Respiratory Health and Spinal Cord Injury

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This factsheet offers basic information about how the respiratory system changes after a spinal cord injury (SCI), how those changes may affect health, and how you can better manage your health.

What Does the Respiratory System Do?

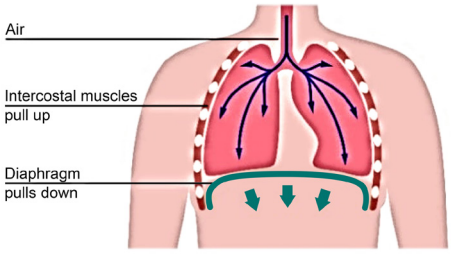
Your respiratory (or pulmonary) system is responsible for breathing. Inhaling draws oxygen into your blood. Exhaling removes carbon dioxide. Your body needs oxygen to survive and removing carbon dioxide prevents the buildup of acid.

How Does the Respiratory System Work?

Your brain manages your breathing without you thinking about it. It does this by sending signals down your spinal cord to the nerves at the third, fourth, and fifth cervical spinal levels to control your diaphragm. The diaphragm is the dome-shape muscle located under your lungs and is the main muscle used for inhaling.

- *Understanding Spinal Cord Injury: Part 1—The Body Before and After Injury* at https://msktc.org/sci/factsheets/understanding-spinal-cord-injury-part-1-body-and-after-injury.

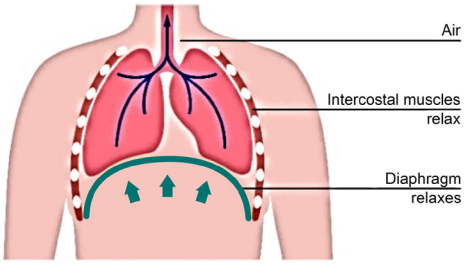
INHALING



Inhaling starts when your brain sends signals to pull the diaphragm downward. This is when you breathe in air that contains oxygen through your nose and mouth. Your lungs, rib cage, and abdomen (belly) expand as you breathe in.

The oxygen travels to your lungs through the main airway (trachea) and smaller airways (a series of tubes called bronchi and bronchioles) that lead to air sacs (alveoli) in your lungs. The air sacs allow the oxygen from the air you inhaled to pass into your blood and allow the carbon dioxide from your blood to pass into the alveoli.

EXHALING



Exhaling starts when your diaphragm relaxes and moves upward. Your lungs, rib cage, and abdomen (belly) relax as you exhale carbon dioxide out of your body through your nose and mouth.

Exercising and coughing require more force than quiet breathing. Your brain sends signals down your spinal cord to the thoracic nerves that control your abdominal muscles over your belly and the intercostal muscles between your ribs. Your abdominal muscles provide most of the force you need to cough.

The Model Systems Knowledge Translation Center works with Spinal Cord Injury Model System (SCIMS) centers to provide free research-based rehabilitation resources for people living with spinal cord injury (see https://msktc.org/sci for more information). This factsheet has been approved by experts from the SCIMS centers.

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- **Coughing** and taking deep breaths are important because you produce small amounts of mucus in your lungs every day. Coughing and deep breaths help to remove the mucus and prevent mucus buildup that can block the airways and air sacs in your lungs. A blockage can cause less air (oxygen) to enter the air sacs and lead to a buildup of carbon dioxide in your blood.

How Does Spinal Cord Injury (SCI) Affect the Respiratory System?

The loss of muscle control needed for breathing and coughing depends on your injury level and whether it's a complete or incomplete injury. The table shows the main muscles that are important for breathing and the spinal nerves that control them. After an SCI, signals sent from your brain may be limited or blocked as they try to pass beyond the damaged area of the spinal cord. This limits your brain's control over the main muscles used for breathing and coughing.

Main muscles normally used for breathing	Spinal nerves controlling muscle groups
Diaphragm	C3–C5
Intercostal (between ribs)	T1–T11
Abdominal (over belly)	T7–T12

Complete Versus Incomplete Injuries

A complete injury most often results in loss of muscle control below your injury level. An incomplete injury may result in all, some, or no loss of muscle control below your injury level.

Cervical Injuries

You may have a loss of diaphragm function or weakness in diaphragm function if you have a complete SCI at or above the C5 level of injury. You may need a tracheostomy (an opening through the neck into the trachea) to breathe or a ventilator that helps you breathe by pushing air into your lungs and then allowing your diaphragm to relax and exhale carbon dioxide.

- A diaphragm pacing system may be an option to reduce ventilator use. The pacing system sends electrical signals to muscles and nerves to pull the diaphragm downward to help you inhale.

Some people with a cervical injury below C5 may need a tracheostomy or ventilator early after their SCI but they can be weaned off the ventilator over time.

Thoracic Injuries

You can lose some or all control of your abdominal muscles if you have a complete thoracic SCI. People with a lower level of injury have more abdominal and intercostal muscle control than do people with higher levels of injury. An incomplete injury may result in all, some, or no loss of muscle control no matter what the level of injury.

Lumbar and Sacral Injuries

People with a lumbar or sacral SCI have no loss of abdominal or intercostal muscle control.

How Does Loss of Muscle Function Affect My Health?

If you have some type of loss in respiratory muscle control, the muscles that remain functional are forced to work harder to get oxygen into your blood and to get rid of carbon dioxide. You may also have trouble when you try to breathe deeply and when trying to cough with enough force to get rid of mucus in your lungs. This puts you at an increased risk for respiratory health problems.

- People having both a higher injury level and a complete SCI are at the highest risk for developing respiratory health problems.

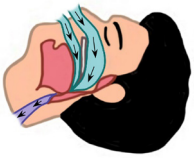
What Are Some Common Respiratory Health Problems?

People with cervical or thoracic SCI are at risk for developing respiratory health problems. The most common respiratory health problems are as follows:

- **Bronchitis** is an infection in the bronchial tubes that lead to the air sacs in the lungs.
- **Pneumonia** is an infection in the air sacs. These infections produce extra mucus and very serious health problems. Mucus builds up if muscle weakness limits the ability to cough well enough to clear the mucus.
- **Atelectasis** (at-uh-LEK-tuh-sis) is a collapse of the air sacs in all or part of the lung.
- **Pulmonary embolism** is a blood clot, usually from within the deep veins of the legs (also known as deep vein thrombosis), that breaks away, travels to the lungs, and blocks an artery in the lungs.

The highest risks for such problems occur among people who:

- Smoke (any product, including marijuana) or vape
- Have chronic obstructive pulmonary disease (COPD) or asthma that is poorly managed
- Have a tracheostomy
- Use a ventilator



Sleep-disordered breathing (SDB) and sleep disturbances are common in people with SCI. This can present as either **obstructive sleep apnea (OSA)**, **sleep-related hypoventilation (SRH)** or both.

OSA occurs when the airway collapses during sleep due to a loss of muscle tone in the tongue, soft palate, or other soft tissues. This collapse "obstructs" the normal airflow when you try to breathe. This typically causes a drop in your blood oxygen level and a rise in the carbon dioxide level in the blood. The brain responds with a brief arousal to "jump-start" breathing without waking you up all the way. You can go through the night without ever knowing that you experienced ongoing interruptions in your sleep.

SRH develops because breathing is too shallow or too slow, especially during sleep, which leads to an increase in carbon dioxide levels and low oxygen levels in the body. After SCI, the brain and body cannot automatically correct for abnormal levels of carbon dioxide and oxygen.

Sleep and pulmonary tests are needed to find out if you have OSA, SRH, or both and to determine your treatment options. You may need a breathing device like a CPAP (continuous positive airway pressure) machine, a BiPAP (bilevel positive airway pressure) machine, a noninvasive ventilation device, supplemental oxygen, or a combination of treatments.

OSA and SRH can lead to medical problems such as:

- Depression
- Diabetes
- Heart attacks, heart failure, and irregular heartbeat
- High blood pressure
- Stroke
- Death

People with a cervical SCI are at high risk for OSA and SRH. This risk is higher for people who:

- Snore
- Are overweight or with obesity
- Are male
- Are postmenopausal women
- Drink alcohol
- Take opioids or muscle relaxant medications
- Have a small jaw or enlarged tonsils
- Have difficulty breathing through the nose

What Can I Do for My Respiratory Health?

Prevention

Your first defense is to do whatever you can to prevent respiratory health problems. Here is a checklist.

- ✓ **Stop smoking and using e-cigarettes (also known as vaping) and avoid exposure to secondhand smoke!** Exposing yourself to smoke from any tobacco product, including marijuana and vaping, harms your respiratory health and worsens many health problems that you may develop. Tobacco smoking causes lung cancer and COPD, which can cause the body to produce extra mucus and reduce lung function.
- ✓ **Avoid the buildup of secretions in the lungs.** A cough assist machine can help clear secretions if you have difficulty coughing. You can train a personal care attendant or family member to do a manual cough assist. You can also use a suction tube to manage mucus and secretions if you have a tracheostomy with or without a ventilator.
- ✓ **Stay hydrated.** Drink plenty of water, especially if you have an infection, unless your doctor tells you something different.
- ✓ **Keep a healthy weight!** People who are overweight or with obesity typically have more respiratory problems. Here are two factsheets to help manage your weight.
  - *Exercise After Spinal Cord Injury* https://msktc.org/sci/factsheets/exercise-after-spinal-cord-injury.
  - *Nutrition and Spinal Cord Injury* https://msktc.org/sci/factsheets/nutrition-and-spinal-cord-injury.

- ✓ **Avoid people who may be sick** with a cold, the flu, COVID-19, or other respiratory infections.
- ✓ **Stay up to date on vaccines** and encourage your family and friends to get vaccinated to protect you and others, too.
  - **Get a flu vaccine every year.** It lowers your risk of getting the flu and may lessen the severity of the flu if you do get it.
  - **Get the latest COVID-19 vaccine.** This vaccine does not cause COVID-19, but it lessens the severity of COVID-19 if you get it and will also lower your risk of getting COVID-19.

- **Get a pneumonia vaccine.** Pneumonia and other pulmonary infections are among the most common causes of death following an SCI. But the vaccine can help keep you from getting a common type of bacterial pneumonia. You should ask your health care provider about the timing of vaccines based on current guidelines from the U.S. Centers for Disease Control and Prevention. There are pneumonia vaccines that cover different types of the most common types of bacteria. Recommendations may depend on your vaccine history and newly developed vaccines.
- **Get the respiratory syncytial virus (RSV) vaccine** if you are 60 years old or older.

✓ **Watch out for symptoms.** Respiratory health problems can develop even with your best efforts to prevent them. The sooner you identify any problems, the better your chance of treating them and getting better.

Signs and symptoms of a respiratory infection like bronchitis and pneumonia can be hard to identify. Mild signs and symptoms might first seem like those of a cold or the flu, but they can last longer and get worse over time. Test for COVID-19 if you feel ill. Test over several days if your symptoms continue.

Signs and symptoms of infection include:

- A fever and chills.
- A cough or feeling the need to cough. Coughing may produce thick, sticky mucus that might be clear, white, yellowish-gray, or green in color, depending on the type of illness.
- Tightness in your chest.
- Shortness of breath.

Signs and symptoms of OSA may also be mild at first and get worse over time. In fact, you might wake and fall back asleep many times throughout the night without realizing it. However, you can watch for some common signs that suggest you might have sleep apnea:

- Other people tell you that you stop breathing at night.
- Loud snoring.
- Restless sleep (especially if you wake up choking or gasping for air).
- Waking up with a sore and/or dry throat.
- Waking up with a headache.
- Daytime fatigue, sleepiness, or not feeling rested after sleeping.

Visit Your Health Care Provider

You should see your health care provider every year for a checkup to look for the health problems that are common to someone your age and with your type of SCI. You may need to see a provider more often if you have other lung diseases, such as COPD or asthma.

- Always contact your health care provider if you have signs of a respiratory infection. It is important to be aggressive and avoid waiting until a mild problem becomes a larger health problem.

- Contact your provider if you think you have sleep apnea. Sleep apnea is a serious condition. Your provider can set up a sleep study and find treatment options that work for you.
- Ask your provider if you should get a lung function test to see how well your lungs are functioning. This is especially important if you have ever smoked, have COPD, or have asthma. If you have problems breathing, you may need medication that opens the airways to help the lungs work, help you breathe easier, and make it easier to do your day-to-day activities.

Authorship

Respiratory Health and Spinal Cord Injury was originally developed by Eric Garshick, MD, MOH; Phil Klebine, MA; Daniel J. Gottlieb, MD, MPH; and Anthony Chiodo, MD, in collaboration with the Model Systems Knowledge Translation Center (MSKTC). This factsheet was updated in 2024 by Eric Garshick, MD, MOH; Susan Charlifue, PhD, FACRM; and Phil Klebine, MA in collaboration with the MSKTC. Dr. Garshick is a member of the Pulmonary, Allergy, Sleep & Critical Care Medicine Section, VA Boston Healthcare System, Department of Veterans Affairs, Boston, Massachusetts.

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Disclaimer: This information is not meant to replace the advice of a medical professional. You should consult your health care provider regarding specific medical concerns or treatment. The contents of this factsheet were developed under a grant from the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR grant number 90DP0012) and it was updated under NIDILRR grants (grant numbers 90SIMS0005, 90SIMS0020, and 90DPKT0009). NIDILRR is a Center within the Administration for Community Living (ACL), Department of Health and Human Services (HHS). The contents of this fact sheet do not necessarily represent the policy of NIDILRR, ACL, or HHS, and you should not assume endorsement by the federal government.

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