the proposed mechanisms of this injury [47, 48, 53]. Symptoms of an apophyseal ring fracture are similar to Disc Herniation - pain in the back and buttock which gets worse after coughing, sports and sitting [48]. Pain may radiate down one or both legs. The straight-leg-raise test is positive, and contralateral straight-leg raise is frequently positive. Paraspinal muscle spasm, lumbar tenderness, scoliosis, intermittent claudication, paraparesis, and cauda equina syndrome have been reported [47, 48].

19.4.4 Disc Herniation

Disc herniation or Herniated Nucleus Pulposus is an injury related to sports, and surgeries for these conditions in athletes are performed many times during a sports season. High-risk activities include weightlifting and collision sports, such as football [48], and also basketball, baseball, and wrestling [50]. The incidence is 95% of herniations occurring from L4 to S1 and is fairly evenly distributed between L4–L5 and L5–S1. The L3–L4 herniation is present in 5% of patients [54].

The symptoms of HNP are leg pain with or without neurological issues. Rehabilitation is demanded as soon as the symptoms appear, and the return to sports is related to the severity of them and the moment of disappearance of these symptoms.

MRI is the gold standard, and the conservative treatment is effective in most cases, while surgery is reserved for the cauda equina syndrome, progressive motor deficits, or failure of the conservative care [37].

19.5 Common Spine Injuries in Sports

19.5.1 Football

In the United States, football is a very popular sport and leads all other sports in the number of injuries [55]. The football lesion rates are figured from 600,000 to 1.2 million injuries of the entire body every year in the United States [56]. As the number of football players continues to increase around the globe, the analysis of prevalent lesions in professional football is necessary in order to help health professionals to understand the risks that the athletes are exposed to during their practice [57].

Using a National Football League (NFL) injury database, recorded from years 2000 to 2010, Mall et al. [56] have identified 2208 axial skeleton lesions, including spinal injuries. This study demonstrates that injuries to the spine accounted for 7% of the lesions in the National Football League (NFL). The number of spinal injuries varied between 152 and 256 per year, during this 10-year follow-up, while 987 (44.7%) of these lesions were cervical injuries which account for the most frequently injured location of the axial skeleton during football practice. The lumbar spine was affected in 30.9% of the cases, the thoracic spine and ribs in 3.9%, and the sacrum, coccyx, and pelvis in 10.1% and the spinal cord was responsible for 0.6% of the injuries.

There are a high number of severe injuries during football practice [4]; because of this, there are probably only a few studies that have demonstrated data on fewer incapacitating injuries in football [58]. These include back contusions, lumbar back pain, back cramp/spasm, back muscle strain, back degeneration, and intervertebral disc disorders [56]. Disc herniations have accounted for 13% of all injuries affecting the entire spine and, more specifically, represented 28% of lumbar spine injuries, 6% of cervical spine injuries, and 5% of thoracic spine injuries [59].

Spondylolysis occurs most frequently among adolescents, with high rates of incidence among athletes, especially football players [60]. Also, the incidence of degenerative disc disease and facet degeneration is higher among the football population than in the general population [61]. Having spondylolysis is a very important risk factor when analyzing football athletes with low back pain [62]. The higher incidence of spine issues in football players is caused by the excessive compressive, torsional, and shearing forces produced in the spine during practice.

The cervical spine is the most affected anatomic location of the spine during football, and it is also where the most severe lesions occur [2]. In order of incidence, the lesions in the cervical spine are presented as follows: nerve root or brachial plexus neurapraxia (burners), cervical strains (muscular injury), disc injury with neck pain only, cervical sprains (ligament injury), disc herniation with radicular symptoms, transient spinal cord compression secondary to stenosis, and cervical fractures [32, 63–65].

Analyzing average time missed after an injury during the football practice, cervical fractures are responsible for the highest mean number of days missed during a season, among all injuries sustained in the National Football League (NFL) [56]. Their accounting for 120 days per injury and disc degeneration/ herniation was responsible for a mean time loss of 85 days per injury, while spinal cord injury responded for 77 days per injury [66].

Tackling is the football movement most related to cervical spine lesions, while blocking produces most of the lumbar spine injuries.

This injury mechanism suggests the reason why defensive players present a higher rate of spine injuries than their offensive teammates. Recent data suggest that these lesions are found not only among professional athletes but also among non-professional players [57].

American football players present a high risk for severe trauma, including spinal cord injury [67]. The incidence of serious cervical spine injuries was highest in early times but declined during the 1970s with the banning of head-down "spear tackling" as shown by Torg et al. [32, 62, 68]. The National Football League (NFL) began its efforts to address SRC (sport-related concussion) with the establishment of the Mild Traumatic Brain Injury Committee in 1994 [63]. In 2010 the committee was reconstituted as the Head, Neck and Spine (HN&S) Committee [69], which defines protocols and guidelines for the management and prevention of these important lesions and also contributes for a safer practice of this sport around the world.

> The education of the athletes, coaches, and referees was responsible for the decrease of the serious cervical injuries in contact sports, especially football and rugby.

19.5.2 Rugby

Rugby is one of the most popular sports around the world [70] and the most popular collision sport. Rugby is a physical contact sport that presents a high risk for traumatic injury and the use of little or no body padding. This risk has increased with the professionalization of the sport, which stimulated players to become larger and stronger [71]. Rugby presents one of the highest overall injury rates of all team sports [72].

Epidemiological studies demonstrated that the most common injuries to the spine during rugby practice are less severe lesions to the lumbar spine as back pain, back muscle strain, and lumbar disc disorders [10, 73, 74]. Iwamoto and colleagues [75, 76] noted structural abnormalities in 74% of the rugby players assessed in the study. Severe lesions are rare in the lumbar spine, and disc herniation is the condition that most needs an intervention such as surgery or steroid injections [77, 78].

Despite all the concerns about the cervical spine during the rugby practice, Hind et al. showed that rugby players also had a higher risk for thoracolumbar fractures, presenting greater rates of this kind of fracture than the previously reported prevalence rates for the general population [79].

Injuries to the cervical spine are the most serious injuries during rugby practice. From the 1970s to the middle of the 1980s, an increase was found in the rates of rugby-related spinal lesions in countries where rugby was commonly played all over the globe. Many injury prevention measures were implemented worldwide by the International Rugby Board (IRB) aiming the alterations of the rules of the game and educational measures of the players searching for safer techniques in the game. The scrum was the part of the game most associated with spinal lesions until 1990; after the rule changed, the rates of spinal lesions occurring during tackle became higher [80].

The most common cervical spine injuries in rugby were facet dislocations. The injury often affects C4/C5 and C5/C6 levels. Hyperflexion of the neck was hypothesized to be the primary mechanism for cervical spine injury in rugby [17, 81–85], but recent studies have identified tackle as the moment of highest occurrence of the cervical injuries and buckling as the main biomechanical mechanism of cervical spine injury during rugby practice [17].

19.5.3 Tennis

Tennis athletes experience few severe injuries on average. Tennis lesions are due to repetitive overload and related with the increasing years of training. Although ankle and knee lesions are more common in tennis practice, lumbar spine lesions are more recurrent than others [86].

There is a paucity of published data in relation to elite athletes, with considerable variability in the reported incidence of lesions, ranging from 0.04 to 3.0 injuries per 1000 playing hours, not related to gender. Lumbar lesions account for around 12–13% and head and neck around 3% of all musculoskeletal lesions [87]. Regarding male athletes, the lumbar region is the third anatomical site of injury, and to female athletes, it is the fifth. This finding is due to the repetitive trunk movements required in tennis practice, especially hyperextension and rapid rotation of the lumbar spine during training and playing a match; this supports the frequent findings of low back pain in tennis athletes and its correlation with radiological abnormalities in this population [88, 89]. As a reference, the lumbar region undergoes substantial loading during the kick and flat tennis serves, including lateral flexion forces approximately eight times those experienced during running.

A study that describes lumbar MRI findings in asymptomatic young elite tennis players concluded that any abnormalities occurred with 84.8% of these players almost exclusively on L4 L5 and L5S1 levels, with facet joint arthropathy, pars, and intervertebral disc injuries [89, 90].

19.5.4 Winter Sports

Sports requiring ice or snow as a playing surface are called winter sports. Most of these sports are associated with high speed, thus susceptible to spine traumas.

After the head and the chest, spine injuries are the most common among these sports. Due to the association with high speed and high energy, the majority of these lesions is caused because of falls and collision against natural objects [91].

The literature contains a wide range of statistics related to lesions due to snow sports, especially depending on the age group, location, and the specific sport. Injuries associated with neurological deficit accounts for 42%, and males are more frequently injured [92, 93]. The most frequent lesions from skiing and snowboard are thoracolumbar junction fractures. Ice hockey presents an equal number of cervical and thoracolumbar fractures since two thirds of them are associated with neurological deficit. These lesions usually occur between levels C5 and C7, caused by head impact against the boards, sustaining an axial compression on the cervical spine [93].

19.5.5 Volleyball

Volleyball and beach volleyball are intensive sports, associated with high impact and repetition of similar movements that may cause spine injuries.

Volleyball is associated with a predominant forward bending and extension posture, which may cause changes in lumbar lordosis and sagittal imbalance. Lumbar lordosis flattening is associated with pelvic retroversion due to increased use of abdominal and gluteal muscles. The finding of a decrease of lumbar lordosis is associated with the increase of thoracic kyphosis.

These changes in lumbar lordosis may be associated with the findings of a higher incidence of low back pain and with a higher prevalence of degenerative findings on MRI, including disc degeneration and spondylolisthesis [94]. In professional volleyball players, the prevalence of disc degeneration is up to three times as high when compared to the normal population. Considering MRI findings in professional beach volleyball players, the prevalence of disc degeneration is 79%, and spondylosis is 21%. Despite these data, MRI findings do not correlate with back pain symptoms [95].

Traumatic lesions may occur due to repetitive stress, as well as impact or sudden and severe contraction of the muscles. The literature on volleyball practice reports few cases such as stable fractures in lower cervical spinous processes, called Clay shoveler's fracture [96], myelopathy due to acute disc herniation, and vertebral artery dissection [97].

Case 1

A 34-year-old female professional volleyball athlete in the national league refers to sudden neck pain during training, associated with right arm pain and weakness. She came to specialized evaluation after 2 days of conservative treatment with analgesics and physiotherapy. She complained of neck pain irradiating to the right arm on the C6 and C7 dermatomes, weakness of wrist and elbow extension, hyperreflexia, and clonus on upper and lower limbs. MRI of cervical spine showed a disc herniation at C5C6 level with medullar compression and hypersignal in the sagittal and axial views (Fig. 19.1a, b). Ten days after this injury, the patient was submitted to decompression and arthrodesis on C5/C6 levels with autologous iliac graft (Fig. 19.2a, b). The complete weakness she experienced improved, and she returned to play 3 months after the surgery when fusion occurred and was confirmed with CT scan (Fig. 19.3).

19.5.6 Boxing

Boxing is an Olympic sport [98–100]; however, it is classified as a dangerous sport by presenting severe neurological complications of head lesions which have been discussed in several studies [101, 102].

Many studies show a small number of severe injuries, but this modality is related to dangerous injuries, especially head and brain lesions. Previous studies on boxing practice showed low injury rates with 0.69 injuries per boxer per year and 2.0 injuries per 1000 h of training [102, 103]. Boxing athletes most often present head, upper limbs, and overall injuries; these injuries resulted in an average of 10.5 lost days [104].

Cervical spine injuries represent around 10–20% of the injuries found in boxing athletes. In the cervical spine, severe injuries as fractures or spinal cord injuries are described as rare ones, but contusions and muscular lesions are the main cervical injuries related to this sport [104, 105].

The lumbar spine is less affected, and the number of injuries is around 8%, while the low back accounts for the highest number of lesions. Disc herniations can also occur, but the mean number of lesions is around 0.5%. Lumbar spine injuries during boxing are classified as less severe injuries and are related to a low rate of lost days of practice [104, 105].

19.5.7 Baseball

Spinal injuries are relatively rare in sports with less contact between the players such as in baseball; yet, there are a reasonable number of writings on the possibility of baseball players having spinal lesions in the entire extension of the

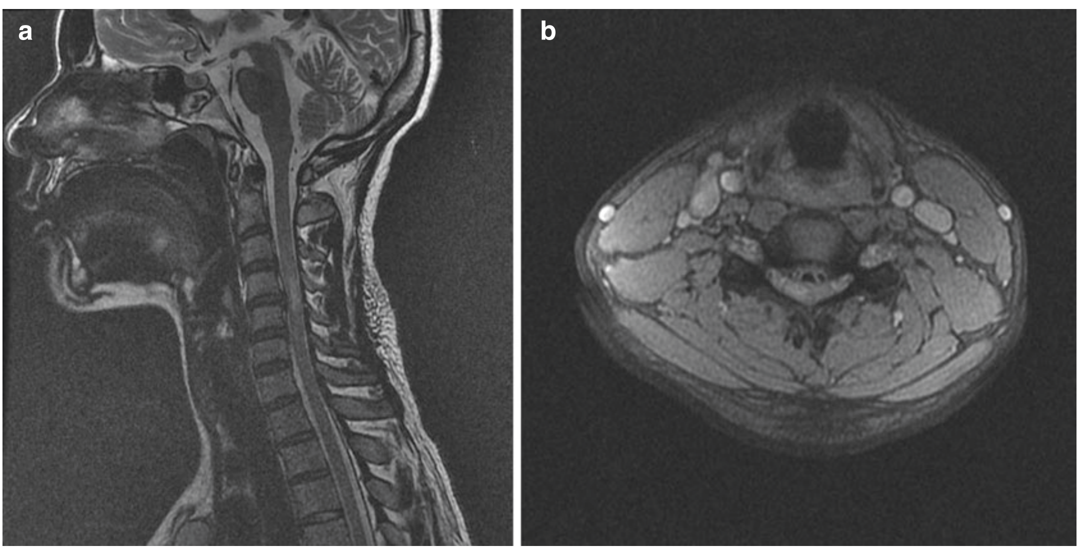

Fig. 19.1 (**a** and **b**) Cervical sagittal (**a**) and axial (**b**) MRI views of disc herniation at C5C6 level with medullar compression and hypersignal

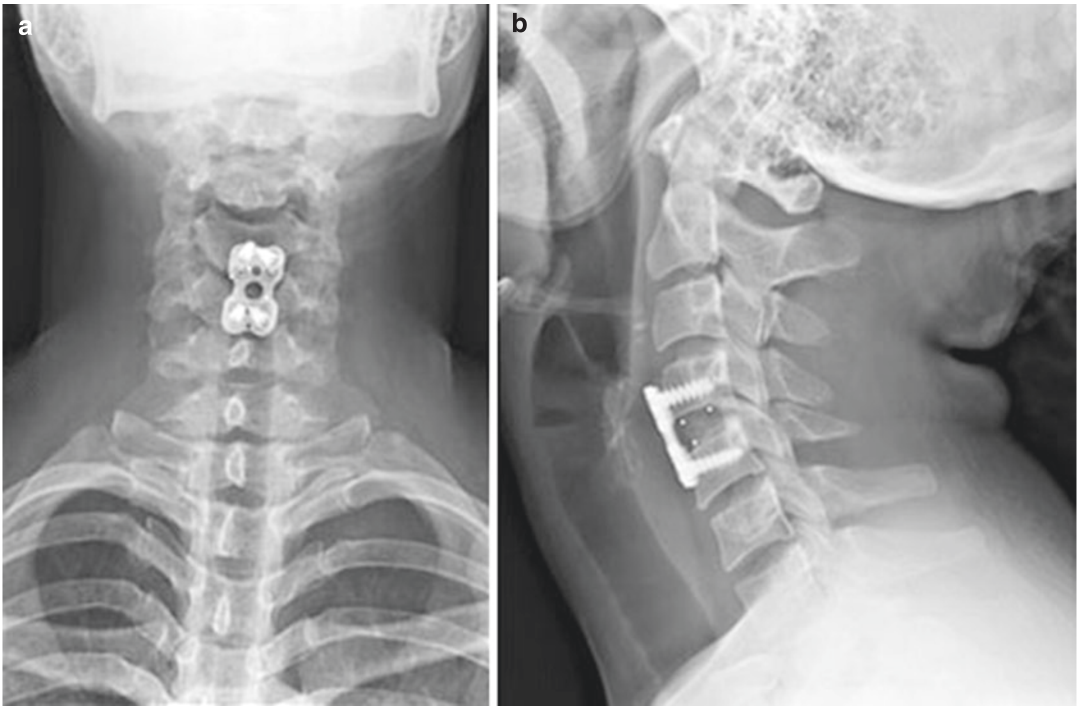

Fig. 19.2 (**a** and **b**) Decompression and arthrodesis on levels C5/C6 with autologous iliac graft 10 days after lesion, anteroposterior (**a**) and lateral (**b**) radiographic views

vertebral spine [106]. Spinal injuries during baseball practice are mostly found in the lumbar spine, and the correct diagnosis and treatment are necessary to allow the player to return to the sport as soon as possible [107].

Among baseball players, the injuries to the spine and core musculature respond with 11.7% of all sports injuries [108]. Lumbar disc herniation, spondylolysis, and spondylolisthesis are the most frequent injuries, while lumbar back pain is the main issue of the players [106, 107, 109–112].

19.5.7.1 Biomechanics of Baseball Injuries

Spinal stability depends on the structure of the bones and soft tissues and is achieved by the important role of the muscles that create dynamic and active support for the spine, allowing complex moves of torsion and extension of the trunk which are necessary for playing baseball.

The pitchers are the most commonly injured players. During a pitch, the torsion of the body begins in the lower limbs; then it raises to the pelvis, creating a hyperextension of the lumbar spine and a torsional movement of the thoracic spine, which produce the energy necessary for the upper limbs to perform the throw of the ball. This sequence of complex movements requires a higher strain on the facet joints [107, 110].

In spondylolysis and spondylolisthesis, the stress to the pars can lead to simple injuries as the local inflammatory response or to more severe lesions as fractures and dislocations. The pitchers present lumbar back pain in 15% of the cases during their careers, while around 9% of them present spondylolisthesis [109, 111, 112].

The treatment of the lumbar conditions in baseball players is widely discussed [113–116]. Low back pain has to be investigated, and other important diagnostics are excluded. The rehabilitation of low back pain without other lesions is based on core fortification of the muscles, training on stabilizers, and progressive stretching of lumbar and hamstrings [110].

Fig. 19.3 Computed tomography showing evidence of bone marking and signs of consolidation at 3 months postoperative

Spondylolysis and spondylolisthesis treatment for baseball players follows the same principles of the guidelines of non-player patients. The choice between a surgical or conservative treatment is controversial, and most studies indicate surgery only after the failure of conservative treatment. Also, the average recovery time after surgery is longer (about 7 months) [114–116].

19.5.8 Soccer

Spinal injuries in soccer are not exclusive among elite or semiprofessional players; they have been reported in all ages and from amateurs to professional players [107]. Reducing injuries and improving the performance in soccer are directly related to neuromuscular control, which is defined as a dynamic process of maintaining balance during the practice [117]. In a physical contact sport, such as soccer, decreased core stability is associated with a higher incidence of low back pain.

Talib et al. collected prospective injury data for players of all 41 English professional soccer youth academies for 5 years, totalizing 12,306 academy players. These players presented 10,225 musculoskeletal injuries, resulting in 310 (4%) of lumbar spine injuries, and most of them was low back pain (49%), with strains being second (15%) and spondylolysis being third (4%). They also reported that there is an increased risk of lower back injury, according to the players' age and the contact mechanism, in the second part of the first half of competitive matches (a risk that was maintained throughout the second half), which was responsible for the majority of the lesions [118].

Back pain is the spinal symptom most frequently reported by the soccer players. The chronic lower back pain results in a time loss of 7–30 days of practice [119]. Longer training sessions, especially on artificial turf, are risk factors to develop back pain [120], and smoking and thigh muscle imbalance are reported with even worse symptoms [121, 122]. Early diagnosis allows appropriate management; the radiological investigation is indicated when this group of players presents back pain lasting longer than 3 weeks [119].

Rassi et al. (2005) [119] observed that 43% of the patients felt pain during the kicking movement, which is the most common moment to perceive pain. Sakai et al. (2010) [123] found that the incidence of spondylolysis was at 30% in the soccer-playing population. Most soccer players with spondylolysis had good or even excellent results after non-operative treatment. Cessation of sports for a period of 2–3 months can optimize the clinical outcome and is a strong predictor of a favorable return to sports. Similarly, Sys et al. (2001) [124] reported that early diagnosis of a fatigue fracture of the pars interarticularis is important because non-operative treatment of active spondylolysis leads to excellent results and sports resumption may be possible within 6 months for the majority of athletes.

19.6 Management of Sports Lesions

19.6.1 Lumbar Injuries

When pain is severe, rest may be necessary for a couple of days for initial pain management. A longer time of rest can start to cause muscular loss and is not recommended. The sooner the player starts some minor and tolerated activity, the quicker and more effective recovery is [125].

Anti-inflammatories and muscle relaxants are recommended for the maximum of 7–10 days, not more than that. Opioid administration can be used for a few days. Local anesthetic injections into the facet joints or into trigger points can be used and may help to establish a diagnostic while finding different causes for the symptoms [125].

Different modalities of physical therapy as ice, tens, massage, or heat can be used in initial treatment, but the player has to start active rehabilitation and strengthening as soon as possible; bracing should be avoided or minimized [125].

19.6.2 Cervical Injuries

During the sports practice, management of the injuries starting from the initial moment of the trauma may reduce long-term risk to the players and improve the return to playing [58]. If a cervical spine injury is suspected, the physician should investigate any spinal pain, search for the altered perception of touch, and interrogate numbness, weakness, or difficulty moving the extremities. Any player with these signs during an on-field examination should not participate in the game or training any longer, and cervical injuries need to be investigated [62].

When examining ambulatory athletes after a cervical trauma, the examiner should evaluate neck range of motion, and perform a motor and sensory examination of the extremities. Alterations observed during the exam mean that the athlete must be removed from competition and immobilized in a cervical collar. If the player is unconscious, it means that the physician should presume that a cervical spine injury exists, and the neck needs to be immobilized. A helmet should be placed and not removed, and the athlete must be immobilized before taken anywhere. Persistent or severe pain means that the player needs immediate radiologic evaluation. Returning to practice will occur when the symptoms have disappeared, and the image exams do not show any injury [125].

19.7 Return to Play

The return to the sport is very controversial, and there are many conflicting guidelines for each modality and injury. In general terms, for lumbar injuries, the athlete can return to play when there is no pain specifically related to the activity of the sport, and when the full range of motion is recovered. There is no definitive test to define when this point is reached. Gradual relief in pain and improvement in performance are predictive of a good prognosis.

The return to play after cervical spine trauma is based on guidelines which recommend waiting for the symptoms to disappear and for the player to have recovered the full range of motion and complete strength [125, 126]. Some studies recommend that the return to sport should be based on normal radiological exams as well [125, 127]. Less complex lesions, such as spinous process fractures, should have the treatment based on immobilization and return to activities only after healing. Patients with more than three burners in the same season should be clinically evaluated as well as with imaging, to make sure that there is no spinal stenosis or severe injury before returning to the sport. A single-level fusion, or one of two levels, may enable the return after healing. With three or more level fusions, the return to play is contraindicated [125, 128] (Table 19.2).

Return to play is based on the type of injury, the relief of symptoms, and the recovery of the range of motion, but each case has to be analyzed for each sport and for each patient, also taking into account previous spine injuries, congenital stenosis, and surgeries for spinal conditions

Table 19.2 Traumatic and ligamentous injuries of the cervical spine: contraindication to return to play

No contraindications	Relative contraindications	Absolute contraindications
Neuropraxia or other neurological symptoms of spinal cord without radiological alterations and after complete resolution	Healed nondisplaced Jefferson fractures in patients who are also pain-free, have full range of cervical motion, and have no evidence of neurological injury	Injuries of C1-C2 that involve fracture or ligamentous laxity
	<3.5 mm of horizontal displacement of either vertebra in relation to the other and depending on the patient's level of performances, physical habits, and position played	>3.5 mm of horizontal displacement of either vertebra in relation to the other
	<11° of rotation of either adjacent vertebra and depending on the patient's level of performance, physical habits, and position played	>11° of rotation of either adjacent vertebra

Adapted from Torg JS. Cervical spine injuries and the return to football. Sports Health. 2009;1(5):376–83 [129]

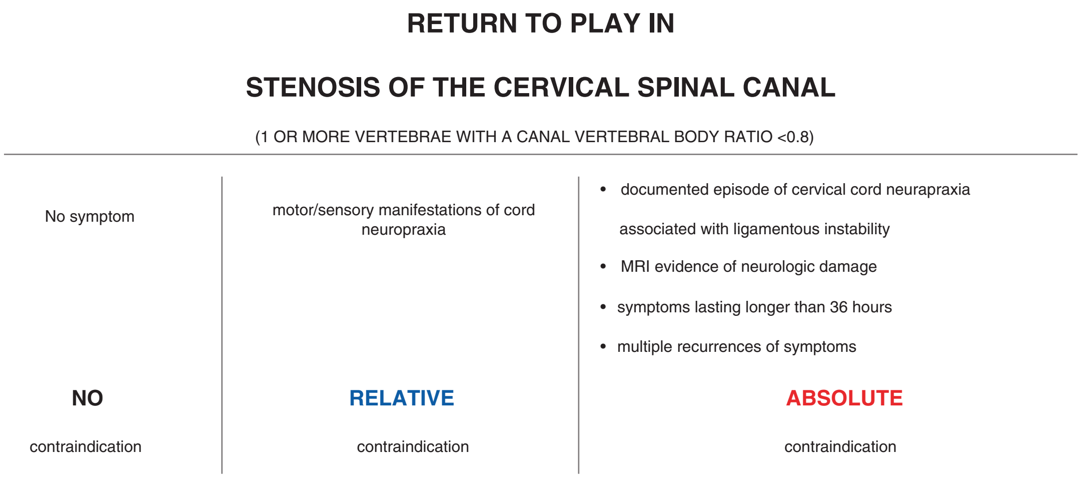

Fig. 19.4 Recommendations on return to play in stenosis of the cervical spinal canal

The suspicion, correct diagnosis, and treatment are the key to avoid permanent lesions and, in some cases, allow the athlete to return to amateur or professional sports practice. Prevention of lesions must be advised especially for those who are under risk due to pathological or congenital conditions, who are under risk for spine lesions and for the practice of sports that expose the spine to dangerous lesions.

The sports medicine physician must be aware of congenital stenosis, congenital intervertebral instability, congenital spondylolisthesis, disc herniation, spondylosis, degenerative stenosis, previous spine surgery, and antecedent spine lesion with temporary or definitive neurological sequel when conducting an initial or periodical evaluation regarding sports practice (Fig. 19.4).

Contact sports and those with the risk of collisions like rugby, football, hockey, and other snow sports expose the athlete to a higher risk of lesions. The association of a previous condition of the spine with the practice of a risk sport to spine lesion is what should be avoided, or, at least, the athlete should be warned about the potentiality of sequels.

Take-Home Messages

- Spine injuries are not only related to professional sports but also to recreational ones and can occur during competitions and training.
- The direct trauma and, also, supraphysiological stress on the spine are the most common mechanisms of spine injury in sports practice.

- Although most of these injuries are related to minor impairment to the athlete, such as lumbago, contusion, and paravertebral muscle contracture, the sports physician should keep in mind that devastating damage to spinal cord can occur in cases of high-energy trauma as well as contact sports.
- The knowledge of sports biomechanics helps the physician to suspect and identify traumas at higher risk to spinal cord injury and, therefore, define a more accurate approach to an athlete in the field.
- The sports physician on initial or periodical evaluation regarding sports practice must be aware of congenital stenosis, congenital intervertebral instability, congenital spondylolisthesis, disc herniation, spondylosis, degenerative stenosis, previous spine surgery, and antecedent spine lesion with a temporary or definitive neurological sequel and should rule them out before allowing the athlete's participation in contact sports such as martial arts, rugby, football, and ice hockey.

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