



# Anatomy and Physiology of the Spinal Cord

A guide for patients

## Key points

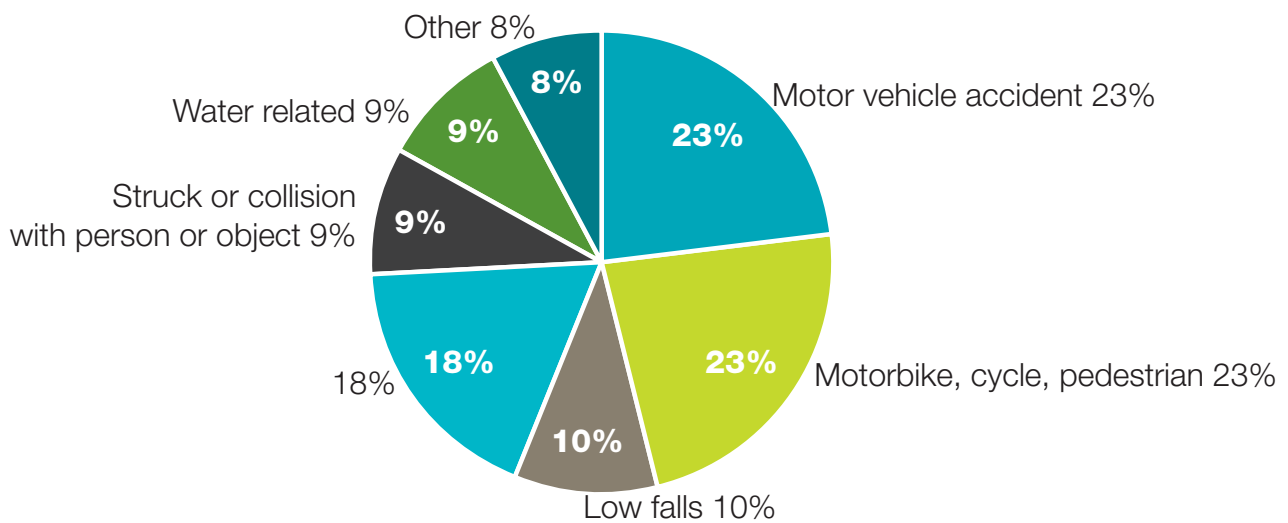
- Your spinal cord is the connection between your brain and the rest of your body
- Your spinal cord is soft, and enclosed in a bony tunnel – the spine
- Your brain communicates via the spinal cord to control voluntary functions such as movement and sensation (feeling), and involuntary functions, which are the things your body does automatically, such as breathing
- Spinal Cord Injury (SCI) can occur after a traumatic injury or as a result of disease
- The amount of function that is affected depends on both the level and the severity of your spinal cord damage
- Paraplegics lose movement and sensation in their legs and sometimes the trunk (abdomen and chest)
- Tetraplegics lose movement and sensation in all four limbs, as well as the trunk. This is also known as quadriplegia
- Most people with SCI (at any level) will experience changes in their bladder, bowel and sexual function
- Following SCI your reflexes (e.g. knee jerk) may still be present depending on the level of your injury
- SCI has a physical impact on many of your body systems and functions
- Rehabilitation and education is fundamental to good health after SCI

## Causes of Spinal Cord Injury

Spinal cord injury (SCI) can be caused by traumatic or non-traumatic injury. Many spinal cord injuries occur with fractures of the spinal column, with bony fragments damaging the spinal cord. Your spinal cord can also be damaged without a bone fracture. Other causes of spinal cord injury include disease, infection, degeneration, cancer, and interruption to the blood supply.

According to statistics published by the Australian Institute for Health and Welfare for 2007-2008, 79% of Spinal Cord injuries were due to traumatic causes and 21% from non-traumatic causes. The greatest proportion of traumatic injuries occur in males aged between 15 and 24 years of age.

## Spinal Cord Injury - Traumatic Causes Australia 2008-2009



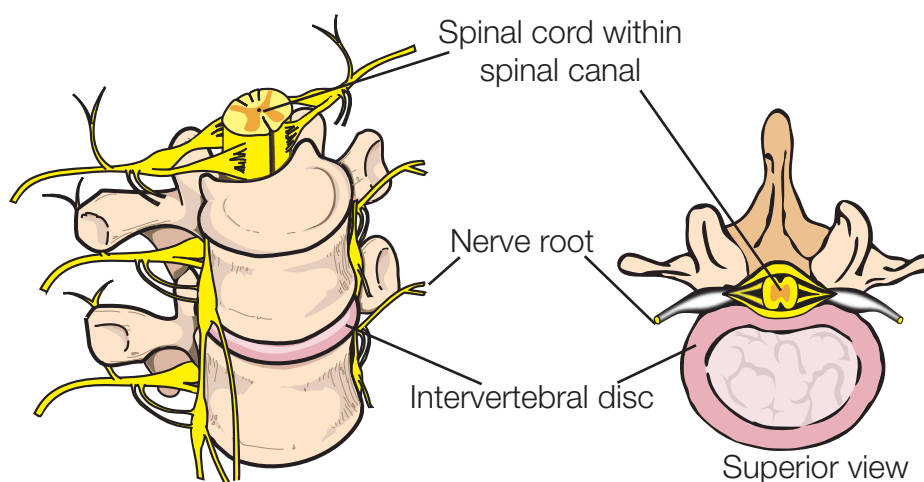
## The Spinal Column

Your vertebrae (neck and back bones) form a circular column to protect the spinal cord. There are 33 vertebrae, starting at the base of the skull, and ending with two sections of joined/fused vertebrae in the pelvis and tail bone. There are 7 cervical (neck) bones, 12 thoracic (chest), 5 lumbar (lower back), 5 fused sacral and 4 fused coccyx bones.

Your spinal column is flexible above the sacrum, and the discs between the vertebrae act as shock absorbers and allow flexibility. Your spinal column is supported by muscles and ligaments. The spinal canal is like a tunnel for your spinal cord. The spinal cord is surrounded by membranes and fluid, and is protected by the vertebrae.

It is possible to fracture your vertebrae without damaging the spinal cord. This is referred to as having 'no neurological deficit', and once your vertebrae have healed or been stabilised by surgery the spinal cord is once again protected. However, if your spinal cord is damaged you will have some degree of neurological deficit.

It is also possible to have spinal cord damage without fracturing your vertebrae.

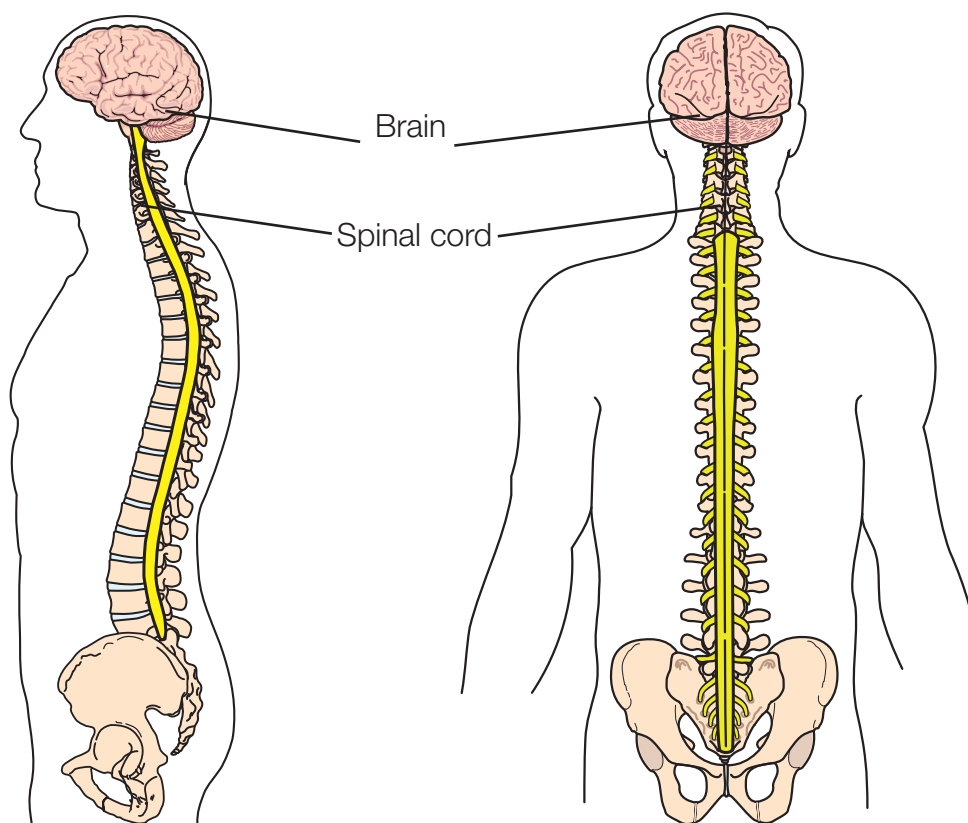


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## The Spinal Cord

Your spinal cord is part of the **central nervous system**, which comprises the spinal cord and the brain. It transmits messages to and from the brain. It has **involuntary** functions such as control of blood pressure, body temperature and breathing, as well as **voluntary** functions such as movement.

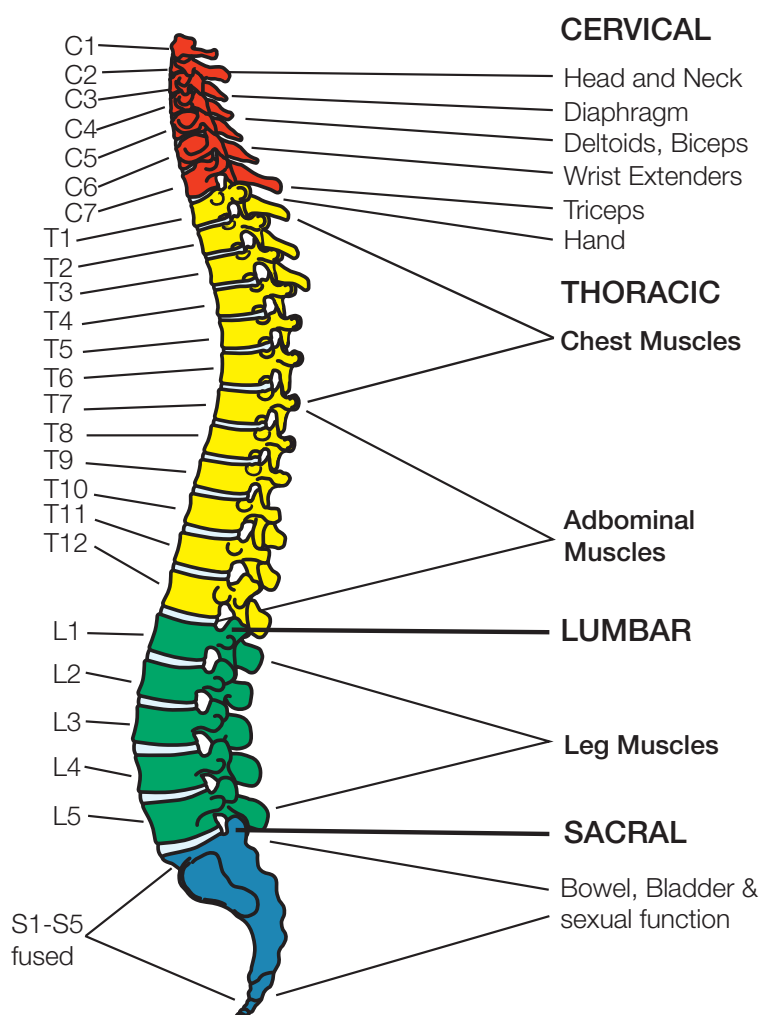
The spinal cord is soft. It is about 50 centimetres long and extends from the base of the brain to your lower back.



The spinal cord is a bundle of spinal nerves wrapped together. The **spinal nerves** enter and exit the spinal cord through small spaces between the vertebrae. The blood vessels which carry oxygen to the spinal cord also use these spaces. You have 8 pairs of cervical nerves, 12 thoracic, 5 lumbar and 6 sacral. Near the waist, the nerves continue in a bundle called the **cauda equina**. This is commonly called the 'horses tail' as that's what it looks like.

Spinal nerves transmit and receive messages to and from the brain. They are the main communication between your brain and your body. There are two main parts to each nerve – one carries sensory (feeling) information, and one carries motor (movement) information.

**Upper Motor Neurones** (UMN) are the long spinal nerves within the spinal cord, and **Lower Motor Neurones** are nerves that connect the spinal cord to organs, skin and muscles.



The effects of spinal cord damage primarily include a lack of movement and sensation below the level of your spinal cord injury. Most spinal cord damage will also result in permanent changes to your skin, bladder, bowel and sexual function. High level spinal cord damage can also result in changes to other body functions such as breathing and coughing, sweating, temperature regulation and blood pressure regulation.

The severity of your spinal cord injury depends on the level of injury and the extent of the damage to the spinal cord. The level of neurological deficit may differ from the level of your bony injury.

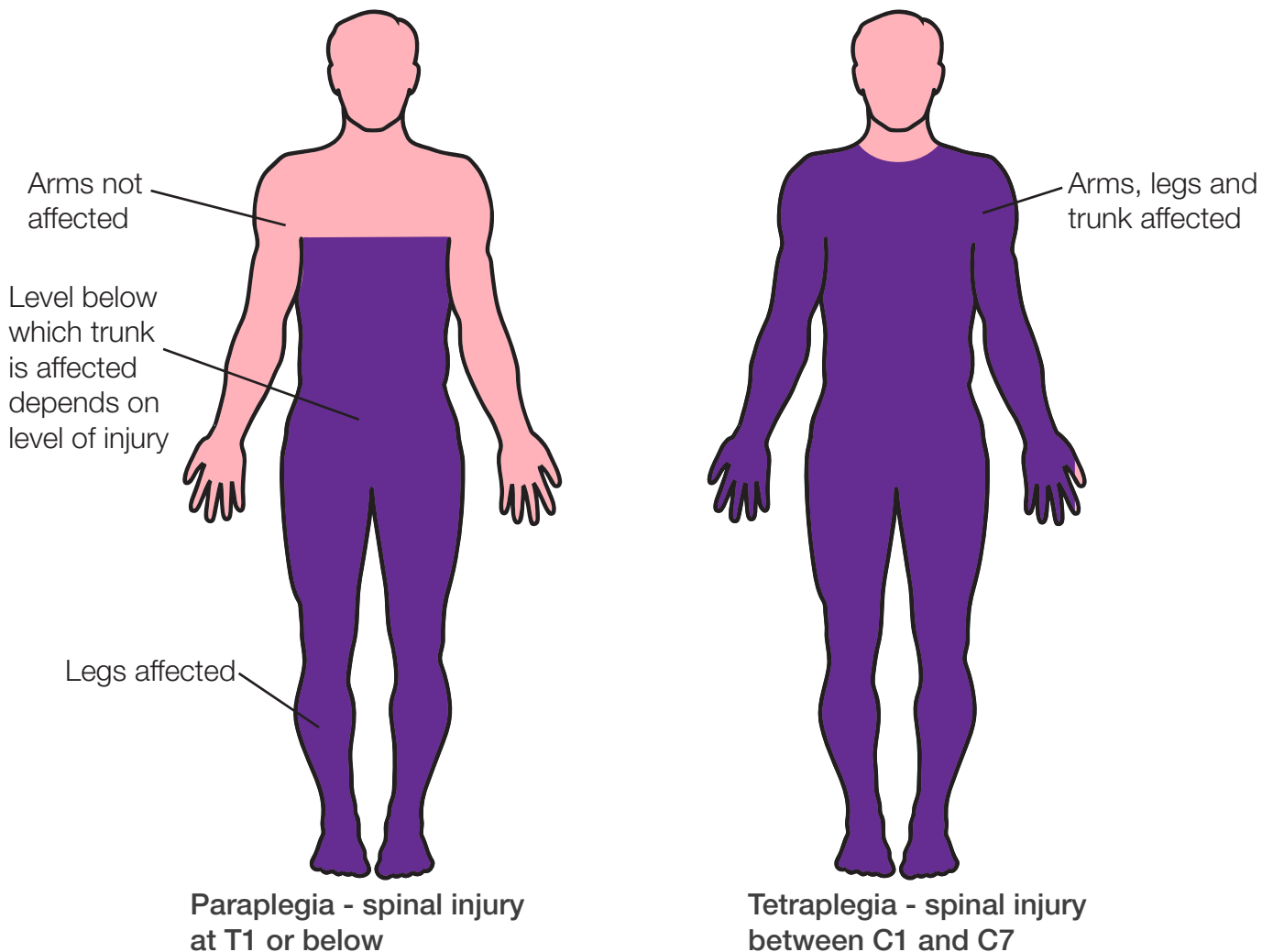
Most body parts and organs can repair themselves after damage, but at present the spinal cord cannot. Although attempts to regenerate function after spinal cord damage is currently being researched worldwide, there is not yet a cure.

## Paraplegia and Tetraplegia

Paraplegia is damage to the spinal cord T1 and below, that is thoracic, lumbar and sacral lesions. It means sensation and movement to your legs and possibly your trunk are affected, but not your arms. Tetraplegia (also known as quadriplegia) is damage to C7. It affects your sensation and movement in all four limbs and the trunk.

Both paraplegics and tetraplegics can expect to have changes in bladder, bowel and sexual function. This is because the nerves that control these functions are the sacral nerves, near the bottom of your spinal cord.

## Paraplegia and Tetraplegia



## Complete / Incomplete Injuries

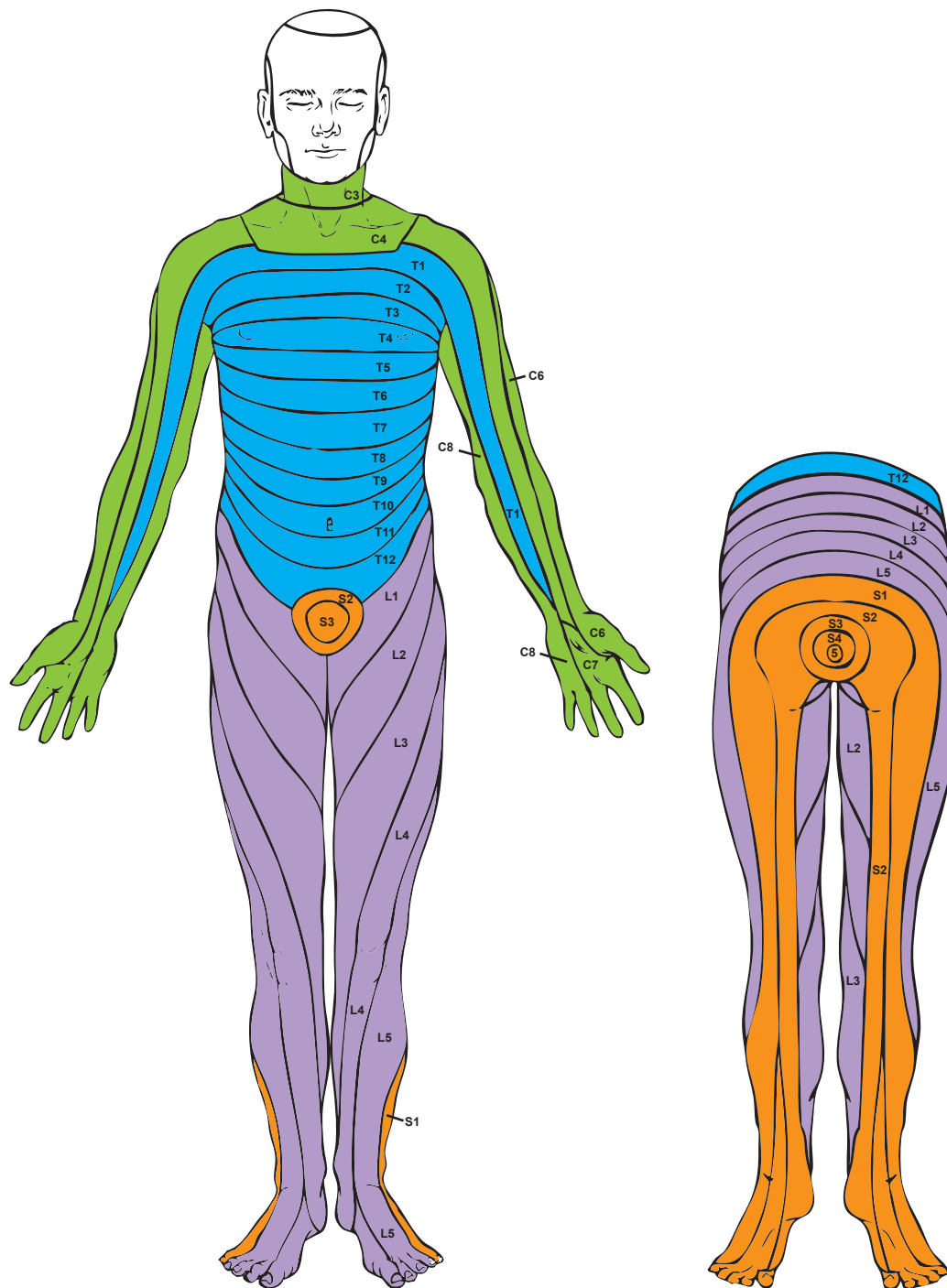
A complete spinal cord injury means that there is a total blockage of signals from the brain to your sacral nerves. An incomplete spinal cord injury means there is some preservation of nerves from the brain to the lowest part of the spinal cord, the sacral level. The amount of movement and feeling that is lost is different for each person as it depends on the extent of your spinal cord damage.

Every spinal nerve activates certain muscles, and this is tested at intervals following injury by medical staff, physiotherapists and nurses. Every spinal nerve also transmits the sensation from a particular patch of your skin to the brain, and this is tested with various types of sensation.

Every person with spinal cord damage will be different in how much they can move or feel. How your injury affects you will be unique to you.

## Level of Deficit

After sustaining a SCI, feeling and movement is absent or impaired below the level of your injury. The diagram below shows the areas of skin (or sensation) supplied by the spinal nerves.



## Expected Outcomes

By knowing the level of injury it is possible to predict your expected functional outcomes. Your outcomes, however, are also dependent on other factors such as your age, general health, fitness, motivation, and the completeness of your injury.

Remember the level of neurological injury referred to below may be different to the level of your bony injury. For example the bony injury might be C6 but the neurological level might be C5.

Level of Neuroinjury	Expected Functional Outcome of Complete Spinal Cord Injury
<b>C1-3</b>	Ventilator dependent. Fully dependent for all care needs.
<b>C4</b>	Dependent for movement. Will need full assistance with Activities of Daily Living (showering, dressing, feeding, toileting, hoist transfers etc). Can drive electric wheelchair with head control. Can shrug shoulders. May be ventilator dependent.
<b>C5</b>	Can drive electric wheelchair with hand control. Can bend elbows. Will need full assistance with Activities of Daily Living (showering, dressing, feeding, toileting etc).
<b>C6</b>	Manual wheelchair if young and fit. Independent slideboard transfer. Can drive with modifications. Has wrist extension and better shoulder control. Maybe able to self-catheterise with splints. Usually dependent for bowel care.
<b>C7</b>	Manual wheelchair. Can feed self, transfer, and do self-catheterisation and bowel care with adapted aids. Lift transfer. Can drive, and live independently. Has full elbow and wrist control and some hand function.
<b>T1-6</b>	Manual wheelchair. Can feed self, transfer, and do self-catheterisation and bowel care. Lift transfer. Can drive, and live independently. Normal arm and hand function. Some upper trunk control at T6.
<b>T7-12</b>	Manual wheelchair. Can feed self, transfer, and do self-catheterisation and bowel care. Lift transfer. Can drive, and live independently. Normal arm and hand function. Abdominal muscles present at T10.
<b>L1-S5</b>	Manual wheelchair. Can feed self, transfer, and do self-catheterisation and bowel care. Lift transfer. Can drive, and live independently. May walk with leg braces/crutches/cane.

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## Reflexes

Reflex activity is when certain movements or sensations are stimulated and there is involuntary muscle movement in response. This occurs automatically, and, often, without you feeling the stimulation. A doctor may have tested your reflexes before your injury by tapping the knee with a small hammer. The knee will kick up without your control. This is a simple reflex.

Your body uses reflexes as a protective mechanism. They are a very fast reaction to potentially harmful stimuli. For instance, after touching something very hot the signal passes through the reflex arc in your spinal cord and the hand is immediately pulled away. Your brain is aware of this event only after it has happened.

## Spinal Shock

Initially after spinal cord damage there is a period of spinal shock when your reflexes are not present. These reflexes can return anytime up to 3 months, usually between 1 to 6 weeks. Until your reflexes return there is a 'flaccid' effect.

The loss of spinal reflexes results in flaccid paralysis below the level of your injury. This also results in lower blood pressure and heart rate, slow gut motility, and reduced urine output.

## Changes to reflexes after Spinal Cord Injury

Depending on your level and extent of neurological injury reflexes may or may not be present as outlined below:

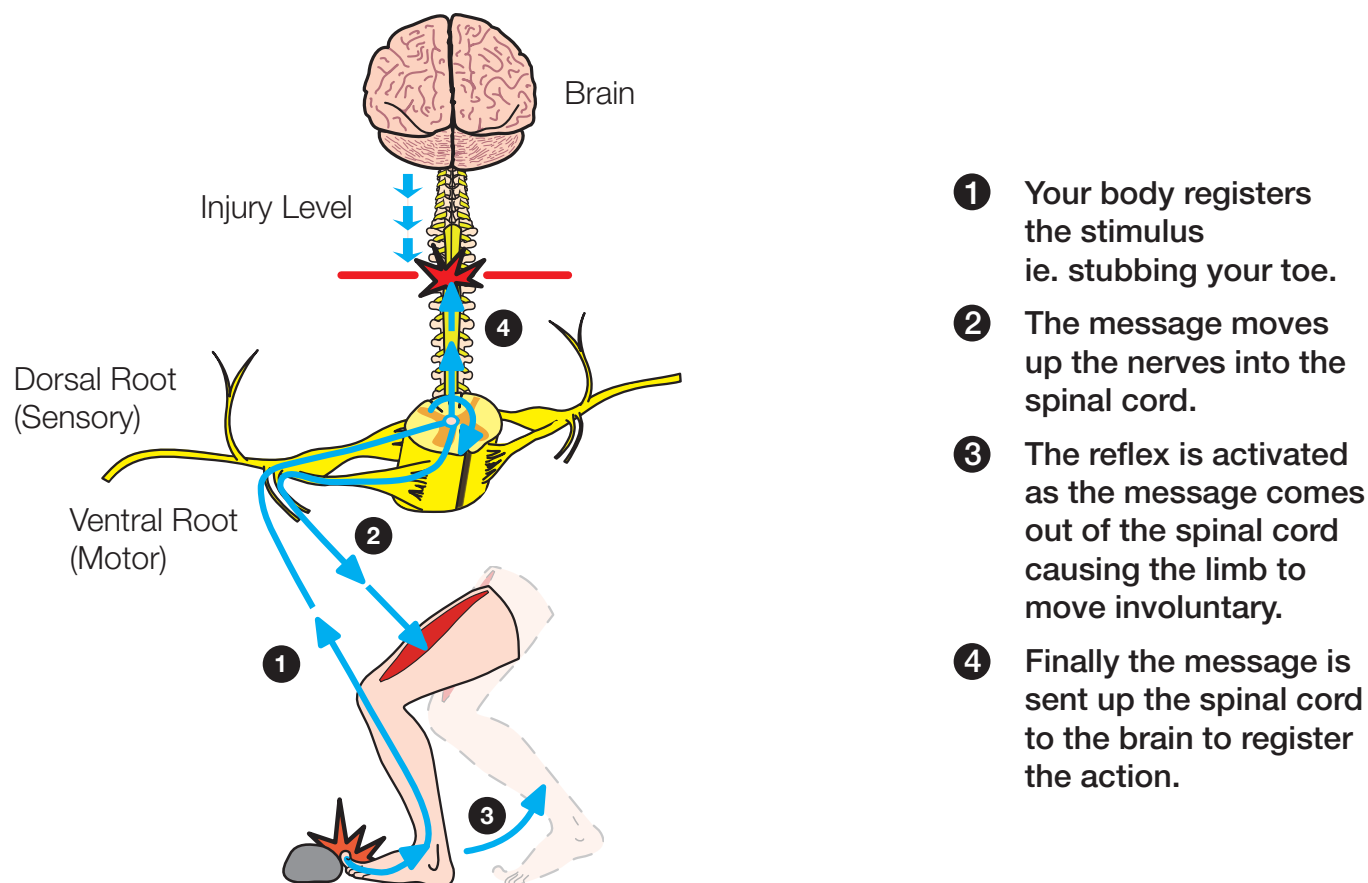
- Above T12/L1 reflexes should be present below the level of your injury (this is known as 'reflexic')
- At T12/L1 may have some reflexes intact below the level of your injury
- Below T12/L1 will generally have no reflexes below the level of your injury (this is known as "flaccid")

If reflexes are present after your SCI, you will probably experience involuntary muscle movement to a stimulus. The response to the stimulus will not be the same as before your injury. The message that goes to the brain telling it what has just happened is blocked by your spinal cord injury. Furthermore, your brain can't send a message back to cancel the muscle movement.

**Spasm** is an exaggerated reflex response to a stimulus. Spasm can be useful because it helps to keep your muscle tone and improve circulation. However, sometimes spasms can be very severe, and may need to be controlled by medication.



Reflexes can also be used for such things as emptying your bladder and bowel after SCI. This is not under voluntary control, because of the disconnection of the body's communication system to the brain, but can nevertheless be useful.



The reflex arc with spinal cord injury above T12/L1

## Reflexic/Flaccid

It is important to know whether your reflexes are intact as this affects many body functions and therefore management options.

Reflexic (reflexes present)	Flaccid (no reflexes present)
Has spasm. Some muscle wastage	No spasms therefore more muscle wastage
May be able to use a reflex to trigger bladder emptying	Loss of bladder tone. Need to self-catheterise
Can use a reflex to trigger bowel evacuation with suppositories and/or stimulation	Slower gut motility. Can evacuate bowel by straining, pushing or manual evacuation
Tight bladder and bowel sphincters	Flaccid bladder and bowel sphincters
May get reflexic erections	Does not have reflexic erections.

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## Physical Effects of Spinal Cord Injury on your Body

As well as changes in movement and sensation to your body, effects on skin, bladder, bowel and sexual function below the level of your SCI, other body systems and functions may also be affected.

### Breathing and Coughing

People with tetraplegia and high level paraplegia lose spinal nerve supply to the chest and abdominal muscles. Your ability to cough is affected, and assistance to cough may be required. Chest physiotherapy is important, especially in the initial stages after injury. People with high level tetraplegia may also lose innervation to the diaphragm, which is the band of muscle at the bottom of the rib cage which allows us to breathe. In some cases a ventilator may be required for you to breathe.

### Heart Rate, Blood Pressure and Circulation

Changes to your body's autonomic nervous system after SCI especially in people with lesions above T6 result in altered control of your heart rate, blood pressure and circulation,. Your blood pressure is lowered, your heart rate is slower, and blood circulation slows. Together with reduced mobility this results in blood pooling in your legs, increasing the risk of blood clots. The fall in blood pressure can also result in you becoming dizzy and feeling faint when sitting upright quickly. This tends to resolve over time as your body gets used to its new physiology. In the initial stages wearing an abdominal binder, anti-embolic stockings, or having someone raise your legs and tilting the wheelchair backwards (with brakes on) helps.

### Temperature Regulation

After SCI, especially in people with tetraplegia, it can be difficult for your body to regulate its temperature effectively, as sweating (to cool the body) and shivering (to heat the body) is impaired. Wearing appropriate clothing is important as you will be prone to taking on the temperature in the environment around you.

## Autonomic Dysreflexia

This is a medical emergency, which affects people with SCI above T6. Autonomic dysreflexia is a rise in blood pressure in response to a stimulus below the level of your injury. If left untreated the blood pressure can continue to rise to dangerous levels. It is vital that all spinal cord injured people with a lesion above T6 know how to treat this emergency. (See section on Autonomic Dysreflexia).

## Contact

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