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# Return to play after cervical spine injuries in athletes.

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# “Return to play after cervical spine injuries in athletes.”

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## Resumo

**Introdução** - As lesões da coluna cervical no desporto podem variar desde pequenas distensões a lesões catastróficas da medula espinal. Embora as lesões catastróficas sejam raras, podem ocorrer em desportos com e sem contacto. O tratamento é normalmente bem definido, mas faltam diretrizes para um regresso seguro à atividade, o que leva a decisões subjetivas e a potenciais riscos para os atletas.

**Objetivo** - Esta dissertação tem como objetivo rever a literatura sobre as lesões cervicais relacionadas com o desporto, incluindo a epidemiologia, os mecanismos de lesão, as manifestações clínicas e o impacto nos atletas, para informar as decisões de regresso à atividade. Oferece aos clínicos um quadro de decisão mais preciso para garantir o regresso seguro dos atletas.

**Métodos** - Foi efetuada uma revisão de artigos utilizando os repositórios PubMed e ScienceDirect. A pesquisa foi efetuada utilizando as seguintes palavras-chave: Return to play; Cervical spine injury; Sports; Cervical fractures; Stingers; Cervical cord neuropraxia; Cervical disk herniation.

**Discussão** - O regresso à atividade após uma lesão cervical é determinado pela avaliação do médico, pelos desejos do doente, pelos relatos de casos e pelas revisões bibliográficas. Alguns parâmetros são essenciais para um regresso seguro, incluindo ausência de dor, amplitude total de movimentos, défices neurológicos e força do pescoço. As fraturas cervicais requerem regeneração óssea e 8-10 semanas de tratamento antes do regresso e fraturas com défices neurológicos residuais, necessidade de fusão, instabilidade ou múltiplas fusões são contraindicações para o regresso. A hérnia discal cervical depende do tratamento, sendo que a gestão conservadora não tem contraindicações, enquanto as fusões a vários níveis são contraindicações absolutas. Os sintomas radiculares cervicais transitórios requerem uma ausência de sintomas e uma amplitude de movimentos completa para o regresso. A neuropraxia da medula cervical pode necessitar de ressonância magnética para avaliar a estenose. A recorrência de quadriparésia transitória é frequentemente contraindicada para desportos de contacto.

**Conclusão** - O regresso à atividade depende da ausência de dor, de défices neurológicos e de instabilidade da coluna cervical. As decisões são multifatoriais, considerando a lesão, a opinião do médico, a recuperação do atleta e as prioridades. As guidelines são cruciais para o bem-estar e a qualidade de vida do atleta, uma vez que existem várias contradições em relação às recomendações. Em última análise, as decisões são específicas para cada caso e baseadas nas necessidades do doente, uma vez que as guidelines servem de orientação para as decisões de retorno e de tratamento.

## Abstract

**Introduction** - Cervical spine injuries in sports can range from minor strains to catastrophic spinal cord injuries. While catastrophic injuries are rare, they can occur in contact and non-contact sports. Non-catastrophic injuries like stingers are more common. Treatment is normally well-defined, but guidelines for safe return to play are lacking, leading to subjective decision-making and potential risks for athletes.

**Objective** - This dissertation aims to review literature on sports-related cervical injuries, including epidemiology, mechanisms, clinical manifestations, and impact on athletes, to inform return-to-play decisions. It offers clinicians a more accurate decision-making framework for ensuring athletes' safe return.

**Methods** - A review of articles was conducted using the PubMed and ScienceDirect repositories. The search was made using the following keywords: *Return to play; Cervical spine injury; Sports; Cervical fractures; Stingers; Cervical cord neuropraxia; Cervical disk herniation*.

**Discussion** - Return to play after cervical injury is determined by the clinician's evaluation, patient's wishes, case reports, and reviews. Certain parameters are essential for a safe return, including absence of pain, full range of motion, neurological deficits, and neck strength. Cervical fractures require bone regeneration and 8-10 weeks of treatment before return and fractures with residual neurological deficits, fusion requirements, instability, or multiple fusions are contraindications for return. Cervical disk herniation depends on treatment, with conservative management having no contraindications, while multi-level fusions are absolute contraindications. Stingers require symptom-free and full range of motion for return. Cervical cord neuropraxia may need MRI to assess stenosis. Recurrence of transient quadriparesis is often contraindicated for contact sports.

**Conclusion** - Return to play depends on the absence of pain, neurological deficits, and cervical spine instability. Decisions are multifactorial, considering injury, clinician's opinion, athlete's recovery, and priorities. Guidelines are crucial for athlete's well-being and quality of life because there are several contradictions regarding recommendations. Ultimately, decisions are case-specific and based on patient's needs as guidelines serve as orientation for both return and treatment decisions.

**Keywords** - *Return to play; Cervical spine injury; Sports; Cervical fractures; Stingers; Cervical cord neuropraxia; Cervical disk herniation*.

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## Introduction

Cervical spine injuries, while a relatively rare entity when associated with sports, are a cause for concern in the athletic population. These types of injuries can vary from minor injuries, like cervical muscle strains or stingers, to serious or catastrophic injuries that can compromise not only the athlete's sports practice, but also their well-being and quality of life.

Cervical spine injuries can be divided in catastrophic and non-catastrophic injuries. Regarding injuries that are catastrophic and potentially devastating, like sports-related spinal cord injuries, they are relatively rare, and are often associated with contact sports, like American football, rugby, or combat sports. However, these injuries may also occur in noncontact sports, such as horse-riding, skiing, snowboarding, or diving. On the other hand, non-catastrophic injuries, like stingers, are more frequent and therefore are easier to approach in terms of treatment and follow-up after recovery and return to the sport.

There are numerous types of cervical spine injuries that can be related to sports, such as cervical spine fractures or dislocations, burners/stingers, cervical disk herniation, cervical cord neuropraxia (or transient quadriparesis) and conditions that can lead to injuries, like congenital or developmental cervical stenosis. These injuries have their pathophysiology, clinical features, diagnosis, and treatment well defined, with a lot of consensuses regarding them. However, regarding the return to play, there are still no guidelines that allow knowing well the timings that define when an athlete should return to activity, after recovering from its injury.

Due to their relative rarity, there aren’t that many opportunities to study the return to play and perform randomized clinical trials to understand outcomes and identify the risk factors of those injuries and their management. So, there aren’t proper approved guidelines for the management of these conditions and the decision to return to play is based on case reports, retrospective case series, review of literature or even expert opinions. For that reason, return to play decision-making is guided by general principles, like being free of pain with full range of motion, having full strength and is centered on the athlete and physician opinion. The subjectivity of the entire process that leads to the decision can end up in an early return that can result in worsening of the injury, or even a late return that can impair the athletes’ performance in their own sport.

## Objective

The main objectives of this dissertation were to review the existing literature on sports-related cervical injuries and address their epidemiology, injury mechanisms of action, clinical manifestations, and their impact on the athlete, so that it is possible to address the return to play.

Finally, the time to return to play will be analyzed, considering the pathology and the type of injury in question, with the goal of providing the clinicians who follow the athlete's entire process, a more accurate decision-making that allows the athlete a safe return.

## Methods

To elaborate this literature review, literature regarding cervical injuries in athletes and in particular the return to play after these injuries was analyzed. For this purpose, a search for articles in the *PubMed* and *ScienceDirect* databases was performed, including only articles written in the English language, and no restrictions were placed on the date of publication. The search was based on the following keywords: "Return to play"; "Cervical spine injury"; "Sports"; "Cervical fractures"; "Stingers"; "Cervical cord neuropraxia"; "Cervical disk herniation".

Information on the epidemiology of cervical injuries in sports was collected and analyzed in order to understand the types of sports involved in this type of injuries and the impact of these injuries on the athletic population. In addition, literature about the biomechanical properties of the cervical spine was also reviewed, so that the injuries addressed could be well understood, and some ways of preventing them were addressed. Then, four injuries, namely cervical fractures, cervical disc herniation, cervical cord neuropraxia, and stingers/burners, were analyzed extensively, so that it would be possible to proceed to the return to play part of the analysis. After collecting all the information present in the found articles and analyzing it, the discussion of this article was conducted, where the indications and some timings regarding the return to activity in athletes after cervical injury were addressed.

## Epidemiology

Cervical spine injuries are relatively uncommon pathologies, particularly when they are related to sports. It is estimated that only about 5-10% of the 10,000 cervical spine injuries that occur in the United States annually are sports related. [1] There are numerous sports and recreational activities that are closely related to this type of injuries, such as American football, rugby, wrestling, gymnastics, diving, hockey, skiing, snowboarding, boxing, horse-ridding, and others. In the United States, the sports that are most associated with cervical spine injuries are American football, gymnastics, and wrestling. In Europe, rugby is the one of the main causes of these injuries, and in Canada they are more associated with ice hockey. However, in general, these injuries always occur more frequently in contact sports. [2]

It is important to differentiate the type of injuries involved, particularly catastrophic injuries. A catastrophic injury to the cervical spine can be defined by an impairment to the cervical spine that is associated with increased risk of spinal cord damage or even injury itself, which can result in permanent and severe neurological consequences for the athlete. That said, sporting events represent the fourth most common cause of spinal cord injury (the three most common being motor vehicle accidents, violence, and falls), accounting for about 7.5% of all injuries.[3] As expected, this type of injury will be more associated with contact sports, such as American football or ice hockey, which represent most spinal cord injury cases related to sports. However, there are other sports that are also associated with spinal cord injury such as rugby, skiing, snowboarding, and equestrian sports.

Most these injuries, which are more associated with contact sports, occur in athletes under the age of 30. [4]

In this chapter, as the epidemiology related to certain sports and recreational activities is addressed, some prevention measures will also be covered. This is because certain behaviors or movements will be identified that can be avoided to reduce the incidence of injury.

### American football

Of all the sports, the one that is the most related to cervical injuries and the one for which there is the most literature in terms of injury mechanism and athlete management is American football. However, regarding cervical fractures or cervical spine cord injury, these represent only about 1% of cervical spine injuries. [5] Compared to other sports such as ice hockey and gymnastics, although these have had slight increases in the incidence of cervical injuries, American football is still the one with the highest number of cervical injuries.

Considering American football-related cervical injuries, during the 1960s and 1970s, there was a peak incidence of catastrophic injuries. This is because it was at this time that athletes began to introduce the technique of tackling with the head flexed, close to the chin, in order to contact the top of the head first (spear tackling). In other words, the player makes initial contact with the crown of their helmet by using their body as a spear (head out, arms by their side), applying the mechanism of axial loading. In addition, the introduction of increasingly stronger, more robust, and modern helmets also caused this peak to occur. After the risk that spear tackling posed to athletes was verified, this movement was banned, in 1976. Since then, the number of catastrophic neck injuries has decreased significantly, and this measure has been important and effective in preventing severe cervical and head injury.[2]

Since 1976, as afore mentioned, there has been a decrease in the number of cases of catastrophic cervical spine injuries in American football, down to an incidence over the next 25 years (1977-2001) of 0.52 per 100,000 players in high school players, 1.55 per 1000,000 in college players, and 14 per 1000,000 in professional players. In addition, it was also determined that players who play defensive roles on the team are more likely to have catastrophic neck injuries (about 71% of catastrophic injuries), with 69% of these injuries occurring due to tackling. [6] Even a finding called "spear tackler´s spine" has been described which is characterized by radiographic findings such as persistent loss of normal lordosis, cervical stenosis, post traumatic degenerative findings, along with evidence that tackling techniques have been used in the past. [7]

## Hockey

Although American football, in general, presents the highest number of cervical injuries, cervical injuries related to hockey have been increasing since 1980. In fact, the annual incidence of spinal cord injuries associated with paralysis is higher in ice hockey, practiced in Canada, than in American football. This increase is due not only to the greater interest in the sport, but also to the use of equipment and techniques that increase the risk of cervical injury. Just as in American football, the incidence of catastrophic injuries in hockey increased with the introduction of super protective helmets that provided a more aggressive way of playing. [8]

One of the techniques that has been most associated with trauma-related cervical injuries in hockey is checking in from behind. This technique consists of pushing the opposing player from behind, against the barrier, which can cause him to hit it with his head, producing an axial load through the cervical spine. Therefore, after the problem was identified, changes were imposed in the rules of the game that prevented the execution of this technique when the player does not have the puck, which caused the cervical injuries associated with hockey to decrease.[8] The injury that is most associated with checking in from behind is a burst fracture, which usually takes place at C5-C6 in this cases. [9]

### Diving accidents

It is important to realize that this type of injuries discussed are not only associated with contact sports, and that they are also not only related to sports themselves, but also to recreational activities. A good example of this is diving accidents, which happen more often to inexperienced divers than to professional divers, where diving is always supervised. Therefore, diving is a frequent cause of catastrophic cervical injuries and is even one of the main causes of quadriplegia related to recreational activities. The mechanism of injury is again axial load, caused by diving in a place with a low bottom, or when there is an object in the bottom that was not located before the dive. The risk factors include the diver's negligence in not checking the depth or the consumption of alcohol before diving, which can be fatal. In this case, the only way to prevent diving accidents is to raise awareness of people's safety and to place signs in areas that may be conducive to diving, because this is a recreational activity. In this scenario, the incidence continues to be higher in men under 30 years of age [10]

### Gymnastics

Considering cervical injuries related to gymnastics, it is almost the same as talking about injuries related to trampoline and mini trampoline. This is because it has been documented that the use of these two instruments is related to a greater risk of cervical quadriplegia, which allows us to conclude that the use of these devices is a risk for cervical injury. Regarding the maneuvers that increase the risk of injury, the somersault is particularly dangerous when performed by athletes or people with no experience. Numerous preventive measures have been proposed to decrease the incidence of cervical injuries related to trampolining and mini trampolining, such as not using these instruments in a school context or even in a competitive context (this one a little more unrealistic). Other measures include raising awareness that dangerous maneuvers, such as the somersault, should only be performed by athletes with experience and training, protecting the material when it is not being used, or even porting it with a barrier when it is being used.[11]

## Theoretical basis

The main objective of this study is to discuss the timing of the return to play and the correct and effective management of the athlete, according to the injury to which he was subjected. However, to be able to understand all the pathology covered here, it is important to address first the anatomy of the cervical spine and adjacent structures, together with their biomechanical properties, in a so-called normal cervical spine compared to a damaged cervical spine. In addition, understanding the mechanisms involved in cervical spine injuries is important, as it can help explain the injury, but also help prevent certain movements and thus the injury.

### Functional anatomy of the cervical spine

Knowledge of the functional anatomy of the cervical spine is crucial to understanding its biomechanical properties and the injury mechanisms to which it is subject. To make the assimilation of the anatomy of the cervical spine more intuitive, many clinicians divide it into two parts, taking into account its morphology and role regarding the biomechanics. The upper part is that which extends from the occipital bone to C2, and the lower part is that which extends from C3 to C7. This division is also useful because as will be shown, most catastrophic injuries will occur in the lower cervical spine, between C3 and C7.

The first vertebra of the cervical spine, the atlas, is also known as the cradle, because it is not only the structure that will support the head but also because it is mainly responsible for flexion and extension movements (nodding movement). This is because the way the atlas articulates with the occipital condyles causes these two structures to move as one, not allowing rotation and lateral flexion in the occipito-atlantal joint. [12]

The second vertebra is called the axis because it contains the odontoid process, or dens, which extends from the body of the axis to the facet on the atlas in its anterior arch, allowing the rotation of the atlas (along with the head) on the axis. In addition to this function, the axis supports the weight of the head, which is transferred to C2 through the lateral atlanto-axial joint. Another particularity of the atlanto-axial joint is the fact that its biconvex nature means that when the cervical spine flexes, the atlas extends and vice versa. This paradox motion is a characteristic that happens elsewhere in the spine and is important to understand some of the mechanisms of injury.[13]

From the C2-C3 joint onwards, the lower cervical spine begins since its elements will all be similar in anatomical and biomechanical terms [12]. In terms of motion, the lower cervical spine will be responsible for the remaining movements of flexion, extension, rotation, and lateral bending. [14] Given that this part of the spine is where most catastrophic injuries occur, it is important to consider its stability and how the energy that hits it is dissipated. The stability of the cervical spine is ensured mainly by its anterior elements. Compression forces are attenuated by the intervertebral discs and vertebral bodies. Shear forces are resisted mainly by the paraspinal muscles and ligamentous structures. Resistance to pure tension forces is provided by the annulus fibrosus and longitudinal ligaments of the anterior part of the spine. With respect to forward translation, this is attenuated by the coronal orientation of the two articular processes (inferior and superior). [3]

The concept of cervical range of motion addresses the extent that it is possible to move the spine in a certain direction. However, as afore mentioned, although the movements are always facilitated by motion segments (2 vertebrae plus the disc), they are very complex because they involve multiple components of the cervical spine, and the movements will never be in only one plane. If the spine is in flexion, it doesn't mean that all the vertebrae are also flexion, which means that a movement in a certain direction is going to be facilitated by all the movements of all the components of the cervical spine.

Overall, the cervical range of motion is 70 degrees in extension, between 80 and 90 degrees in flexion, up to 90 degrees in rotation to either side, and between 20 and 45 degrees in lateral flexion.[13]

### Biomechanical properties of the cervical spine

As afore mentioned, the cervical spine is composed of seven vertebrae, which together with the intervertebral discs, ligaments, neck muscles, and other adjacent structures cause it to adopt a lordotic shape. The normal lordosis is lost when the head is slightly flexed, causing the cervical spine to become straightened. The normal lordosis of the cervical spine is important because when a force hits the head or even the neck, it will allow for better dissipation of the force by the neck, thus avoiding certain types of injuries. However, if there is a loss of lordosis, the load that will hit a straighter spine will be absorbed more directly by the spine itself, i.e., by the bony structures, and not by all the components through which the force normally dissipates, such as the surrounding muscles and ligaments. Due to this reason, the loss of lordosis makes the cervical spine more prone to injury as other studies have shown.[15]

Cervical stenosis is a risk factor for catastrophic injuries in particular and can sometimes even be a contraindication for return to play in athletes who have suffered this type of injury. To objectify the concept of cervical stenosis, the Torg-Pavlov ratio has been developed, which can be used as a method to determine whether an athlete has cervical stenosis. This ratio corresponds to the division between the width of the spinal canal (distance from the posterior edge of the vertebral body to the nearest point of the corresponding spinolaminar line) and the width of the vertebral body. Therefore, a normal ratio is approximately 1, while if it is less than 0.8, indicates that there is cervical stenosis. [16] However, it was determined that this ratio, despite having a high sensitivity, has a low specificity and a low positive predictive value, since there may be athletes with large vertebral bodies, resulting in false positives. For this reason, other methods are used to determine if there is cervical stenosis, such as the loss of cerebrospinal fluid or the presence of compression or deformation of the spinal cord, through an MRI or myelogram, which is classified as functional cervical stenosis.[17]

In order to address the mechanisms of injury and pathologies such as cervical strain or sprain, it is also important to assess cervical instability, which is usually detected radiographically after the injury, but can be detected before and prevent it. According to White et al. a cervical spine is considered unstable mainly when there is a displacement greater than 3.5 mm or an angulation/rotation of more than 11 degrees of a vertebra in relation to the adjacent vertebra (above or below). As such, these values and the concept of cervical instability will be important in deciding when to return to play. [18]

## Mechanisms involved in cervical spine injury

The main mechanisms of cervical spine injury are hyperflexion, hyperextension, compression, shear, rotation, and distraction.[19] However, it is wrong to think that when there is a cervical spine injury it is only one of these movements that is involved. In fact, when some of these are applied together, their forces can be amplified, increasing the risk of injury. It is certainly important to understand these forces and their consequence on the cervical spine to understand the pattern of injury.

The mechanism of injury is often independent of the sport itself. The injury mechanism that is responsible for the largest number of cervical spinal cord injuries, including catastrophic cervical injuries, is axial loading. This mechanism is based on the application of an intentional or unintentional compressive force at the top of the head when the head and neck are slightly flexed (about 30 degrees). As afore mentioned, when the normal lordosis of the cervical spine is lost and it becomes straightened, the absorptive component by the elements adjacent to the spine is also lost. In other words, when the compressive force exerted exceeds the absorptive capacity of the spine, the components of the cervical spine (bones, ligaments, or muscles) will give way, resulting in cervical injuries such as fractures, and dislocations. This injury mechanism will be seen most often in American football through head-down contact or spearing, however, it can also be seen in other sports like diving.

Several sports-related injuries such as cervical spinal cord neuropraxia or transient quadriplegia will be discussed later. It is important to talk about a mechanism that may underlie it which is the "pincer mechanism". This mechanism suggests that when there is a forced hyperextension of a low cervical segment, it causes the posterior area of the endplate of the vertebral body to approach the spinolaminar line of the underlying vertebra, causing compression of the spinal cord, which can result in spinal cord injury and dysfunction. [20]

## Sports-related cervical spine injuries

This chapter will address the main sports-related cervical injuries, considering their pathophysiology and approach.

### Cervical Spine Fractures and Dislocations

Cervical spine fractures are one of the least common injuries in sports-related cervical injuries. It is correct to correlate these injuries with contact sports such as rugby, American football, and hockey, as they are more frequent in these, although they also occur for example in mountain biking.

Not all cervical spine fractures will be the same and the type of fracture will always depend on a series of mechanisms of injury, some already discussed like axial loading and the loss of cervical lordosis. In addition, fractures will be differentiated by the site where they occur in the cervical spine, by the time it will take for the bone to regenerate, and by the involvement or not of neuronal or vascular structures in the periphery. However, it is important to note that most fractures and dislocations will occur in the lower cervical region. Therefore, some type of fractures that may be related to sports will be discussed here.

Regarding upper cervical fractures, is stated that most cervical fractures occur in the lower cervical region and therefore these are rare.[14] Another particularity of these fractures is that they are more frequent in mountain biking than in American Football or hockey.[21] Within this category it is important to adress atlanto-occipital dissociations, instability between C1 and C2, isolated fractures of C1 or C2 without ligament involvement, or odontoid fractures. All of them are going to be different from each other in terms of pathophysiology and mechanism of injury and so the approach is never going to be the same. The important thing to remember is that if there is neurological injury, surgical intervention should be considered. However, this may also be necessary in the case of atlanto-occipital dissociation, due to its instability. In the case of odontoid fractures, they are usually treated with the use of a cervical collar, and surgery is reserved for cases where there is displacement of the fragment greater than 5 mm, or as already mentioned, if there is neurological injury.[4] Jefferson's fracture is a type of upper cervical fracture and it is characterized by a burst fracture of C1, which hits either the posterior or anterior vertebral arch, or both. This is an unstable fracture and may require surgical stabilization.[22] Finally, regarding Hangman's fracture (traumatic spondylolisthesis of the axis – bilateral fracture traversing the pars interarticularis of C2), while it can often be managed conservatively, with a rigid collar, it may require surgery if unstable.[23]

Spinous process fracture is a form of fracture that can appear in isolation, and which usually has a good prognosis because of its relative stability. Thus, it usually requires no treatment, other than the possible use of a cervical collar. These have been mainly associated with stress injuries caused by tension of the surrounding muscles.[24] However, there are other mechanisms that may be at its genesis, namely hyperextension-hyperflexion or hitting an object in the spinous process.

Getting back to axial loading, when it occurs together with neck flexion, an injury called a "teardrop fracture" can occur. This occurs when the posterior ligamentous band is damaged and loses its tension under the force exerted, which causes a fracture of the anteroinferior portion of the vertebral body. It is stated that this is an unstable fracture that may involve damage to the spinal cord and, therefore, surgical intervention should be an option.[25]

Finally, compression and burst fractures, are caused by the pure compression of an axial force on an aligned or flexed head, which will lead to fracture of the vertebral body because the intervertebral disc can no longer withstand the force exerted. While compression fractures can have a good prognosis when they are well identified, because they do not affect the vertebral ligaments. However, in some burst fractures, the fracture elements can reach the spinal cord or neuronal structures and cause severe neurological injury. As usual, if there is neurological injury, surgical intervention is mandatory. [14,26]

### Cervical Disk Herniation

A herniated disk occurs when a fragment of the disc nucleus is pushed out of the annulus into the spinal canal through a tear or rupture in the annulus and becomes symptomatic when it reaches and compresses the spinal nerve. Usually, a herniated disc occurs when the nucleus pulposus becomes dehydrated, with age, causing the fibrous annulus to rupture. However, when considering herniated discs related to sports, injuries are acute nature, related to flexion, rotation, or compression movements, in younger athletes. Thus, cervical disc herniations are more common in contact sports such as American football or rugby compared to non-contact sports and the general population, with axial loading again being involved as the injury mechanism. [26]

While sports-related cervical injuries, such as fractures, occur more often in the low cervical regions, in the case of cervical disk herniations, it is stated that when related to contact sports, the upper cervical region is more at risk, with a higher frequency at the C3-C4 level. The symptoms can range from upper extremity and neck symptoms, including severe pain, numbness, or weakness, regardless of the extent of the injury. Symptoms can range from a radicular pain to a myelopathy or even transient quadriparesis. [4,27]

Regarding the management of the hernia, there is a great discrepancy in the algorithm concerning the choice between conservative or surgical treatment. This decision will depend on the symptomatology, the involvement of neurovascular structures and limitation, but regarding athletic population, conservative treatment should always be the priority. This will involve relative rest (never absolute), muscle strengthening exercises, and non-steroidal anti-inflammatory drugs. However, surgical treatment should be considered if conservative treatment is not effective or if the pain and muscle weakness is prolonged and there is spinal cord compromise. In regard to surgical treatment, the options are usually discectomy or fusion, or both. [27]

### Stingers or Burners

Cervical burners or stingers are characterized by injury to the brachial plexus (in one of its divisions) or a cervical nerve root, at the level of the neuronal foramen. This peripheral neuronal injury is usually transient and self-limited, lasting from minutes to 24-48 hours. Another important aspect to differentiate it from other lesions is that it affects the upper extremities unilaterally, especially in the C5 or C6 root. In other words, if this type of injury occurs bilaterally, it is necessary to look for a spinal cord injury. And so, the symptoms that characterize a stinger, as the name suggests, is a sharp, piercing, burning pain that can radiate down the arm, accompanied by weakness of the proximal muscles of the upper extremity, and the weakness can last longer after the pain stops (usually days). [28]

These lesions are among the most common cervical injuries in athletes, especially in contact sports. It is described that more than 50% of American football players experience this type of syndrome, and therefore it has been extensively studied regarding its pathophysiology and return to play. The mechanisms of injury include: stretching injury, which occurs in the brachial plexus contralateral to the site where neck flexion occurred; a direct blow to the brachial plexus; nerve root compression by ipsilateral flexion and extension (usually when there is cervical stenosis). As far as treatment is concerned, the main option is conservative treatment, and surgical treatment should be reserved for individuals who, after attempting a conservative approach, maintain neurological deficits due to irreversible nerve root injury. [29]

### Cervical Stenosis and Cervical Cord Neuropraxia (Transient Quadriplegia/Paresis)

Neuropraxia of the cervical spinal cord can be a synonym for transient quadriparesis and is a relatively rare entity in the athlete but is mostly associated with contact sports. This entity is characterized by the appearance of bilateral motor and/or sensory symptoms that last from seconds or minutes to 24-48 hours, which is why it is called transient. The symptoms are, on the sensory side, numbness, paresthesia, or even loss of sensation, and on the motor side, muscle weakness, which can range from mild motor loss, to mild quadriparesis or severe quadriplegia. It is important to mention cervical stenosis, since it is a risk factor for neuropraxia of the cervical spinal cord, mainly in athletes who practice contact sports, whether it is a developmental or congenital stenosis. [30] In order to differentiate a stinger from a cervical cord neuropraxia, the last one occurs bilaterally and, when in mild cases, shows a relatively faster recovery than a stinger.

Regarding the mechanism of injury, the main one is the “pincer´s mechanism”, in which during extension, the cervical cord is compressed between the posterior margin of a vertebral body and the anterior margin of the spinous process of the vertebra below it, and this compression is more likely to occur in a hyperextension lesion with axial load.[20]

Just like the stinger, the treatment of cervical cord neuropraxia is conservative, involving immobilization of the athlete. However, whenever there is an episode of transient quadriparesis, it is necessary to rule out cervical stenosis or even an extensive neuronal injury, through a plain radiograph and magnetic resonance imaging (MRI), because if this is present it can be a contraindication for the return to play.[26]

### Muscular and Ligamentous Injury Sprain/Strain

Regarding ligament sprains or muscle strains in the cervical region, the return to play is not going to be as ambiguous as it is in the other pathologies discussed. This is because if one of these isolated entities occurs, there won't be any kind of neuronal or bone involvement, which facilitates not only the recovery, but also the return to play. Therefore, the athlete should return to activity when he or she has no symptoms, when there is complete range of motion, and when the neck muscle strength has been re-established. Considering the symptoms, both can be translated into a low level of pain, which may be accompanied by tenderness, swelling, headaches, and muscular spasms.[23]

### Spear Tackler's Spine

Spear tackler's spine, refer to an entity that occurs in contact sports, namely American football, and rugby, in which the player uses the spearing technique to knock down the opponent. Once again, the axial loading mechanism plays an important role, as the athlete, with semi-flexed head, uses the top of his head to encounter the opponent's body. Repeated tackles can lead to radiological changes in the spine, which will then generate the spear tackler's spine. The changes caused by this movement are the narrowing of the spinal canal, loss of normal cervical lordosis, cervical stenosis, and evidence of vertebral and ligamentous changes on imaging exams. [7]

As already mentioned, spear tackling has been banned from American football, and this caused the incidence of this diagnosis to decrease. However, being a well-known entity that can endanger the athlete's quality of life, usually when it is diagnosed, the athlete is advised by the clinician to cease his or her sports activity, especially when playing a contact sport.[7]

## Return to play

As previously stated in the introduction and objective of the article, the return to play of the athlete after cervical injury may be something controversial and that is mainly based on the experience of the clinician who evaluates the situation and on the patient's wishes, but also on case reports, case series and reviews, such as this one. However, there are certain parameters that are essential and almost mandatory for a return to play, regardless of the injury in question, and that also cut across all the literature. These are the absence of pain together with the presence of full range of motion and the absence of neurological deficits accompanied by full neck strength. In other words, if an athlete maintains stiffness, pain, or weakness in the cervical region, or has any type of injury that is recurrent, he or she should not return to the activity and should be evaluated and handled more carefully before returning.

This chapter will discuss the timings and recommendations for returning to play, considering the different types of pathology afore-mentioned. In the end, a list of recommendations and contraindications will be reported, considering all the bibliography used (Table I)

### Cervical Fractures

After a cervical fracture, the athlete may return to play when there is no pain, no neurological injury, full range of motion and full strength in the extremities and neck muscles. However, in the case of a fracture, it is also necessary to have bone healing/fusion before returning to play. Therefore, in cervical fractures return to activity should only be considered when this occurs, i.e., at least from 8 to 10 weeks after the injury, regardless of whether it is a stable or unstable fracture.[31] Thus, before thinking about returning to play, it is important in these cases to perform dynamic studies such as a flexion and extension radiograph, and CT-scans, in order to understand if the bone has healed/fusion and to exclude cervical instability. [32]

The fact that there are different types of fractures with unique characteristics, as afore mentioned, makes it more difficult to find concordant guidelines for the return to play in this chapter. However, it is recommended that whenever there is a fracture, the risks associated with it, namely the possibility of the persistence of the initial injury or even the possible additional risk of injury due to a previous fracture should be considered. Thus, there are some parameters that are transversal in all articles. Some of them are that return to activity is contraindicated in cases of fractures associated with residual neurological deficits, fractures that require fusion between the occipital and C1 or fusion between C1-C2, subaxial instability (defined as an angulation greater than 11 degrees or a translation greater than 3.5 mm), multiple fusions at various cervical levels, and finally the spear tackler's spine, since stenosis and loss of lordosis, along with bony or ligamentous changes are a major risk factor for new injury. [4,23,26,31,33]

Regarding relative contraindications, this may be the gray area, where the bibliography may differ, however, according to the reviewed articles, there are some cases that converge. The main fractures that fall under relative contraindications here are upper cervical fractures, namely, already treated fractures between C1 and C2 that have required surgical stabilization (excluding fusion between C1 and C2, which is an absolute contraindication, as afore mentioned), and all upper cervical fractures that did not require surgical treatment also fall under relative contraindications. Examples include odontoid process fractures (only types 1 and 2, whereas odontoid abnormalities can be considered absolute contraindications) [34], Jefferson fracture, and compression fracture of C2. Regarding subaxial fractures, there are also some that translate into relative contraindications, such as stable compression or burst fractures or fractures of the posterior cervical portion (except for spinous process fracture). It is important to report that in all the situations addressed, return to play can only be considered when there is good bone healing demonstrated in the CT-scan, absence of instability reported in flexion and extension radiographs, full range of motion and no pain, preserved neck muscle strength, and absence of bony or ligamentous structures that may compromise the spinal canal. [4,26,33,34]

There are some fractures that, due to their relative stability and the fact that they also do not require surgical treatment, will not cause any restriction regarding the return to play, except for the parameters required for the return, such as full range of motion, no pain, and full neck muscle strength. These are the unilateral transverse process fracture in the subaxial region and the spinous process fracture, especially if it is subaxial (clay shovler's fracture for example, which is at the C7 level). However, in this second entity, it should be considered that if there are multiple fractures of the spinous processes, the management should be more controlled and the return to activity should be well managed but not contraindicated. [4,23,26,33]

Finally, in the case of cervical fractures, it is particularly important to address the return to contact or non-contact sports. There are authors who argue that even if there is some type of permanent mild neurological changes after the resolution of a stable fracture, it is possible to return to a non-contact sport, such as golf. Cantu et al.[23] argue that in cases of resolved fractures with fusions at multiple cervical levels, or a fusion involving C1-C2, which normally translates as an absolute contraindication for a return to play, the return to contact sports is contraindicated, but the performance of non-contact sports is not.

### Cervical Disk Herniation

In the presence of cervical herniations, return to play will always depend on the basic principles for return, such as full range of motion without pain and recovery of neck muscle strength. However, in these cases there is a nuance regarding professional athletes with treated herniations, in that some symptomatology, such as slight pain and numbness in the upper extremities may persist upon return, regardless of the type of treatment and management chosen. In these cases, the return to play will translate into a relative contraindication, instead of absolute as it would be normal, since in these athletes, sport is their profession and source of income, so the return to play may be considered in some way. However, when discussing a non-professional athlete and under these conditions, the return to play must be more carefully considered, because the risk of spinal cord injury and worsening of the condition will always be significant. [26]

The factor that most influences the return to play for herniated disks is the treatment. The easiest to approach is the athlete who has a herniated disk treated conservatively, who, if he meets the necessary parameters for return, has no contraindications for doing so. There is an absolute contraindication for a symptomatic disk herniation treated conservatively, due to the risk of severe spinal cord compression. [35] However, there are studies that show that in athletes who have undergone surgical treatment, the rate of return to activity is relatively higher than in athletes who have undergone conservative management. [36,37]

Regarding surgical treatment, a technique that will be widely used in herniated disks is the anterior cervical discectomy and fusion (ACDF) which is a surgery that removes the herniated or degenerated disk in the cervical region through an incision in the anterior part of the neck, providing spinal decompression, followed by a spinal fusion, and this can be performed at a single cervical level or at multiple levels. This has been shown to be a safe technique for return to play when performed at a single cervical level, as demonstrated in a study by Maroon et al. [38], in which 13 of 15 athletes who perform ACDF at a single level safely returned to activity. Therefore, an athlete who has undergone an ACDF at a single cervical level, when the necessary parameters for return to play are met, along with radiographical evidence that there has been a consistent fusion, the athlete can return to play. However, if an ACDF is performed at two levels, most agree that it is a relative contraindication for return to play and if it is performed at three levels, there is an absolute contraindication [4,23,33,35]

Therefore, according to Cantu et al. [23], anterior or posterior fusions at one or two levels are a relative contraindication for return, while 3-level anterior or posterior fusions are an absolute contraindication to return to play. Another absolute contraindication described is the return after cervical laminectomy. However, there are authors that defend that a laminoforaminotomy does not represent a contraindication for the return to play, as long as it complies with the parameters described and there is radiographic evidence of cervical stability. [35]

### Stingers or Burners

As already mentioned, the treatment of stingers will involve a conservative approach, which will make it simpler to agree on the return to play. This means that an athlete who has had a stinger can only return to play when he or she is symptom-free and has full range of motion. However, there are some nuances here regarding the recurrence of the episodes and how this injury is managed if it persists for a long time. Therefore, the decision to return to play will usually be clinical, and it may be necessary to resort to neurological or even imaging studies.

It has been described by Cantu et al. [23] that when an athlete has had only one or two stingers, which have had a duration of symptoms of less than 24 hours, they can return to play if they then have full range of motion. Athletes who have only had one or two episodes of stingers in a season, have no contraindications to return to play. [39] However, an athlete who has had three or more stingers in a season, or an athlete who has had symptoms for more than 24 hours, have a relative contraindication for return to activity.[39] This is where it will be important to introduce neurological studies.

In cases where an athlete that appears to have a stinger and the symptoms persist, it is a suspicious case of ligament instability or even cervical stenosis and, for this reason, imaging exams are necessary, such as a simple radiograph or in flexion-extension (if it is possible), or even a magnetic resonance image (MRI). However, in the case of stingers, according to Weinstein [40], the exam that will be most used when there is a persistence of the symptomatology for more than two weeks is the electromyography. This test will be informative and can help us in the decision to return to play only if the symptoms have been present for more than two weeks, because until then the decision will be made based on the presence of symptoms, physical examination, and eventual imaging tests. However, even if it is informative, a normal electromyography will not be a condition for the return to play. In other words, it will only tell in which cases it is recommended waiting to return to play and maintain observation, namely when fibrillation potentials and sharp positive waves together with clinical weakness are present. [40]

Paulus and Kennedy [26] created a list to guide the clinicians regarding the return to activity after a burner:

- First stinger: return to play after absence of pain with full range of motion and normal neck strength.
- Second stinger: return to play after absence of pain with full range of motion and normal neck strength. Do not play the rest of the game.
- Third stinger: return to play after absence of pain with full range of motion and normal neck strength. Imaging studies are necessary. Do not play the rest of the game.
- Any stinger with persistent symptoms: cease the activity. Electromyography is needed to help in the decision to return to play.

### Cervical Cord Neuropraxia and Transient Quadriparesis

Whenever there is an athlete who appears with symptoms suggestive of a cervical cord neuropraxia, the normal thing to do, besides the physical exam, is to take a plain radiograph and an MRI, to try to understand if there is any underlying change that is causing this syndrome. This is because, as afore mentioned, cervical stenosis is the main risk factor for transient quadriparesis, and its presence can condition the decision about returning to play. Thus, besides trying to find out the athlete's Torg ratio, many authors assume that this will not be enough due to its low specificity and low positive predictive value for cervical stenosis. Therefore, MRI is going to be the essential tool to figure out if there is functional cervical stenosis (described by, for instance, the loss of cerebrospinal fluid). This is one of the injuries in which recommendations may vary a little due to the difficulty in detecting cervical stenosis in a general way, and because all the literature is based on case series.

Most authors argue that the presence of a functional cervical stenosis detected by MRI is a contraindication for return to activity per se [9,23] while some state that if an athlete has a transient quadriparesis episode, with resolution of symptoms in less than 24 hours and complete recovery of range of motion, with a Torg ratio of 0.8 or less, they can return to activity. [33] Here, the correct screening for functional cervical stenosis is preferably done by MRI and will be important for the decision on return to play.

In general, for an athlete who has had only one episode of transient quadriparesis, lasting less than 24 hours (more than 24 hours may be a relative contraindication), to return to activity, including contact sports [41], there must be complete recovery of symptoms, with preserved range of motion. In addition, there must also be an absence of imaging findings of functional cervical stenosis or even ligament instability. On the contrary, if we have an athlete with a diminished stenotic canal (less than 13mm), with functional cervical stenosis evidenced on CT or MRI scan, spinal cord compression with or without symptoms, discomfort in the neck region, edema around the cord, or duration of symptoms for more than 36 hours, return to play should be contraindicated. [23,33]

Regarding recurrence of symptoms, there are authors who argue that a second episode of transient quadriparesis should be a contraindication to return to contact or collision sports, regardless of whether there is evidence of cervical stenosis or not; however, non-contact sports are not contraindicated. [26,41] This is because there is evidence that athletes who have had cervical cord neuropraxia and who return to contact sports have an overall symptom recurrence of 56%.[42]

In a study by France et al. [34], in which the opinions of different surgeons were evaluated when faced with some scenario cases, it was determined that, in addition to all of the above, the duration of the neuropraxia and the presence of congenital cervical stenosis are other important parameters in the decision to return to activity. That is, if a case of congenital cervical stenosis or a case of neuropraxia that is not brief appears, most surgeons do not recommend a return to play.

In the end, once again, the decision will be determined by the clinician's opinion, but it is important to attend the patient's condition and wishes. When addressing a young American football player who doesn't want to pursue a professional career in sports, probably the best decision will be to advise for the cessation of the activity, so as not to put at risk some kind of neurological damage that may prevail for the rest of his life. On the other hand, if there is a professional player, in which the source of income depends on sports, then the return to the activity must be seen differently.[41] However, the decision should be clinical. All other factors can weigh into the decision, but if there is a contraindication they should not return to play.

## Conclusion

When approaching the return to play of an athlete to his or her sport in question, there is one aspect that is transversal to all the literature reviewed. In general, regardless of the injury in question, return is only considered when the athlete has no pain or other symptoms that suggest neurological deficits and has a full range of motion, along with the absence of neck muscle strength deficits that translate into instability of the cervical spine.

The decision to return to play will be multifactorial and cover the injury part, namely the injury mechanism, pathophysiology and treatment, the opinion of the clinician who will guide the process, taking into account his personal experience and the athlete's part, namely his recovery process, his will to return to sports and his priorities. There is a need for guidelines because are facing situations that involve multiple factors and can compromise the athlete's well-being and quality of life if the wrong decision is made. Therefore, despite the difficulty of implementation due to the relative rarity of these entities studies such as randomized trials that allow for more valid outcomes about the return to play should be implemented.

It was noted throughout the study that there are numerous contradictions in the recommendations regarding the return to play in certain entities. For example, cervical herniation associated with mild symptoms should be seen as an absolute contraindication for return to sports practice for not meeting in some way the essential parameters for return, however this can be considered in some athletes, namely professional athletes, as was seen. From this we can conclude that, despite the extreme importance and need to obtain standardized guidelines to facilitate the decision to return to play, in the end this decision will be made based on the particularities of the case in question and the needs and intentions of the patient. In other words, it is important to realize that these guidelines, like all the others, will only serve as an orientation not only for the decision to return but also in the decision of the treatment instituted.

Another important aspect to be mentioned is that most of the literature addresses mainly contact sports, due to the higher incidence of cervical injuries in this type of activities. This means that, although it is intuitive to realize that there is greater safety in returning to play for sports that do not involve contact, we do not know if this return to activity is safe or not. Therefore, there is also a need for studies to evaluate the return to activity in non-contact sports after a cervical injury associated with contact and non-contact sports.

## Appendix

**Table I** – Return to play criteria after cervical spine injuries in athletic population.

| |
|---|
| **No contraindications (if no symptoms, no neurological findings, and full range of motion)** |
| Subaxial transverse process fracture |
| Spinous process fractures (if not multiple) |
| Clay shovler's fracture |
| Healed, stable C1 or C2 fracture, treated conservatively |
| Healed cervical disk herniated, treated conservatively |
| Anterior cervical discectomy and fusion (ACDF) at a single cervical level, with radiographic evidence of solid fusion |
| Laminoforaminotmy with radiographic evidence of cervical stability |
| One or two episodes of stingers with symptoms duration of less than 24 hours |
| One episode of transient quadriparesis with symptoms duration of less than 24 hours and no evidence of functional cervical stenosis or ligament instability |
| Asymptomatic athlete with Torg ratio less than 0.8 |
| Muscular sprains and ligamentous strains |
| |
| **Relative contraindications** |
| Treated cervical fractures between C1 and C2 with surgical stabilization (excluding fusion between C1 and C2) |
| Upper cervical fractures treated with conservative management |
| Odontoid process fractures (type 1 and 2) |
| Jefferson fracture |
| Compression fracture of C2 |
| Odontoid process fractures (type 1 and 2) |
| Subaxial stable compression or burst fractures |

| |
|---|
| Subaxial fractures of the posterior cervical portion (except spinous process fracture) |
| Two levels anterior cervical discectomy and fusion (ACDF) |
| Anterior or posterior fusions at one or two cervical levels |
| Three or more episodes of stingers in a season |
| Episode of stingers with more than 24 hours of symptoms duration |
| One episode of transient quadriparesis with symptoms duration of more than 24 hours |
| |
| **Absolute contraindication** |
| Fractures associated with residual neurological deficits |
| Fractures that require fusion between the occipital and C1 |
| Fractures that require fusion between C1 and C2 |
| Odontoid abnormalities |
| Subaxial instability |
| Healed cervical fractures, but with the presence of symptoms and abnormal image findings or limited range of motion |
| Three or more fusions at various cervical levels |
| Radiological evidence of spear's tackler spine |
| Symptomatic cervical disk herniation |
| Three or more levels cervical fusions |
| Cervical laminectomy |
| Congenital cervical stenosis |

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