

Secondary Conditions  
Prevention & Treatment:  
B Series---N0.2

# Contractures

**The Research  
and Training  
Center on  
Independent  
Living**



---

University of Kansas/4089 Dole  
Life Span Institute  
Lawrence, KS 66045-2930

Funded by a grant from the Education and Training Foundation  
under the Aegis of the Paralyzed Veterans of America

Research and Training Center on Independent Living, University of Kansas. (1996).  
*Contractures*. Lawrence, KS: Author.

*Abstract:* The clue to understanding joint contractures rests within the smaller word “contract.” Something that contracts can be said to pull up, shorten, or shrink. A contracted joint becomes rigid because the muscles that cross the joint have shortened. This shortening limits a joint's movement. The fluid-filled spaces inside the joint shrink and dry up and are replaced by a network of interwoven fibers.

Most often contractures affect the joints important to daily living hips, knees, ankles, wrists and shoulders. So contractures can cause problems with dressing, eating, transferring, sleeping comfortably, using a wheelchair, or doing any tasks that require full joint movement. Problems in any of these areas can decrease a person's independence.

Contractures can occur in anyone whose joints have become immobile. They affect nearly everyone who has a SCI, so everyone with a SCI must stay on the alert for signs of stiffening joints.

Two basic things can help people prevent contractures. First, people need information. If they know what causes contractures, they'll be more likely to know how to prevent them. Second, they must commit themselves to a routine of good self-care. Taking care of your joints includes proper joint positioning and regular joint movement. These movements include regular stretching exercises and daily movements that keep the muscles flexible.

The Secondary Conditions Prevention & Treatment series of booklets was written and produced three times yearly by the Research & Training Center on Independent Living, Dole Human Development Center, 1000 Sunnyside Avenue Room 4089, University of Kansas, Lawrence, KS 66045-7555, Voice: (785) 864-4095, TTY: (785) 864-0706, Fax: (785) 864-5063, email: [RTCIL@ku.edu](mailto:RTCIL@ku.edu).

Supported by a grant from the Education and Training Foundation under the aegis of the Paralyzed Veterans of America.

Staff Director: John Youngbauer

Researchers: Julie Steward, Katherine Froehlich

Editor: Judith Galas

Graphic Designer: Mike Irvin, Ken Golden

Consumer Focus Group: Ashley Wilson, Jeri Johnson, Sandy Etherton, Ranita Wilks, Lorraine Connistra, Barb Lumley, Chip Jewel, Bob Mikesic

Editorial Consultants: Steven E. Brown, Ph.D., Barbara Hall-Key, M.A. Frederick Maynard, M.D. Cheryl Vines, M.A., June Isaacson Kailes, MSW

Guest Consultant: Ien Sie, M.S., P.T.

Notice: This information is intended as a guide only and should not be used in place of consultation with your doctor and Independent Living Center. Contact your ILC for more information on this topic. © 1996 RTC/IL

## **Joint Contractures Preventing a Common Problem**

The clue to understanding joint contractures rests within the smaller word “contract.” Something that contracts can be said to pull up, shorten, or shrink. All of these words relate to the contractures identified in people with spinal cord injuries (SCI).

A contracted joint becomes rigid because the muscles that cross the joint have shortened. This shortening limits a joint's movement. The fluid-filled spaces inside the joint shrink and dry up and are replaced by a network of interwoven fibers.

Most often contractures affect the joints important to daily living hips, knees, ankles, wrists and shoulders. So contractures can cause problems with dressing, eating, transferring, sleeping comfortably, using a wheelchair, or doing any tasks that require full joint movement. Problems in any of these areas can decrease a person's independence.

Contractures can occur in anyone whose joints have become immobile. They affect nearly everyone who has a SCI, so everyone with a SCI must stay on the alert for signs of stiffening joints. Two basic things can help people prevent contractures. First, people need information. If they know what causes contractures, they'll be more likely to know how to prevent them.

Second, they must commit themselves to a routine of good self-care. Taking care of your joints includes proper joint positioning and regular joint movement. These movements include regular stretching exercises and daily movements that keep the muscles flexible. These movements can be done right at home either by yourself or with the daily help of a family member or personal assistant. You don't need to be hospitalized; you don't need drugs or frequent visits to your doctor. Following a daily exercise routine and carefully maintaining proper joint positioning will cost you nothing more than your time.

Occasionally contractures become troublesome enough that people may have to have surgery or to undergo measures such as joint wrapping, splinting or casting to help loosen an immobile joint. But most people with a SCI never look to extreme measures for solutions to contractures.

The information in this booklet will tell you what you need to know to take care of your joints and prevent this common problem from affecting your life.

## **Learning About Contractures**

### **What is a contracture?**

A contracture is a permanent stiffness in a joint that comes from two major causes one outside and one inside the joint. In one case, the muscles and ligaments on the outside of a joint that hold it in place and help it move shorten through disuse. This shortening stiffens the joint and makes it feel tight. Adhesions, or fused tissue inside the joint, also can stiffen it and make it lose flexibility.

In some ways, your joint's movement, fluids, muscles and ligaments can be compared to a door hinge. A working hinge lets a door fully swing open or closed. The door moves smoothly and easily, and regular movement of the hinge helps to ensure that it will keep working. But if the hinge becomes rusted from disuse, the door becomes harder to open and close, and it takes more effort to move the door. If the hinge rusts tight into one position, the door stays in one position.

The soft tissues around and inside a joint that is bent and stretched throughout the day stays flexible just like a well-oiled and freely moving hinge. Through disuse, a joint loses its stretch, and the longer it stays stiff and hard the less likely it will ever move freely again. Like a hinge that is rusted tight, your joint would no longer move.

Contractures tend to occur at the flexors of joints where the joint bends such as at the ankles and wrists. They also are common in the adductor muscles of the shoulders and of the hips. These are the muscles that draw the arms and legs back to the body. They also occur in the abductors, the muscles that draw the arm or leg away from the body's mid-line.

### **Who gets contractures?**

Anyone who stops using a joint or who keeps a joint in one position for a long time can get a contracture. Anyone who has worn an arm or leg cast, for example, can get a contracture in their unmoved joints. People who spend long periods of time in a bed also are strong candidates for contractures. But prolonged bed rest isn't the only culprit.

People who sit still in wheelchairs for long periods of time also can get contractures in their hips, knees and ankles. Improper posture in a wheelchair can lead to upper body contractures in the shoulders and arms.

Among those people who have a SCI, quadriplegics are at a higher risk for contractures than paraplegics, possibly because quadriplegics are less active and less able to move their joints independently. Many also must rely on others to take them through their stretches and passive range-of-motion exercises. They also have more joints in need of passive movement and stretching.

People with paraplegia are able to independently move their wrists, elbows and shoulders, and they use these joints routinely throughout the day. Even though they may be moving their upper bodies, wheelchair users don't have to move their legs. So the muscles and connective tissue in their hips and knees can shorten. Some people with paraplegia, however, are able to use adaptive exercises to move their lower joints.

Joint movement and stretching is especially important for those with a new SCI. People may not realize that the prevention of contractures begins right after their injury. Some may incorrectly assume that if they can't feel or independently move a joint, they don't have to worry about it. Nothing could be further from the truth. Any joint that is not moved through its natural,

full range of motion soon after the injury, and at least once a day after that, will begin to stiffen and a contracture is likely to follow.

Research also shows that people who live in nursing homes are eight times more likely to get contractures than people living at home.<sup>1</sup> Nursing home residents may not have an illness associated with contractures, but they often spend long hours in a bed or wheelchair without moving. Some nursing home attendants think it's easier to care for people if the residents stay in one place. Some nursing homes are short staffed and can't make sure every one stretches and exercises daily. Whatever the cause of this immobility, it can lead to contractures.

### **What causes contractures?**

Several diseases or types of injuries can cause a paralysis or reduced joint movement that can lead to contractures:

- Stroke
- Brain injury
- Spinal cord injury
- Spasticity
- Multiple sclerosis
- Cerebral palsy
- Muscular dystrophy
- Impaired circulation
- Broken bones
- Arthritis

In a broad sense then, contractures develop when an illness or injury or the resulting pain reduces movement of the joints and muscles.

Bed rest may be a common treatment for the sick or injured, but it can also lead to contractures. The inactivity makes muscles weaker and stiffer, and it sets up a vicious cycle. For the longer a person remains still in bed, the more tired and stiff he or she becomes. Because it hurts to use stiff muscles, the person moves even less as a way to avoid discomfort. This inactivity ensures that eventually the muscles will tighten so much that they won't be able to stretch enough to move the joint.

Another cause of contractures is spasticity — that sudden, uncontrolled tightening in a muscle or muscle group. If the spasticity is severe enough, the spasms can make the muscles rigid and force the joints into one position for long periods.

With time, recurring and severe spasticity can change the positions and shape of some muscles and bones. Ankles may turn in, heel cords may shorten and cause severe foot drop, hip and knee joints may tighten and become contracted. Regardless of what causes contractures, one thing remains true: When movement stops, contractures develop.

### **Changes in and around the joint**

You've heard the expression "Use it or lose it." Well, muscles that aren't used lose some of their strength. The muscle fibers literally shrink. It's as if the body is saying, "You aren't using the length of muscle you have, so you must not need all of it." Shortened muscles limit a joint's range of movement.

The shortened muscle also triggers changes inside the joint itself. The spaces between the bones that come together to form the joint are filled with protein-rich fluids and gels that look a

little like egg whites in their thickness and color. When healthy joints move, the movement keeps the fluids circulating through the joint space. The egg-white substance oozes around the bones and lubricates them, keeping them from rubbing against each other.

If the bones in the joint can't move, they can't push and squeeze the fluids and gels around the bones that make up the joint. So, nothing is being lubricated. When the fluid stops moving, it becomes thick and hard. The joint not only freezes outside with its muscles, but inside as well.

## Prevention

Far and away, prevention is the best method for dealing with contractures, and contracture prevention begins the day of the injury.<sup>2</sup> Study after study<sup>3</sup> has shown that people with a new SCI have far fewer complications if they receive proper care in a rehabilitation center skilled in the treatment of SCI rather than in a general hospital. Contractures are one of the complications of SCI that are less likely to occur, or to occur with less severity, if the person is cared for by health care professionals familiar with SCI.

### ROM, stretches and proper positioning

The key elements in any prevention program are range-of-motion movements known simply as ROM and proper positioning. From as early as the 1930s, research has shown that ROM exercises prevent contractures because they take the joint through the fullest range of stretch and movement.

Each joint has its own natural, full range of motion. A healthy shoulder joint, for example, can rotate in a full circle. A healthy wrist joint can rotate in a full circle, but it can also stretch the hand up and down and a little from side to side.

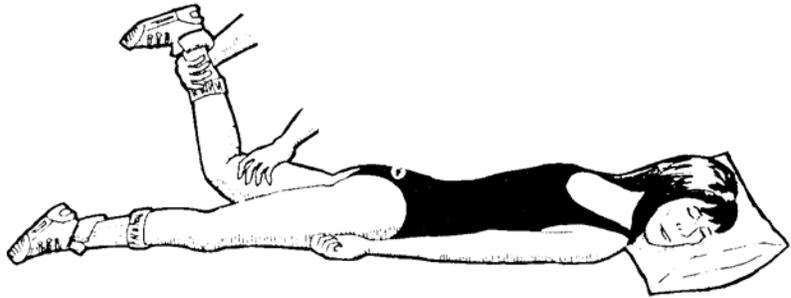
Most people involved in the prevention of contractures recommend daily ROM movements of each joint.

Some people, however, need to go through these joint motions twice or even three times a day. Research hasn't determined what is the ideal amount of ROM movement or the length of stretch for each type of contracture, illness or

person. So people have to select the schedule that lets them keep their muscles and connective tissue supple and their joints flexible. If you see or feel that your joints have less flexibility, increase your exercises.

Ideally, a person with a SCI performs a daily set of movements that include all joints. They also include passive stretches and movements of all the joints and muscles. These exercises are called passive because they are done with the help of another person who moves the limbs and joints that the person cannot move independently.

A typical schedule is one where active and passive ROM exercises are done before breakfast. Sometimes it's convenient to do them in bed before getting dressed for the day. Arm exercises, however, are better done while sitting up so that the elbows and shoulders can move



fully. The routines may be repeated in the afternoon during a rest period, and again right before bed.

Although ROM is good for prevention, a prolonged stretch of moderate tension is the best way to reverse or "treat" a developing contracture. This longer stretch is more effective than the gentle, quick stretch that comes with ROM exercises. For many people the stretch can be even more helpful when combined with heat, such as from a heating pad, warm bath, or a towel soaked in warm water. Take a look at the illustrations in the center of this booklet for some examples of people doing a passive stretch.

ROM movements and stretches are not hard to learn and they are easy to do. Most people benefit from having a physical therapist show them how to perform full stretches and ROM movements. The therapist can show the person with SCI how to do the exercises he or she can do alone and can teach family members or personal assistants passive ROM techniques. The therapist can also show you how to expand your exercise routine to include simple equipment like therobands and elastic straps.

It helps to have an expert show you and your personal assistant how to go through the exercises and stretches. To prevent injury to the muscles, ligaments and joint, it's important to move each joint fully and carefully. Many people use personal assistants to help with their exercise routines, so a well-trained assistant is a strong plus in the prevention of contractures.

Sometimes viewing a video with the person who will help you with your stretches and passive ROM exercises will give you both confidence that these movements are being done correctly.

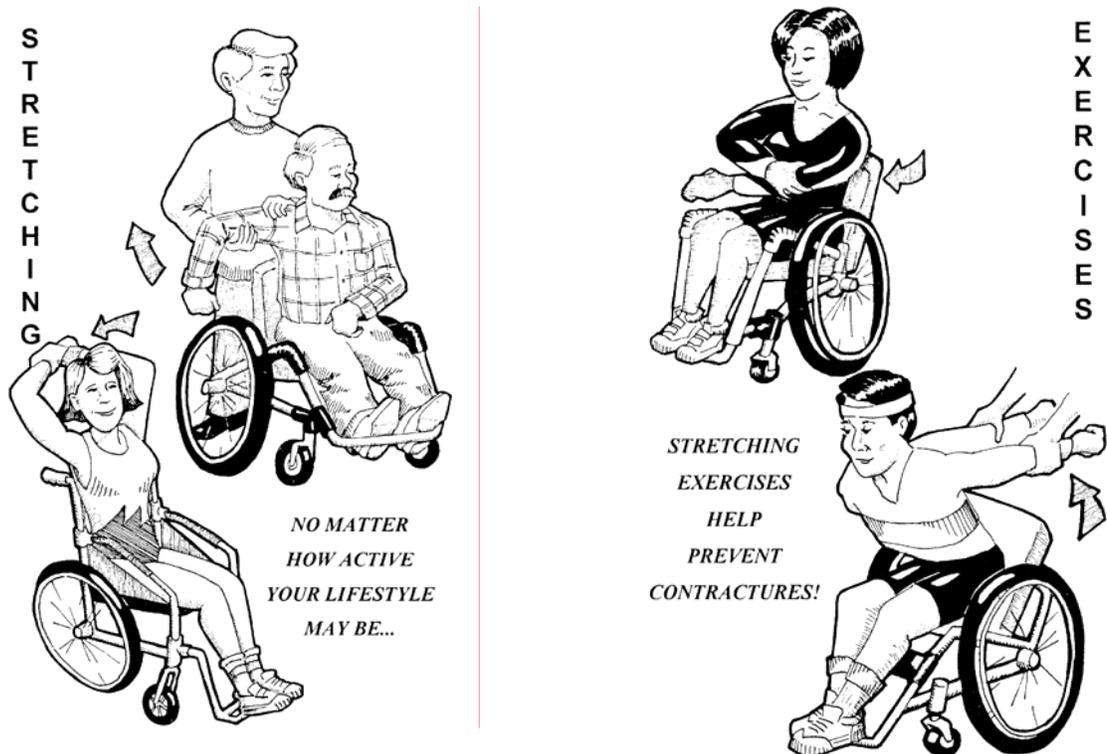
### **Joint assessment**

When you meet with the therapist, he or she will examine each joint and determine the amount of stretch each can tolerate. During the assessment the therapist will measure each joint's range-of-motion movement.. The therapist looks at how far and in what direction a joint can bend or be bent. Then she or he compares that movement with that of a healthy joint. The therapist then decides if the joint's movement is less than it should be and if it indicates a contracture.

Once you know how much each of your joints can and should move each day, you can perform or instruct someone else to perform your ROM movements so they most fully and safely move each joint. In addition to the important ROM exercises, here are additional things you can do to keep your joints supple:

- Pay attention to proper posture when sitting in a wheelchair or propelling it. Poor posture affects the shoulder joints.
- Prolonged sitting can cause hip flexion and knee flexion contractures. If possible, lie prone on your stomach when resting during the day or at night to stretch out the hip flexors. This posture will also stretch and extend your knee joints.
- To help your posture, use a proper back support in your chair and adjust or replace stretched-out wheelchair upholstery. A physical therapist can help you select the right type of back support.
- When resting or sleeping, make sure your joints are properly positioned. Good positioning provides an equal stretch to the muscles around the joints.
- If spasticity is a problem, include weight-bearing exercises that strengthen the muscles opposing your tight spastic muscles.

- Be especially careful when stretching or exercising parts of the body in which you



have limited or no sensation.

- People who use wheelchairs sit all day with their knees flexed. When possible put your feet up during the day to stretch and extend your knees. Pay special attention to your knees when doing your stretches and consider more frequent ROM knee exercises during the day and lying prone at night.
- If your arms stay motionless on your chair's armrests, give them extra attention during your ROM routines.
- Pay attention to your skin. Signs of skin breakdown redness or broken skin offer clues to areas of the body that are not moving often enough.
- Maintain good blood flow to your arms and legs. Wear loose-fitting clothes. Don't let chair edges press against the backs of your knees or catheter leg-bag bands constrict your legs. You can make an exception for TED hose. TED hose are tight fitting and they may restrict joint bending. But they help improve circulation and their use is not linked to contractures.
- Don't just stop moving if your joints hurt. Bed rest or inactivity may not be the best way to handle joint pain.<sup>4</sup> If you have joint pain, check with your doctor to be sure you don't have a problem that needs treating. If you don't, carefully continue your ROM exercises.
- Commit yourself to a daily routine of exercise and passive stretches throughout your life.
- Remember, however, to be reasonable in the amount of stretching you do each day. Some stiff joints may simply need some gentle loosening up, rather than prolonged and extended stretches. Take care not to injure yourself.

## **Prevention is critical**

The need for prevention goes beyond just keeping the joints flexible. Contracted joints can lead to other serious complications. They may cause pain, leg swellings, circulation problems, pressure sores, even fractures of the joints or bones.

Just as important, contractures can affect a person's daily routine. For example, contractures can make it harder to manage personal hygiene. People who can't transfer because of contractures may not be able to toilet themselves. Those with quadriplegia may get contractures that pull their hands into a ball and make it almost impossible for them to feed themselves or write.

Positioning and seating may become more difficult and leave a person in danger of falling out of his or her chair. Transfers to and from the bed, wheelchair and car may also become difficult. Contractures in both the hips and knees may make it necessary for two people to assist with a transfer instead of just one, so transferring becomes more inconvenient. In short, contractures can alter a person's life.

## **Extra Measures**

Contractures are serious health care issues. If they occur, several things can be tried to stop further changes in the joint and to reverse greater shortening of the muscle. Proper positioning, casting and splinting and physical therapy are essential.<sup>5</sup> You may want to discuss these options with your doctor or physical therapist.

For mild contracture, a sustained stretch lasting 20 to 30 minutes may be enough.<sup>6</sup> Prolonged stretches of 30 minutes or more combined with correct positioning are necessary for severe contractures. Serial casting or dynamic splinting is used for sustained stretches that last a few days. These procedures are repeated over time until the joint's range of motion approaches normal levels.

## **Serial casting**

In serial casting, the therapist applies plaster or a type of plastic bandage being careful to pad the areas where the bone is near the surface. The joint is heated, using moist heat, and manually stretched to obtain maximum ROM. The cast is left on for two to seven days depending on the treatment; then it's removed so the skin can be checked for pressure sores. The cast is then reapplied in a new position of greater stretch for several days more until the contracture eases enough to permit sufficient ROM. During a serial casting, care must be taken to avoid pressure sores. Physical therapy must also be used to make sure the muscles not being stretched are strengthened after their period of disuse.

## **Splinting**

Dynamic splinting is another way to obtain a repeated stretch. In this method a spring or elastic band provides some pull and tension to get the joint to move in the desired direction. Splinting is often used on hands, wrists and arms because it allows some movement as it attempts to loosen the joint. The splints can be repositioned to gradually get a greater degree of stretch.

Long periods of casting or splinting, however, may have some drawbacks. Although they stretch the shortened muscle, these techniques can cause loss of ROM in the opposite direction because they hold the joint in a forced position for long periods.<sup>7</sup> The soft tissue may also

become stiff or brittle, and these changes can cause tearing and pain. These drawbacks make it necessary to combine physical therapy with these treatments.

### **Proper positioning**

Proper positioning of the joints while a person is in bed or seated in a wheelchair also can prevent contractures. Be sure your mattress is right for you. Some people need a firm mattress to keep their joints in proper alignment. Others must sleep on a water, low pressure or air circulation mattress to prevent pressure sores. Just be sure your body is positioned so that your joints are not bent out of alignment while you sleep. Pillows, padded rolls, and hand and foot splints and braces can be used to hold the shoulder, elbow, hand, ankle and knee joints at the point where they are fully extended.

### **Strengthening exercise**

Restoring muscle strength also is a part of treating contractures. A strong muscle moves more easily. An unused muscle quickly weakens. A muscle that hasn't been used will lose 10 to 15 percent of its strength each week. After three to five weeks of immobility, a person will lose half of his or her strength.<sup>8</sup> Once contractures set in, it may be almost impossible to revive the muscle again.

Regularly scheduled exercise is one of the best ways to strengthen the joint. Electrical stimulation also can promote strengthening of specific affected muscles. Once the contracture has been treated, the person must work to eliminate any poor postures or movement habits, to increase his or her strength through exercise, and to regularly use the joint. This combination of treatment, strengthening, and exercise and use will prevent recurring contractures.

### **Surgery**

Depending on the severity of the contracture and how long it has existed, surgery may be necessary.<sup>9</sup> Joint capsules the membranes and tissue surrounding the joint may need to be released. Tendons may need to be lengthened. Contractures left untreated can eventually lead to changes around the involved joint, including joint fusion or ankylosis, a condition in which the bones merge and form a single unit.

The goal of surgery on the muscles and tendons is to enable them to establish a new length that lets the joint resume a natural resting position. However, while surgery can lengthen the ends of the tendon, it can't lengthen the thickest part of the muscle, which will stay short forever. So surgery may not restore full active ROM<sup>10</sup>.

Some surgeons also have found that the muscles and tendons develop scar tissue along the cut. This tissue restricts the tendon's stretch and may need to be surgically removed again.<sup>11</sup> Overall, surgery does not offer a permanent or satisfactory solution. It also won't keep more contractures from developing if an exercise program is not followed after surgery.

Most often, surgery is a last resort. Physical therapy and the less invasive methods mentioned most often are tried first.

## **Some Final Thoughts**

### **Nursing home care**

Many people who have a SCI may spend some or a great deal of time in a nursing home. This may be especially true among older people with SCI. It's important to remember that residents of nursing homes are more likely to have contractures. In some cases this is because

people who enter nursing homes already are less independent than the average person who uses a wheelchair. Some may have moved to nursing homes because their contractures kept them from living independently.

But nursing home routines and sometimes the level of care may encourage contractures to develop. Some homes enforce long periods of staying in bed or sitting in a chair. Given that people with SCI are likely to have contractures, a move to a nursing home should be considered carefully. If you or a member of your family who has contractures plans to move to a nursing home, discuss contracture prevention with the home's nursing personnel.

Set up a daily routine of ROM movements with the home's nursing staff trained in restorative exercise or with a family member. Be sure you or your family member participates in the home's daily exercise program, and try to maintain as many personal care routines as possible.

Keep alert to any sign of pressure sores, because they are linked to contractures and immobility.<sup>12</sup> About one-quarter of the people in skilled care or nursing home facilities have pressure ulcers, with even higher rates for those in the high-risk groups, such as people with SCI and those who smoke.

For some people, nursing home care has been replaced by home-based and this trend is growing and more and more communities expand their home care services. Programs such as visiting nurses, homemaker services and personal assistant services make it easier for people with SCI to remain in their own homes. If you're thinking about nursing home care, check with your closest ILC Office on Aging or county offices to find out about the home-care services in your area.

### **Staying informed**

Today we have more information than ever on what causes contractures and how to prevent them. As recently as 10 years ago, little information was available; and there was little to no data on the incidence of contractures in those with a SCI.<sup>13</sup> More has been written on contractures and SCI, but the condition still is not as well researched as spasticity or urinary tract infections, for example.

Researchers are still studying whether obesity contributes to the development of contractures. Some think it does, especially in the hips. Some research suggests that some people, because of heredity or their physical make up, are more susceptible to getting contractures. And research may one day be able to tell us what amount of ROM movement is most beneficial and what length of stretch.

Remember to ask your health care professionals, the staff at your independent living center and others with SCI if they have learned any new information about contractures. Sometimes your own experiences will be the best teacher, so be sure to share what works for you with others.

While researchers continue to learn more about contractures, two things remain certain: Contractures can be prevented and daily exercise and stretching remain the key to prevention.

## **Glossary**

**Abductor** (ab-duct'-or): A muscle that draws the limbs away from the body's head-to-toe midline.

**Adductor** (ad-dukt'-or): A muscle that draws the limbs toward the body's head-to-toe midline.

**Ankylosis** (ang-ke-lo'-sis): The consolidation or merging of bones or their parts to form a single unit.

**Contracture** (con-trak'chur): A tightness of tissue around the joints and in muscle that limits movements and function.

**Extensor** (ik-sten'ser): A muscle that extends or stretches a joint.

**Flexor** (flek'-ser): A muscle that acts to flex or bend a joint.

**Joint capsule:** The membrane and tissue that creates an envelope or sac around the joint.

**Pressure sore:** Areas of skin or soft tissue damage caused by excessive or long-term pressure on the skin. The pressure cuts off the blood supply to the skin, killing the tissue's cells.

**Quadriplegia** (kwod'-re-ple-jah) Damage or loss of movement and feeling caused by disease or injury to the nerves located in the neck that results in complete paralysis from the neck down. This term is sometimes replaced by the term tetraplegia.

**Range of motion:** The movements that move and stretch a joint through the fullest range of movement of which the joint is capable.

**ROM:** The abbreviation for the term "range of motion."

**Spasm** (spaz'-em): A sudden, uncontrolled tightening or contraction of a muscle or group of muscles.

**Spasticity** (spa-stis'-e-tee): A condition of the nervous system characterized by exaggerated reflexes, increased muscle tone and involuntary jerking movements of muscles.

**Tetraplegia** (tet'-re-plee-jah): The term means the same as quadriplegia and is appearing more often in information about SCI.

## References

- 1, 5, 12 Contractures and Loss of Function in Patients with Alzheimer's Disease. *Journal of the American Geriatrics Society*, 43, 1995, Lidu-n E.M. Souren, Emile H. Franssen and Barry Reisberg.
- 2 *Spinal Cord Injury: Clinical Outcomes from the Model Systems*, Stover, Delich, Maynard. Gaithersburg, Maryland: Aspen Publishers.
- 3, 13 Contractures Complicating Spinal Cord Injury: Incidence and Comparison between Spinal Cord Centre and General Hospital Acute Care. *Paraplegia* 32, 1985, Gary M. Yarkony, et. al.
- 4 Pain Assessment: An Interdisciplinary Perspective. *Home Healthcare Nurse*, Vol. 7, No. 6, Kent Nelson Tigges and William Matthew.
- 6, 8, 10 Contracture and Other Deleterious Effects of Immobility, by Eugen M. Halar and Kathleen R. Bell, in *Rehabilitation Medicine: Principles and Practice*. Lippincott, Philadelphia, 1993.
- 7 Static Progressive Stretch to Reestablish Elbow Range of Motion. *Clinical Orthopaedics and Related Research*, No. 303, 1994, Peter M. Bonutti, et. al.
- 9, 11 Muscle Release in the Management of Spasticity in Spinal Cord Injury. *Paraplegia* 28, 1990, I. Eltorai and R. Montroy.