

# Exercise in Spinal Cord Injury

## Recommendations and Special Considerations



Charles-David Clayton, Lee Bauer, Jordan Friedmann, Michael McGregor

January 2017



a place of mind  
THE UNIVERSITY OF BRITISH COLUMBIA  
Faculty of Medicine



University  
of Victoria

let's talk  
science

# Disclosures

We have no conflicts of interest or financial disclosures

Although some of this content overlaps with the UBC MDUP Yr 1 curriculum, this presentation is entirely supplementary to the curricular material and no exam questions will be generated from this presentation

We are not experts in this field. This presentation is intended to provide a brief overview of the physical activity recommendations and considerations for persons with SCI

# Objectives

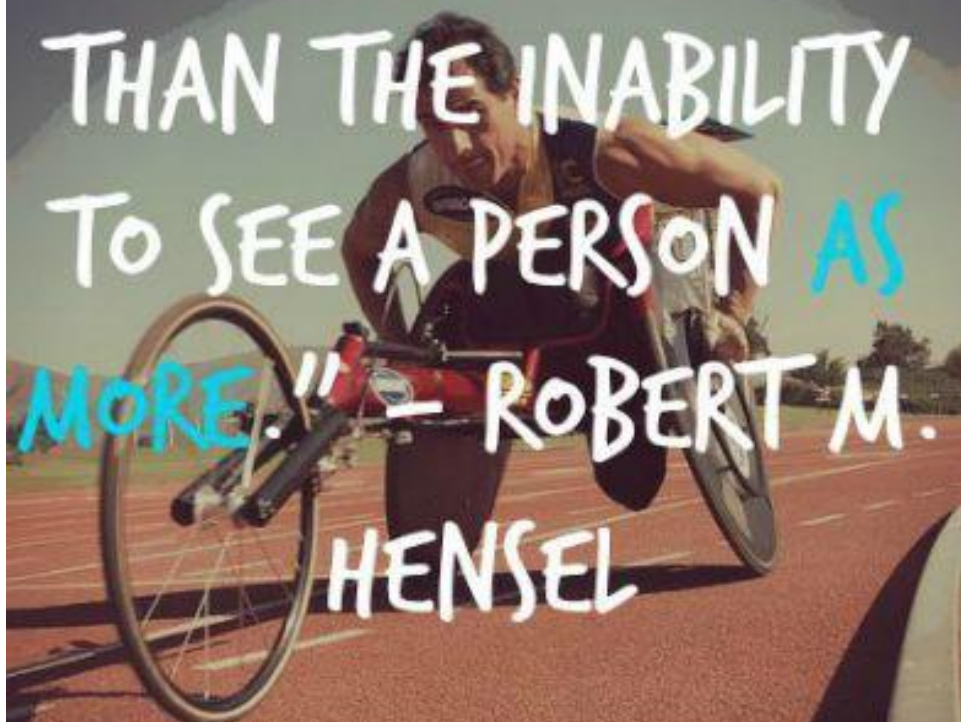
1. Briefly overview the epidemiology and etiology of spinal cord injury (SCI)
2. Overview of the nervous system and terms used to describe SCI
3. Discuss some of the health related consequences for persons with SCI
4. Discuss the use of physical activity in SCI
5. Discuss the current physical activity recommendations for persons with SCI
6. Discuss the special considerations and risks of physical activity for persons with SCI
7. Exercise referral and resources for more information

**“IT’S NOT OUR DISABILITIES, IT’S OUR ABILITIES  
THAT COUNT.”**

**CHRIS BURKE**

 **Lifehack Quotes**

THERE IS NO GREATER  
DISABILITY IN SOCIETY,  
THAN THE INABILITY  
TO SEE A PERSON AS  
MORE." — ROBERT M.  
HENSEL

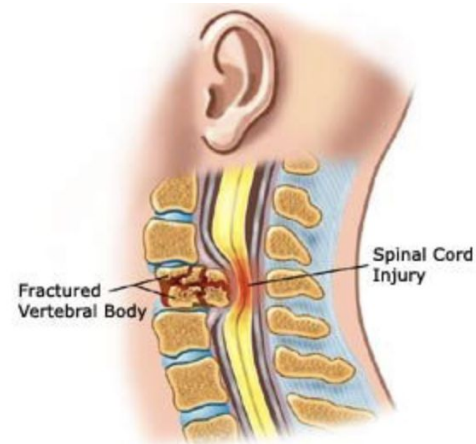
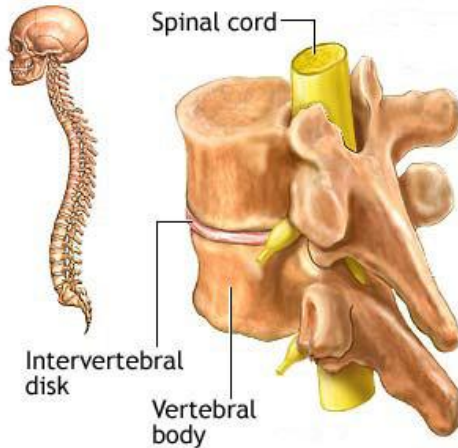


# Epidemiology and Etiology of Spinal Cord Injury (SCI)

## SCI Prevalence in Canada (McMaster University, 2011)

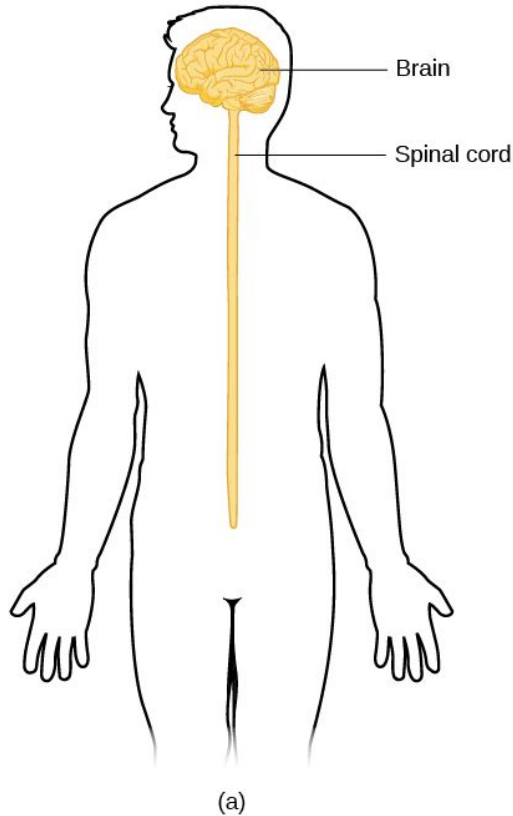
~86,000 individuals with SCI

~44,000 resulted from **traumatic** cause

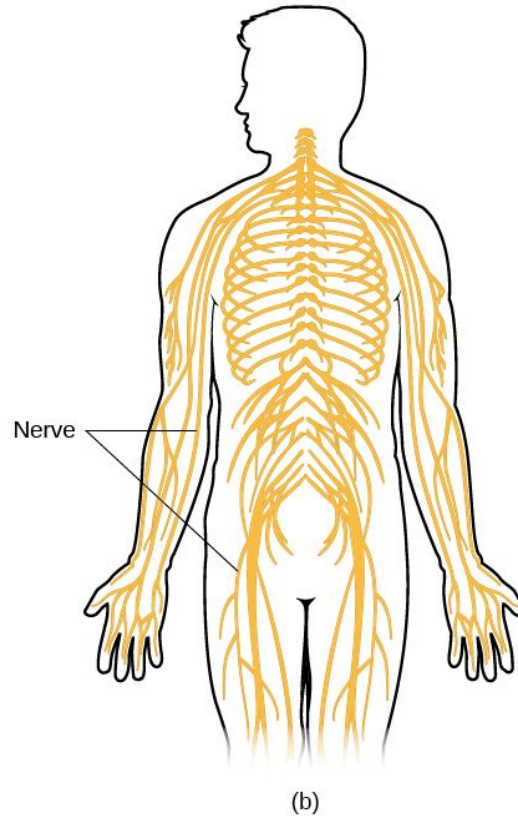


# Organization of the Nervous System

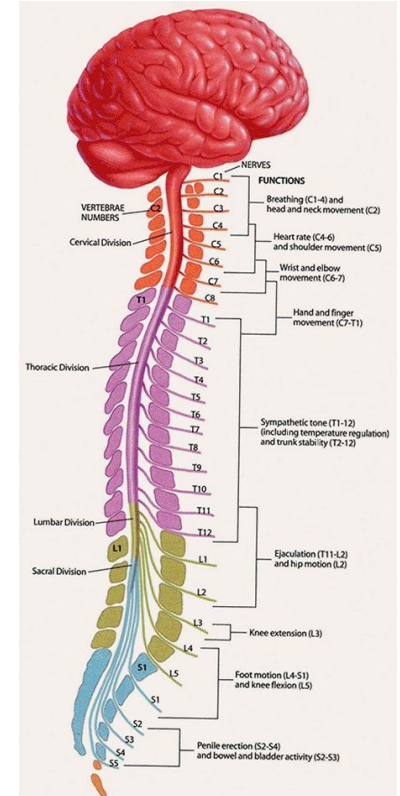
Central Nervous System



Peripheral Nervous System



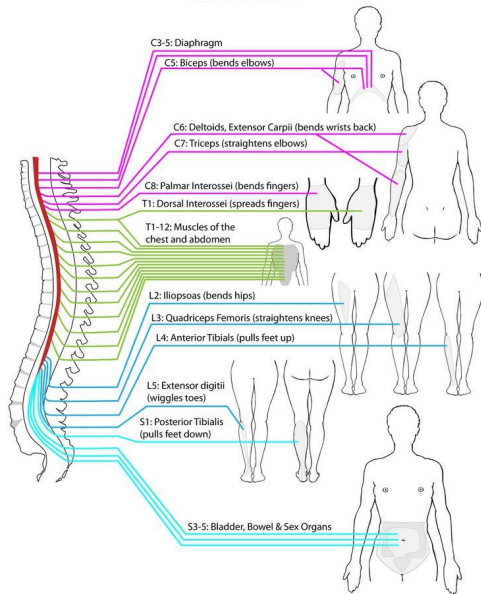
Spinal Levels



# Functions of the Spinal Cord

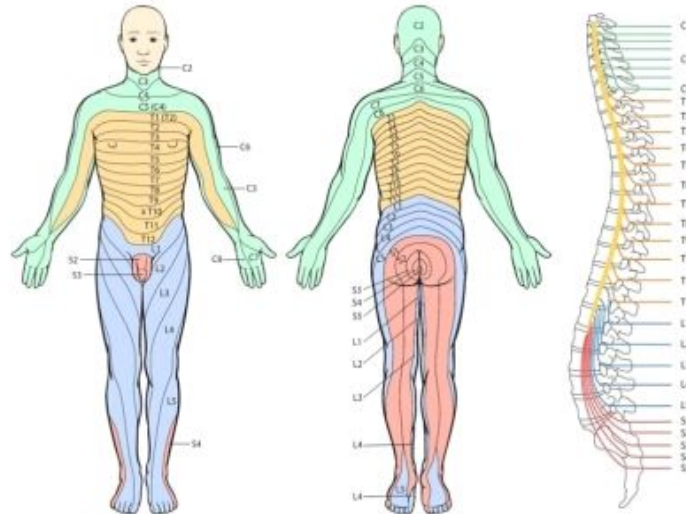
## Motor

Muscle function, tone and bulk



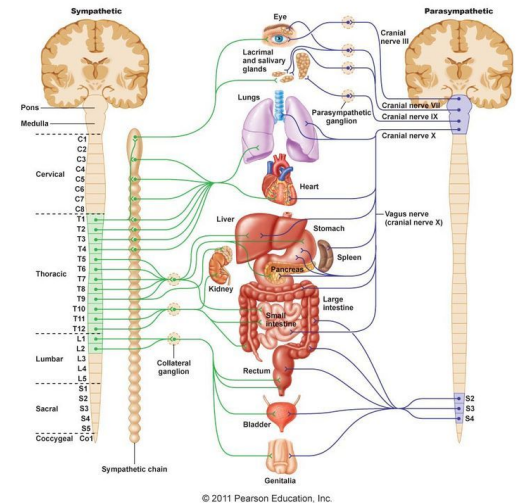
## Sensory

Touch, pain, temperature, vibration, proprioception



## Autonomic

Parasympathetic & Sympathetic





**FUNCTIONS**

- Breathing (C1-6) and heart and blood movement (C2)
- Heart rate (C4-6) and bladder movement (S3)
- Hair tone (C4-6) and movement (C6-7)
- Hand and finger movement (C7-T1)
- Sympathetic tone (T1-12) including temperature regulation and heart rate (T1-12)
- Ejaculation (T11-12) and hip extension (S1-2)
- Knee extension (S1)
- Foot movement (S4-S5) and hip flexion (S1-2)
- Pelvic movement (S4-5) and bowel and bladder activity (S3-S5)

# MYOTOMES

The diagram illustrates the myotomes of the human body, organized into 13 segments. Each segment is represented by a colored line that branches out to show the muscles and actions associated with that segment. The segments are labeled as follows:

- C3-5: Diaphragm**
- C5: Brings (bends elbow)**
- C6: Deltoideus, Extensor Carpi (Bends wrist back)**
- C7: Flexes (straightens elbow)**
- C8: Flexor Interossei (bends finger)**
- T1: Dorsal Interossei (spreads finger)**
- T1-12: Muscles of the chest and abdomen**
- L2: Slopates (bends hips)**
- L3: Quadriceps Femoris (straightens knees)**
- L4: Anterior Tibialis (pulls feet up)**
- L5: Extensor digiti (raises foot)**
- S1: Posterior Tibialis (pulls feet down)**
- S3-5: Bladder, Bowel & Sex Organs**

**Acute Spinal Cord Injury**

Quadruplegia (loss of movement and sensation in all four limbs)

Paraplegia (loss of movement and sensation in the lower half of the body)

The diagram illustrates the human spine with color-coded regions indicating the extent of paralysis. A purple band at the top represents the brain and cervical spine, leading to quadruplegia. An orange band represents the thoracic and lumbar spine, leading to paraplegia. A green band at the bottom represents the sacral region. To the right, two human figures illustrate the effects: the top figure is entirely blue, representing total paralysis (quadruplegia), and the bottom figure is white with blue legs, representing partial paralysis (paraplegia).

The diagram illustrates the human nervous system and its functional components. On the left, a human figure shows the distribution of the nervous system. The **Central Nervous System (CNS)** is located in the brain and spinal cord. The **Peripheral Nervous System (PNS)** consists of all other neural tissue. A flowchart on the right details the functional flow:

- 1. Information processing:** Includes the integration and distribution of information in the CNS.
- 2. The motor division of the PNS:** Carries motor commands from the CNS to peripheral tissues and systems. It includes:
  - Somatic nervous system (SNS):** Controls voluntary movements of skeletal muscle contractions.
  - Autonomic nervous system (ANS):** Controls involuntary functions, including smooth muscle, cardiac muscle, glands, and adipose tissue.
- Sensory division of the PNS:** Brings information to the CNS from receptors in peripheral tissues and organs. This includes:
  - Somatic sensory receptors:** Provide position, touch, pressure, pain, and temperature sensations.
  - Special sensory receptors:** Provide sensations of smell, taste, vision, balance, and hearing.
  - Visceral sensory receptors:** Monitor internal organs.
- Effectors:** Are target organs whose activities change in response to neural commands. Examples include skeletal muscle, smooth muscle, cardiac muscle, glands, and adipose tissue.

A red arrow labeled "Start" points to the "Receptors" box, indicating the beginning of the neural pathway.

**Corticospinal tract**

The diagram illustrates the corticospinal tract, a major pathway for motor control. It begins in the brain, where the **upper motor neuron** originates. The tract descends through the brainstem and spinal cord. Key features shown include the **Decussation of pyramid** (crossing of the pyramids) and the division into the **Lateral corticospinal tract** and the **Anterior corticospinal tract**. The tract terminates at the **Lower motor neuron**, which innervates the muscles.

[illegible]

**THE TRACTS OF THE SPINAL CORD**  
 Ascending tracts in blue, descending tracts in red.

**Ascending Tracts (Blue):**

- Fasciculus gracilis:** Proprioception, fine touch, vibration from the legs.
- Fasciculus cuneatus:** Proprioception, fine touch, vibration from the arms.
- Posterior spinocerebellar tract:** Proprioception.
- Lateral spinothalamic tract:** Pain and temperature.
- Anterior spinocerebellar tract:** Proprioception.
- Spinocerebellar tract:** Proprioception.
- Spinotactile tract:** Spinothalamic reflex.
- Anterior spinothalamic tract:** Pain.

**Descending Tracts (Red):**

- Interfascicular fasciculus:** Short posterior spinal reflex arc.
- Septomarginal fasciculus:** Short posterior spinal reflex arc.
- Lateral corticospinal tract:** Fine motor control, upper limbs.
- Robustospinal tract:** Rigid, rapid flexion of arms (responsible for deceleration/posturing).
- Lateral reticulospinal tract:** Postural motor control.
- Anterior reticulospinal tract:** Gross motor control.
- Anterior reticulospinal tract:** Postural motor control.
- Tectospinal tract:** Coordinates reflexes postural head and eye movements.
- Mediolateral tract:** Postural motor control.

# Questions to consider in SCI

- What level is the lesion?
- How severe is the lesion?



# What level is the lesion?

## Tetraplegia (Quadriplegia):

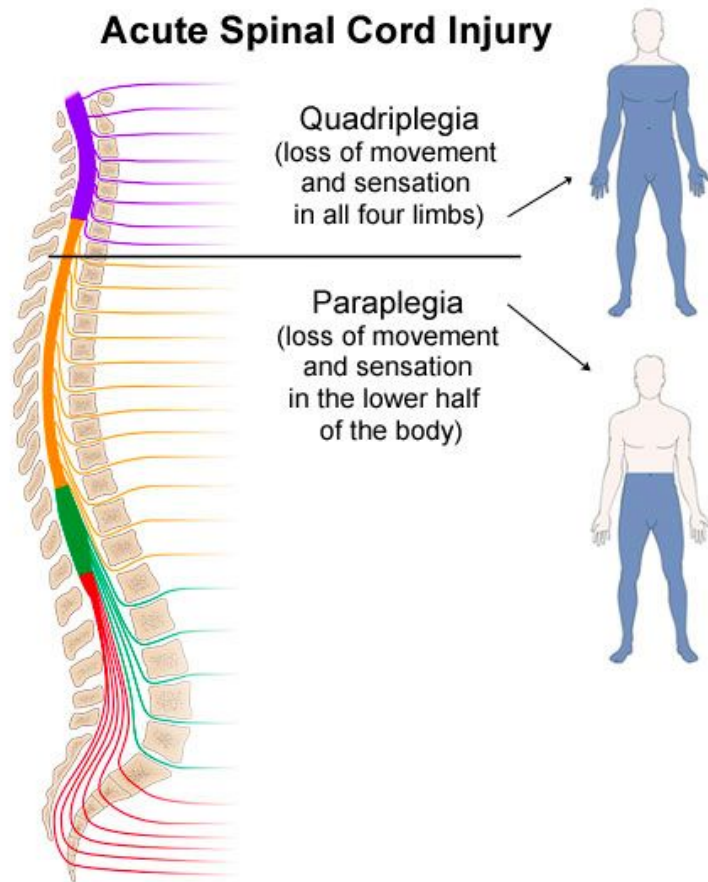
*“impairment or loss of motor and/or sensory function in the **cervical segments** of the spinal cord”*

## Paraplegia:

*“impairment or loss of motor and/or sensory function in the **thoracic, lumbar or sacral (but not cervical)** segments of the spinal cord.”*

**= OVERSIMPLIFICATION**

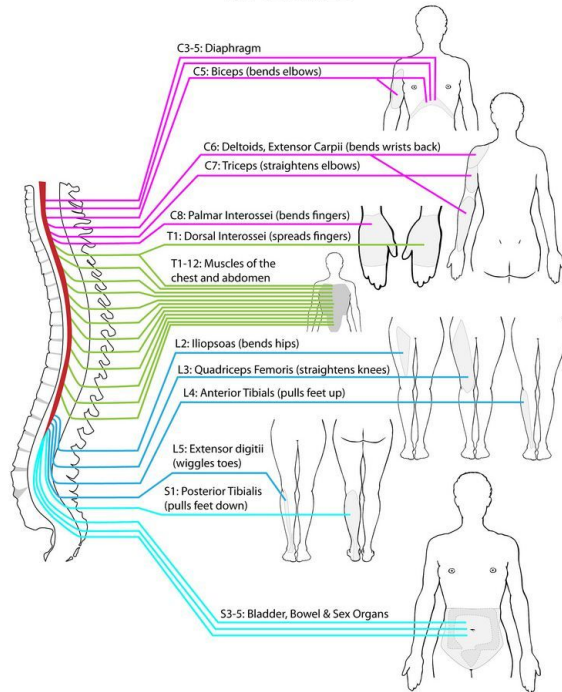
## Acute Spinal Cord Injury



# What is the level of the lesion?

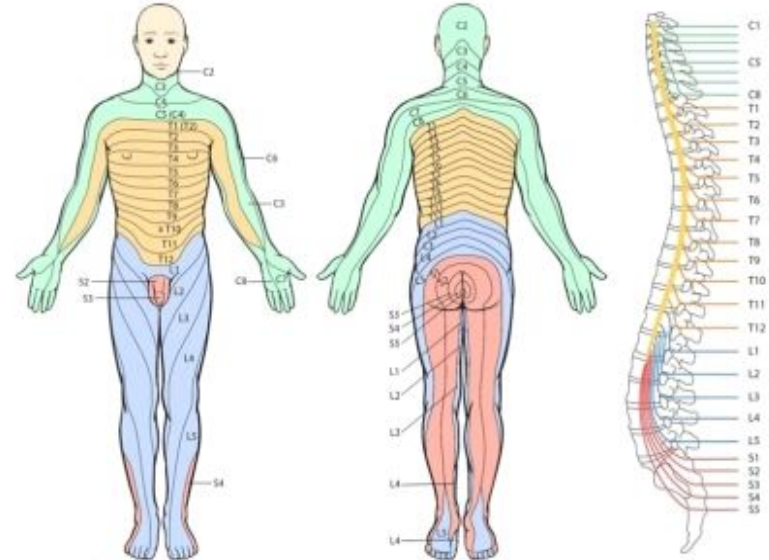
## Motor Level (Myotome)

Normal level of muscle function, tone and bulk



## Sensory Level (Dermatome)

Normal level of touch, pain, temperature, vibration, proprioception



# Autonomic Level

## Parasympathetic

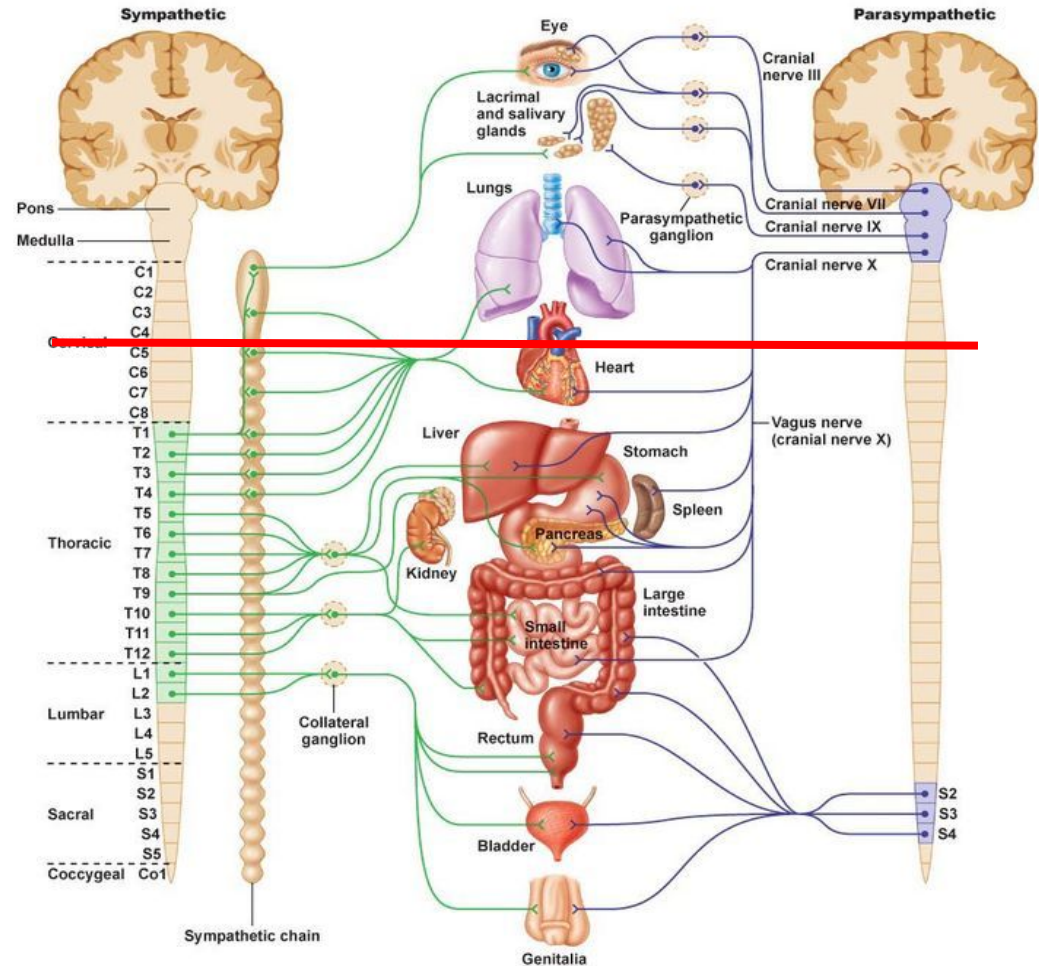
- CNs III, VII, IX, X
- S2-S4

VS.

## Sympathetic

- T1-L2

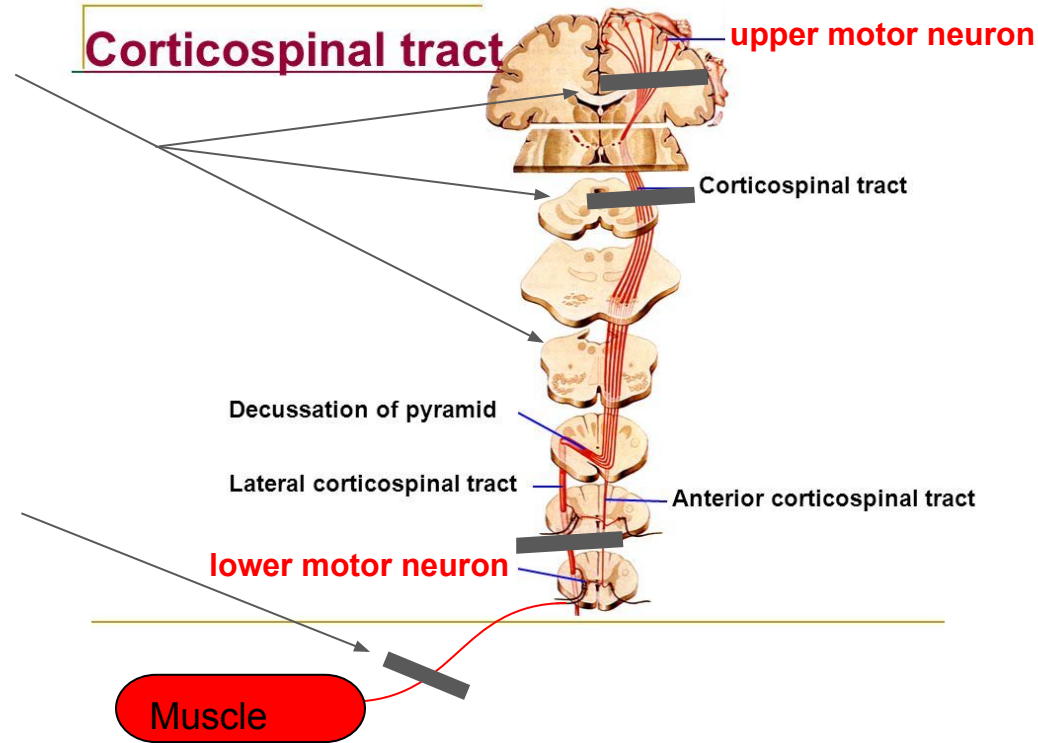
Life Threatening: **Neurogenic Shock**



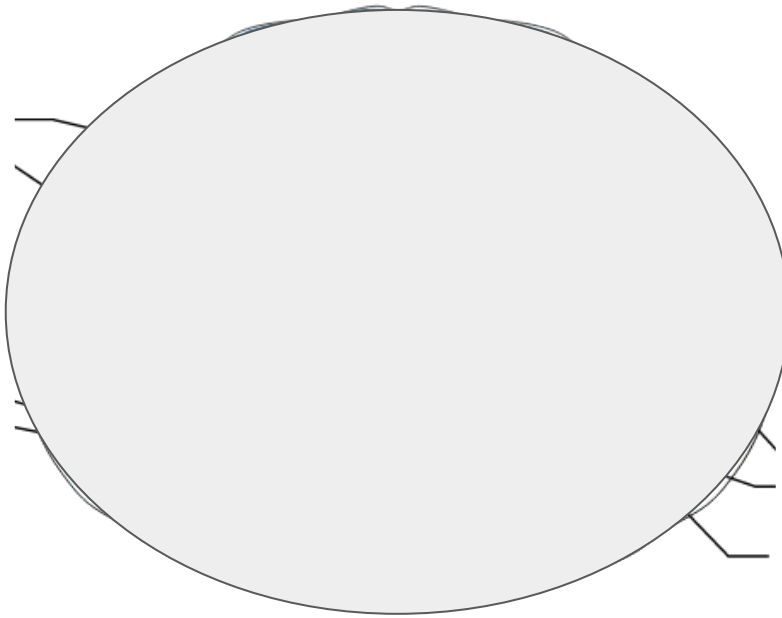


# Clinical findings: Where is the lesion in the CNS?

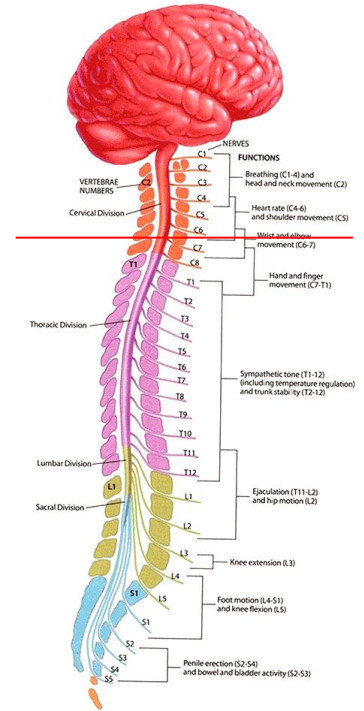
- **UMN signs:** Hyperreflexia, hypertonia, mild weakness, grossly normal muscle bulk, rigidity, Babinski sign, pronator drift
- **LMN signs:** hyporeflexia/areflexia, hypotonia, severe weakness, muscle atrophy, absent Babinski's sign



# Where is the Lesion within the Spinal Cord?



Complete SCIs present as LMN lesions at the spinal level of the injury, and as UMN lesions below the level of the injury



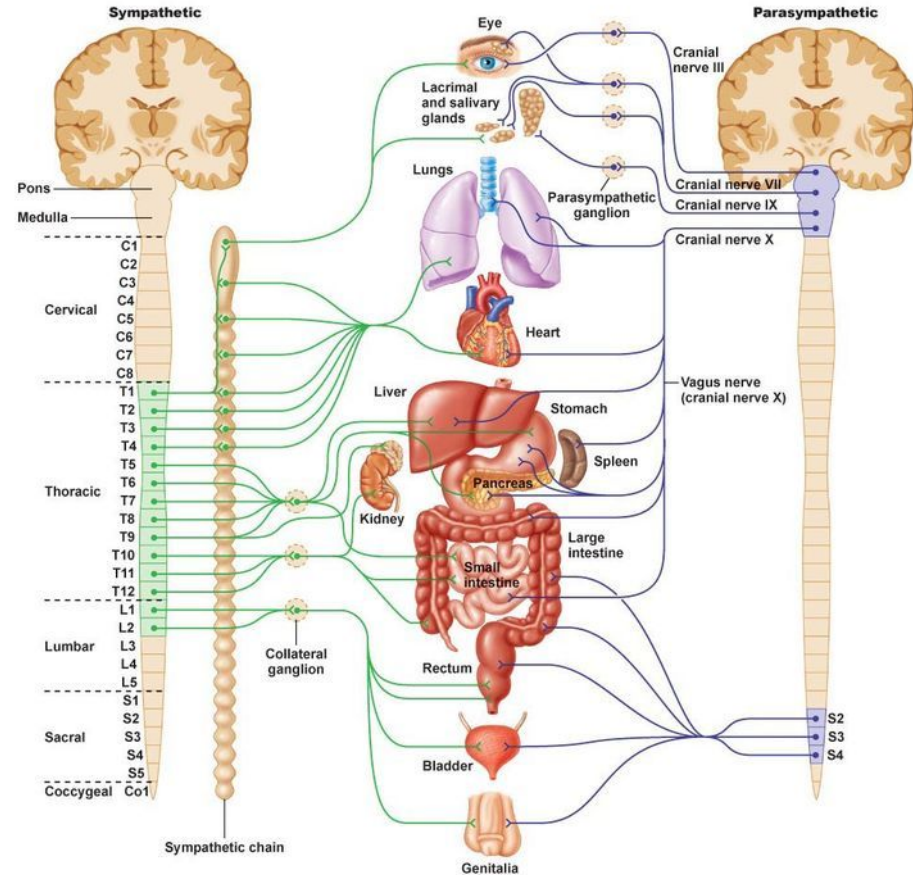
# Major Considerations in SCI

Motor level

Sensory level

## Autonomic function

- Parasympathetic (S2-S4)
- Sympathetic (T1-L2)





# Health Considerations Beyond Paralysis

1. Physical deconditioning
2. Musculoskeletal changes
3. Autonomic dysregulation
4. Cardiovascular dysfunction
5. Impaired thermoregulation
6. Burden of chronic disease
7. Depression and anxiety

SCI can le



conclu  
than 8  
physic

**Exercise is medicine**



ow smoking”

hour of moderate to  
physical activity per day!

# SCI alters the musculoskeletal system

Skeletal muscle below the lesion → **atrophy**

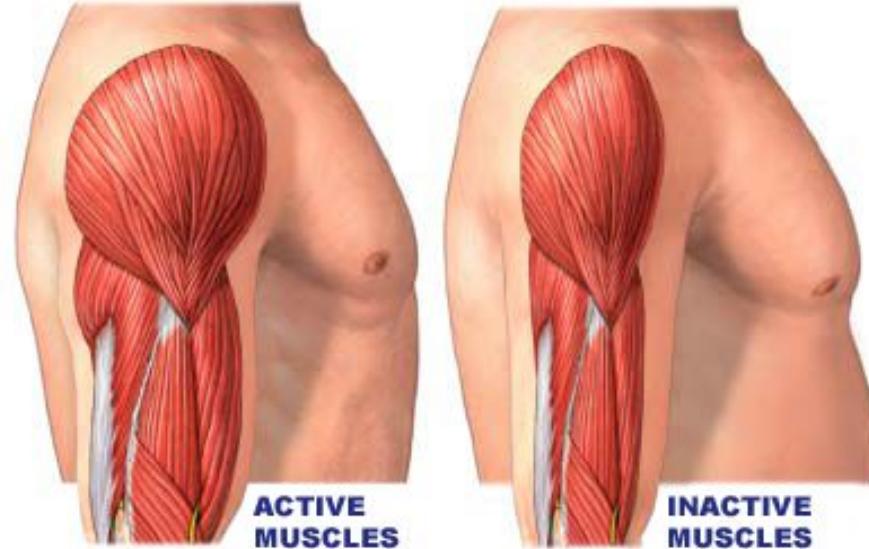
- LMN vs. UMN lesion
- Early rehabilitation and physiotherapy is important!

## Spasticity and contractures

- Hyperreflexic muscles can cause contractures  
→ can impair function and mobility
- Stretching and range of motion very important!

Bone resorption and loss of bone density  
→ **osteopenia and osteoporosis.**

- Risk of **fracture**



“Use it or lose it” phenomenon

# SCI can result in **sympathetic** ANS dysregulation

Recall: UMN lesions cause hyperreflexia, while LMN lesions cause areflexia.

This applies to autonomic neurons as well!

**Tetraplegia** → loss of central command over all sympathetic nervous system functions.

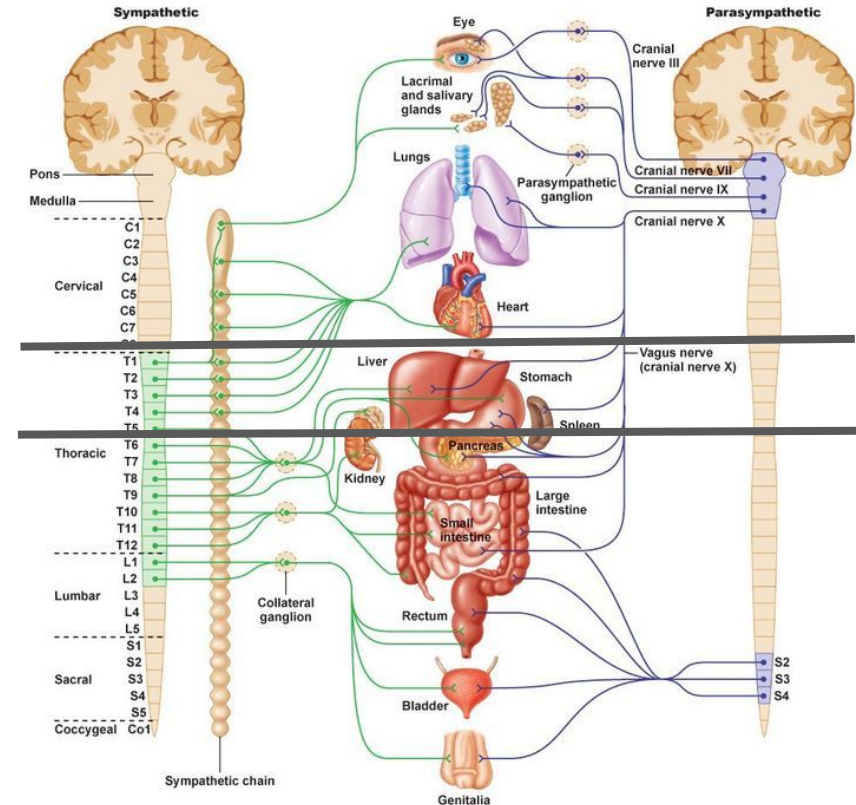
- Blunted heart rate response to exercise
- Blunted or absent catecholamine response
- Lack of sweating response below the level of the lesion

**Paraplegia** → partial loss of sympathetic function

- Reduced catecholamine, vasomotor, and sweating responses to exercise.

## **Autonomic hyperreflexia**

- Complete lesions above T6 = lack of control over sympathetic input to adrenal medulla.
- Noxious stimuli can result in sympathetic overactivation
- **Can be life-threatening**



# SCI can result in **parasympathetic** ANS dysregulation

Recall: UMN lesions cause hyperreflexia, while LMN lesions cause areflexia.

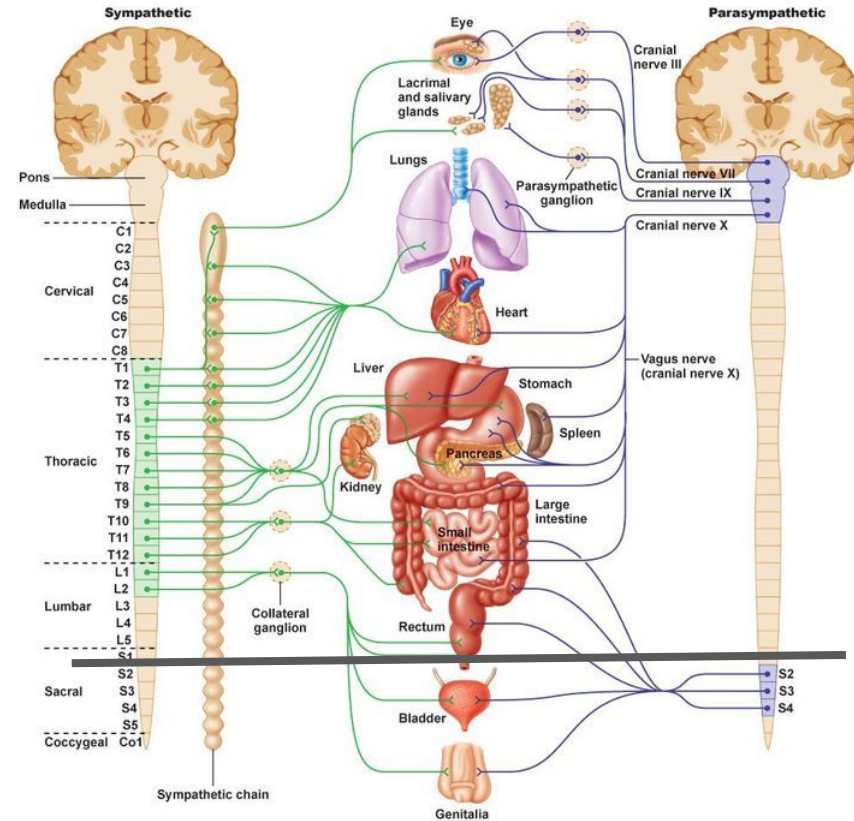
This applies to autonomic neurons as well!

## Neurogenic bladder dysfunction

- Incontinence, urinary retention

## Neurogenic bowel dysfunction

- Dysmotility, constipation, incontinence

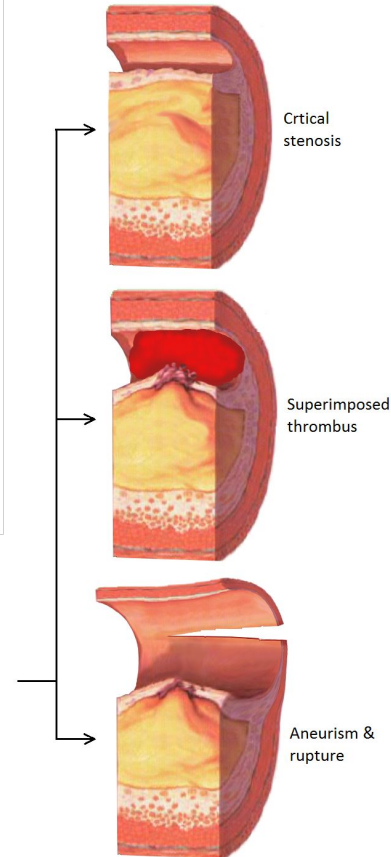
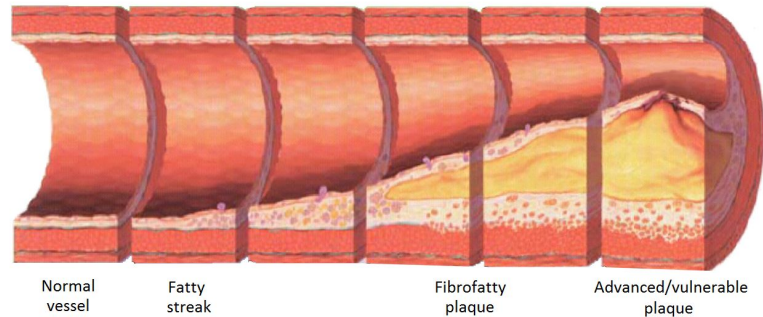


# SCI causes alterations in the arterial vasculature

Autonomic dysregulation: hypotension and orthostatic drop contribute to difficulty exercising, falls.

People with spinal cord injury have a high risk of atherosclerotic cardiovascular disease (CVD).

- CVD is now the most frequent cause of death in individuals with paraplegia, accounting for 46% of deaths in individuals over 30 years of age.
- Traditional risk factors, including **diabetes**
- **Chronic sedentary behavior**
- **Physical activity prevents and treats CVD!**





# SCI causes alterations in the venous vasculature

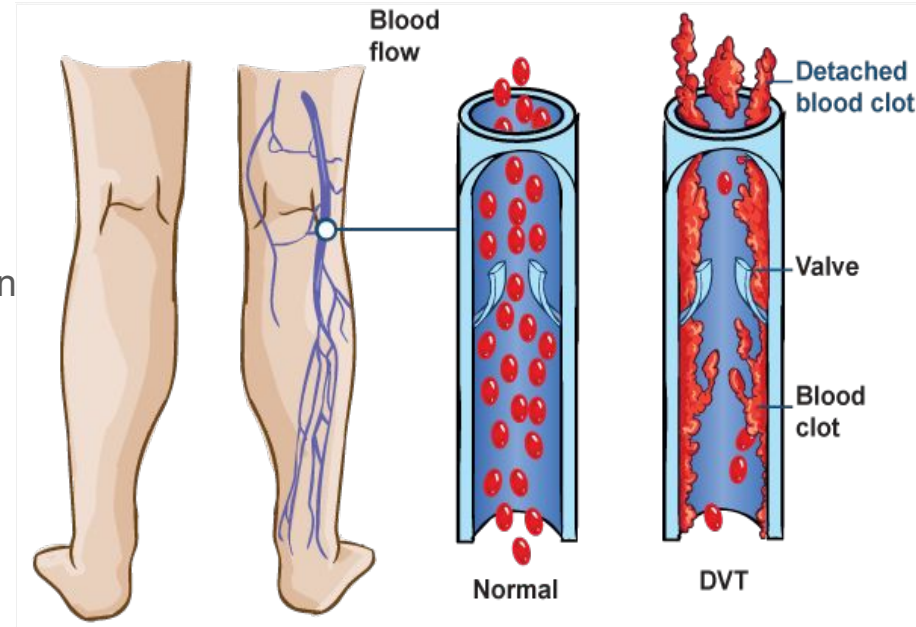
Venous return to the heart is aided by movement, and by sympathetic venoconstriction.

In SCI, both of these mechanisms can be impaired.

- especially when **chronically sedentary**
- This causes **pooling** and **slow velocity** of blood in the legs (circulatory hypokinesia)

Result: Increased risk of **venous thrombosis**

- Clots from deep veins can detach and travel to the lungs, resulting in **pulmonary embolism** → **potentially life-threatening**
- **Positional (orthostatic) hypotension** after vigorous exercise due to lack of ability to return pooled venous blood.



# SCI can cause changes in cardiac function and structure

Tetraplegia: Poor venous return + lack of sympathetic vascular tone → chronic state of hypotension and bradycardia.

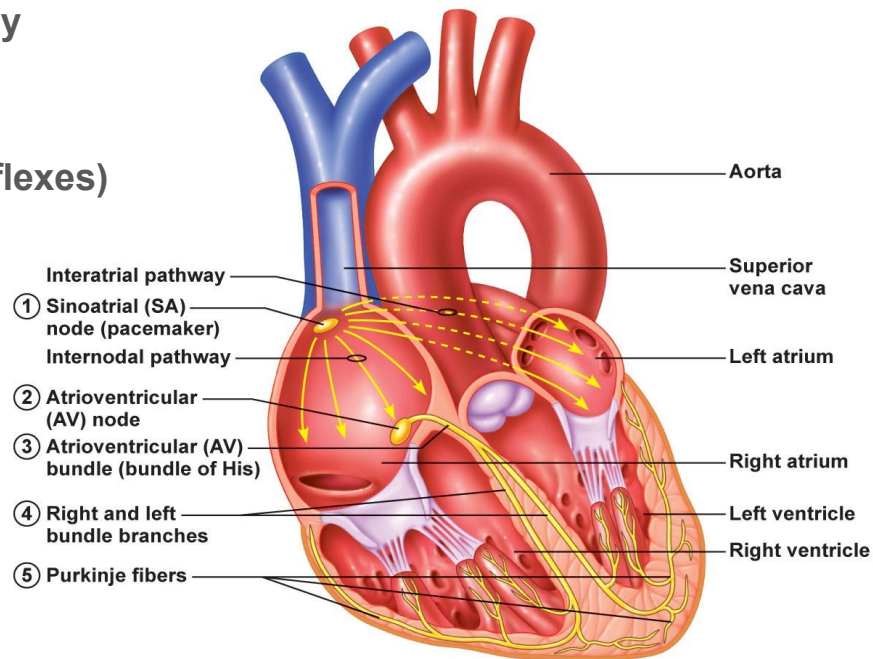
- Pressure unloading results in **left ventricular atrophy**
- Limited ability to increase cardiac output via  $\uparrow$  HR
- **Poor exercise tolerance is a large barrier to PA**
- **Extensive warm-up helps! (sympathetic spinal reflexes)**
- **PA helps preserve heart muscle!**

Paraplegia: Poor venous return, but some level of sympathetic tone → chronic state of normotension and tachycardia.

Autonomic innervation of the heart

Parasympathetic: vagus nerve (CN X)

Sympathetic: T1-T4 spinal levels





# SCI can cause impaired thermoregulation

Lack of sublesional vasomotor responses → lack of blood flow redistribution to skin for heat loss

- Result: insufficient heat loss via radiation, convection, +/- conduction.

Loss of sublesional sweating reflexes → lack of evaporative cooling

\*most important heat loss mechanism in exercise\*

Result: Predisposition to developing **hyperthermia** (high core temperature) **during exercise**.

- Worse with higher lesion levels and more complete lesions.
- Worse in hot / humid environment.
- Intensity of the activity



# Increased Prevalence of Secondary Disease

People with SCI are at increased risk of suffering from:

- Cardiovascular disease
- Depression and anxiety
- Diabetes
- Thromboembolic disease
- Pressure ulcers
- Osteoporosis and risk of fracture
- Urogenital and bowel complications

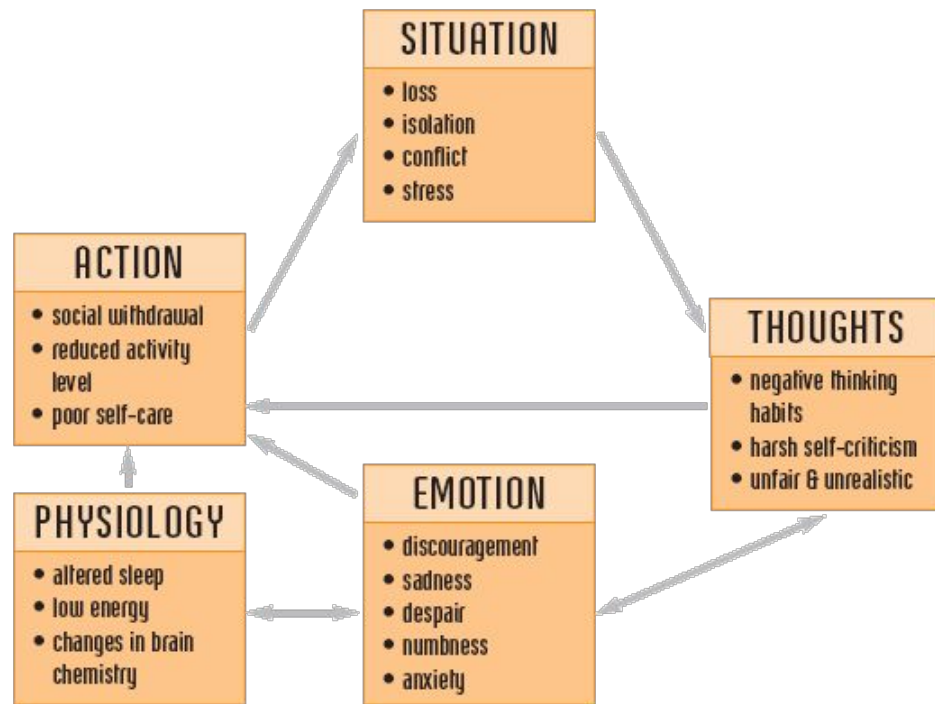
**Regular physical activity  
has a role in treatment**

**Regular physical activity  
has a role in prevention**



# Coping with functional loss after SCI

- **SCI is a devastating, life-altering event**
- Impacts physical, psychological, emotional, social, and spiritual well being
- Changed social roles, self-image, self-esteem/confidence
- Sense of loss of control over body, future
- **The majority of people with SCI adapt and cope with these changes amazingly well**
- However, not everyone: still a high prevalence of depression and suicidal ideation
- **Physical activity** contributes to sense of independence, ability, community, physical health.



***The resilience of  
the human spirit  
will astound you***

***- Dr. Jennifer Yao, Physiatrist***

**...and, exercise is medicine...**



www.olaa1aa.com

**How others see you, is not important..  
How you see yourself means everything.**

# Physical Activity:

## Benefits and Recommendations

**MOVE**  
EVEN IF HAVEN'T LATELY  
**MOVE**  
EVEN IF IT'S SLOW  
**MOVE**  
EVEN IF YOU HAVE TO ROLL  
**MOVE**  
EVEN IF IT'S JUST AN INCH  
**MOVE**  
EVEN IF IT'S MOVING OTHERS  
**MOVE**  
MORE AND MORE  
EVERYDAY.







# Enhancing Function and Restoring Independence

- Key consideration post-SCI
- Involves an interdisciplinary and collaborative approach
  - Doctors, PTs, OTs, kinesiologists, family, family doctor, etc...
- Level and degree of lesion must be considered











# Rehabilitation:

## Activity-Based Restorative Therapies

- Based on theory of neuroplasticity
- Repeated activation of pathways using task specific training and assistive devices
- Shown to improve functional mobility and decrease risk for CV and other metabolic diseases
- Expensive, accessibility issues



# Why Use Physical Activity in SCI?

Improved strength, endurance, and energy (Hicks et al., 2011, Hetz et al., 2009; Wolfe et al., 2010)

Less spasticity and pain (Wolfe et al., 2010)

Decreased movement during sleep (Wolfe et al., 2010)

## **Better overall health and quality of life**

**(Wolfe et al., 2010)**

Reduced cholesterol and fats in your blood (Wolfe et al., 2010; Buchholz et al., 2009)

Improved regulation of blood glucose (Wolfe et al., 2010; Buchholz et al., 2009)

Lowered risk of depression and stress (Wolfe et al., 2010)

# Types of PA



# Physical activity terms

## **FITT Principle** for physical activity:

- **F**requency (number of days per week)
- **I**ntensity (mild to moderate to vigorous)
- **T**ime (duration of physical activity)
- **T**ype (type of exercise; eg. swimming, leg cycling, arm cycling)

## Canadian Physical Activity Guidelines





# PA Recommendations (CSEP)

## Canadian Physical Activity Guidelines

FOR ADULTS - 18 – 64 YEARS

### Guidelines



To achieve health benefits, adults aged 18-64 years should accumulate at least 150 minutes of moderate- to vigorous-intensity aerobic physical activity per week, in bouts of 10 minutes or more.



It is also beneficial to add muscle and bone strengthening activities using major muscle groups, at least 2 days per week.



More physical activity provides greater health benefits.

# Current physical activity recommendations for persons with SCI (2011)

## PHYSICAL ACTIVITY GUIDELINES for Adults with Spinal Cord Injury



[www.sciactioncanada.ca/guidelines](http://www.sciactioncanada.ca/guidelines)

- Similar to Canadian PA guidelines
  - Strength and aerobic PA considerations
  - FITT principle used
- More specific guidelines
  - Sets and reps indicated for strength training activities



# Current physical activity recommendations for persons with SCI (SCI Action Canada, 2011)

- **Aerobic PA**

- **Frequency:** 2x/week
- **Intensity:** moderate to vigorous
- **Time/amount:** gradually increase to 20 minutes of continuous PA
- **Type:** upper body, lower body, whole body

- **Strength PA**

- **Frequency:** 2x/week
- **Intensity:** 8-10 reps max (safely finish this amount); rest 1-2 minutes between sets
- **Time/amount:** 8-10 reps of each exercise; work up to 3 sets
- **Type:** free weights, resistance bands, machines, functional electrical stimulation

# Types of PA



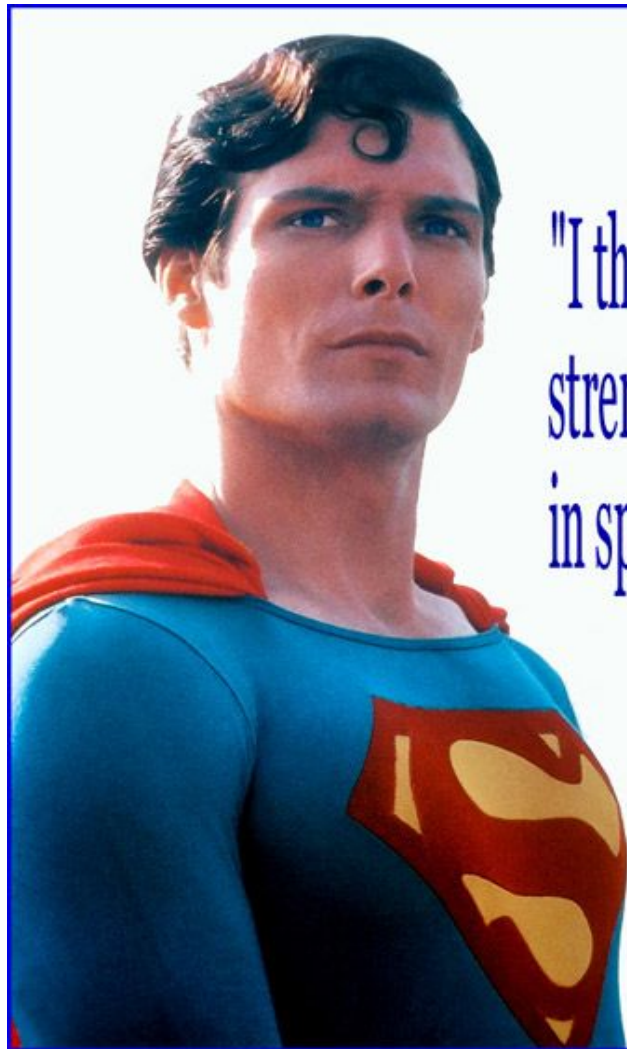
# Special Considerations: Wheelchair Sports





# Special Considerations: Extreme Wheelchair Sport





"I think a hero is an ordinary individual who finds strength to persevere and endure in spite of overwhelming obstacles..."

- Christopher Reeve (1952-2004)

# Special Considerations and Risks of Exercise after SCI

(Nash, 2005)

1. Thermal Dysregulation
2. Musculoskeletal Injury
  - a. Overuse
  - b. Fracture
3. Adrenergic Dysregulation
  - a. Pressor Decomensation (during and after exercise)
  - b. Autonomic dysreflexia





# Thermal Dysregulation (Nash, 2005)

- Causes:
  - Altered blood flow redistribution during exercise
  - Loss of sublesional vasomotor responses
  - Absence of sublesional sweating reflexes
    - Worse with higher lesions of injury
- Prevention strategies:
  - Exercise in temperate environment
  - Appropriate clothing, cooling vests, fans, mist spray bottles
  - Frequent monitoring for hydration and signs and symptoms of heat stress



Cooling Vest

# Musculoskeletal Injury (Nash, 2005)

## Overuse injury

- **Cause:** use of upper body for locomotion
  - Most common site → shoulder/rotator cuff
    - Can lead to major impact on Activities of Daily Living
  - Decreased sublesional sensation
- **Prevention:**
  - Upper extremities: monitor for ROM, strength, balance and skill of locomotion
  - Especially in wheelchair sports
  - Lower extremities: monitor for spasticity, swelling, pain, warmth or erythema



# Musculoskeletal injury (Nash, 2005)

- **Fracture:** pathological fracture risk (i.e. normal forces on abnormal bone):
- **Cause: Osteoporosis/Osteopenia**
  - ~35% decrease in total trabecular bone two years post-SCI (de Bruin et al., 2000)
  - 50% decrease in BMD in paralysed limbs of SCI patients 3 years post-SCI (Beiring-Sorensen et al., 1991)
- **Prevention:** Cannot maintain/increase sublesional bone mineral density with any intervention (including exercise).
  - Careful transfers and avoidance of trauma.



# Adrenergic Dysregulation (Nash, 2005)

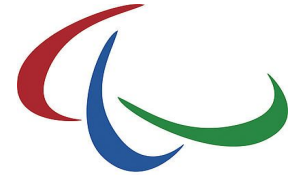
- **Pressor decompensation** during and after exercise
  - **Cause:** loss of sympathetic reflex responses to exercise and post-exercise pooling of blood in lower extremities
  - **Prevention:** careful avoidance of orthostatic decompensation through conservative exercise progression and active cool downs post exercise to support venous return. Can recline subjects post exercise to prevent syncope.



# Adrenergic Dysregulation (Nash, 2005)

## Autonomic Dysreflexia (AD) with exercise

- **Cause:** loss of central autonomic control → reflex adrenergic responses to noxious stimuli
- **Prevention:** bowel and bladder routine emptying; avoid noxious stimuli
- Bhambhani, Y., et al. (2010). **Boosting in athletes with high-level spinal cord injury: knowledge, incidence and attitudes of athletes in paralympic sport.**
  - Of 99 participants, >50% had previously heard of AD
  - 16.7% (all males) had used AD to enhance performance.



International  
**Paralympic**



# Who Prescribes the Exercise?

- All health professionals should prescribe or refer
  - Family physicians
  - Medical Specialists (Physiatry, Neurology, Orthopaedic surgeons etc.)
  - Therapists (physical, occupational, recreational)
  - Allied (Exercise Physiologists, Kinesiologists, dietician etc.)
- Remember how important physical activity can be for persons with SCI, and also how dangerous it can be if prescribed ineffectively





# Exercise Prescription and Referral

Exercise prescription & referral

Exercise is Medicine Canada

Name

Date

Age

Relevant diagnoses

REDUCE SEDENTARY BEHAVIOUR

Move more / Sit less / Use stairs / Limit screen time

PHYSICAL ACTIVITY RECOMMENDATIONS

AEROBIC / CARDIOVASCULAR ACTIVITY

Frequency	2	3	4	5	6	7	days / week
Intensity	Light		Moderate		Vigorous		
Time	10	15	20	30	40	more	minutes / session
Type							

STRENGTH / RESISTANCE ACTIVITY

2	3	4	5	6	7	days / week
---	---	---	---	---	---	-------------

Example

**CANADIAN PHYSICAL ACTIVITY GUIDELINES FOR ADULTS 18 YEARS AND OLDER**  
To achieve health benefits, adults aged 18 years and older should accumulate at least 150 minutes of moderate- to vigorous-intensity aerobic physical activity per week, in bouts of 10 minutes or more. It is also beneficial to add muscle and bone strengthening activities using major muscle groups, at least 2 days per week. More physical activity provides greater health benefits.

REFERRAL FOR ADDITIONAL EXERCISE ASSESSMENT AND COUNSELING

Name / Contact

Follow-up / Other

YOUR HEALTH PROFESSIONAL

Name

Signature

Licence #

## WHAT DO WE KNOW ABOUT EXERCISE?

- **Exercise will make you feel good and can be fun!**
- **Exercise is effective.** If exercise was a drug, it would be one of the most effective and safe ways to prevent and treat many chronic diseases such as heart disease, hypertension, diabetes, osteoporosis, anxiety disorders and depression!
- **Exercise is safe for your joints.** Regular low impact exercise and gradual muscle strengthening can stabilise and protect your joints from osteoarthritis and reduce the risk of falls and injuries that is associated with poor physical fitness.
- **Improving fitness is more important than losing weight.** Low cardiovascular fitness is associated with a much higher risk of disease and death than being overweight.
- **Walking is free anywhere and any day of the year!**

## WHAT ABOUT AEROBIC INTENSITY AND MUSCLE STRENGTHENING?

How can I assess intensity?

- **Light exercise will usually not cause adults to sweat and breathe harder.** It is easy to have a conversation at this intensity. Walking is the typical example of light exercise.
- **Moderate-intensity exercise will cause adults to sweat a little and breathe harder.** It is possible to have a conversation in short sentences. Examples are brisk walking (as if you are late for the bus!) and bike riding.
- **Vigorous-intensity exercise will cause adults to sweat and be "out of breath".** It is difficult to have a conversation. Examples are jogging, swimming laps, cross-country skiing and hiking on hills.

What is strength and resistance exercise?

- Strength and resistance exercises make your muscles work harder by adding weight or resistance to the movement.

For more information

You can consult your health professional, an exercise professional or visit the Resources page on [exerciseismedicine.ca](http://exerciseismedicine.ca).



# Summary

- SCI incidence is projected to increase (up to 5800 per year) by 2030
- SCI is very complex
  - Not as simple as the terms Tetraplegia and Paraplegia
- Special Considerations must be taken when consulting patients with SCI about physical activity
- Physical Activity is beneficial when prescribed appropriately for chronic disease and ADLs
  - When in doubt, refer to an exercise is medicine specialist
- Guidelines exist for SCI and other special populations (on the CSEP and ACSM websites)





The goal you set must be challenging. At the same time, it should be realistic and attainable, not impossible to reach. It should be challenging enough to make you stretch, but not so far that you break.

— *Rick Hansen* —

**AZ QUOTES**

# References

- Bhambhani, Y., Mactavish, J., Warren, S., Thompson, W.R., Webborn, A., Bressan, E. et al. (2010). Boosting in athletes with high-level spinal cord injury: knowledge, incidence and attitudes of athletes in paralympic sport. *Disability and Rehabilitation*, 32(26): 2172-2190.
- Buchholz AC, Martin Ginis KA, Bray SR, Craven BC, Hayes KC, Hicks AL, Latimer AE, McColl MA, Potter PJ, Smith K, & Wolfe DL (2009). Greater daily leisure time physical activity is associated with lower chronic disease risk in adults with spinal cord injury. *Applied Physiology Nutrition & Metabolism*, 34, 640-647.
- de Bruin, E.D., Dietz, V., Dambacher, M.A., & Stussi, E. (2000). Longitudinal changes in bone in men with spinal cord injury. *Clinical Rehabilitation*, 14(2): 145-52.
- Demirel, G., Yilmaz, H., Paker, N., & Onel, S. (1998). Osteoporosis after spinal cord injury. *Spinal Cord*, 36: 822-825.
- Dolbow, D.R. *et al.* (2015). Activity-based restorative therapies after spinal cord injury: Inter-institutional conceptions and perceptions. *Aging and Disease*. 6(4): 254-261.
- Hetz SP, Latimer AE, Arbour-Nicitopoulos KP, & Martin Ginis KA (2009). Secondary complications and subjective well-being in individuals with chronic spinal cord injury: Associations with adiposity. *Spinal Cord*, 47, 550-554.
- Hicks AL, Martin Ginis KA, Pelletier CA, Ditor DS, Foulon B, & Wolfe DL. (2011). The effects of exercise training on physical capacity, strength, body composition and functional performance among adults with spinal cord injury: A systematic review. *Spinal Cord*, 49(11), 1103-1127

Jacobs, P.L., & Nash, M.S. (2004). Exercise recommendations for individuals with spinal cord injury. *Sports Medicine*, 34(11), 727-751.

Martin KA, Latimer AE, Francoeur C, Hanley H, Watson K, Hicks AL, et al. (2002). Sustaining exercise motivation and participation among people with spinal cord injury: Lessons learned from a 9-month intervention. *Palaestra*, 18, 32-37.

Mazzeo, F., Santamaria, S., & Iavarone, A. (2015). "Boosting" in Paralympic athletes with spinal cord injury: doping without drugs. *Functional Neurology*, 30(2), 91-98.

Nash, M.S. (2005). Exercise as a health-promoting activity following spinal cord injury. *Journal of Neurological Physical Therapy*, 29(2), 87-106.

Scelza, W.M., Kalpakjian, C.Z., Zemper, E.D., & Tate, D.G. (2005). Perceived Barriers to Exercise in People with Spinal Cord Injury. *American Journal of Physical Medicine & Rehabilitation*, 84(8), 576-83.

SCI Action Canada (2011). Physical activity guidelines for adults with spinal cord injury. Retrieved from: <http://sciactioncanada.ca/guidelines/>

SCI Action Canada. The Benefits of Physical Activity for Adults with SC (2011). Retrieved from: <http://sciactioncanada.ca/guidelines/docs/regular-physical-activity.pdf>

Tasiemski, T., Kennedy, P., Gardner, B. P., & Taylor, N. (2005). The association of sports and physical recreation with life satisfaction in a community sample of people with spinal cord injuries. *NeuroRehabilitation*, 20, 253-265.

Wolfe, D.L., Martin Ginis, K.A., Latimer A.E., Foulon B.L., Eng J.J., Hicks A.L., Hsieh J.T.C. (2010). Physical Activity and SCI. In Eng JJ, Teasell, R.W., Miller, W.C., Wolfe, D.L., Townson, A.F., Hsieh, J.T.C., Connolly, S.J., Mehta, S., Sakakibara, B.M., editors. *Spinal Cord Injury Rehabilitation Evidence*. Version 3.0. Retrieved from: [www.scireproject.com](http://www.scireproject.com)

# How Severe is the Lesion?

American Spinal Injury Association (ASIA) scale uses sacral sparing (motor and sensory) as the criterion for determining neurological completeness

**Complete:** a term describing absence of sensory and motor function in the lowest sacral segment

**Incomplete:** partial preservation of sensory and/or motor functions below the neurological level and including the lowest sacral segment


Sacral sensation includes sensation at the anal mucocutaneous junction as well as deep anal sensation

Patient Name \_\_\_\_\_ Date/Time of Exam \_\_\_\_\_

Examiner Name \_\_\_\_\_

**ASIA**  
AMERICAN SPINAL INJURY ASSOCIATION

**STANDARD NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY**

**ISC** 

### MOTOR

KEY MUSCLES  
(according to reference side)

	R	L	
C5	<input type="checkbox"/>	<input type="checkbox"/>	Elbow flexors
C6	<input type="checkbox"/>	<input type="checkbox"/>	Wrist extensors
C7	<input type="checkbox"/>	<input type="checkbox"/>	Elbow extensors
C8	<input type="checkbox"/>	<input type="checkbox"/>	Finger flexors (partial pronators of middle finger)
T1	<input type="checkbox"/>	<input type="checkbox"/>	Finger abductors (middle finger)

UPPER LIMB TOTAL (MAXIMUM) ☐ + ☐ = ☐

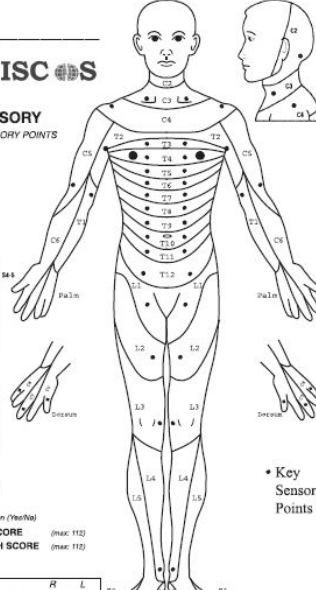
(25) (25) (50)

Comments:

### SENSORY

KEY SENSORY POINTS

☐ = absent  
1 = impaired  
2 = normal  
NT = not testable



• Key Sensory Points

### NEUROLOGICAL LEVEL

The most caudal segment with normal function

	R	L
<b>SPINAL CORD LEVEL</b>	<input type="checkbox"/>	<input type="checkbox"/>
<b>KEY MUSCLES</b>	<input type="checkbox"/>	<input type="checkbox"/>

### ASIA IMPAIRMENT SCALE

COMPLETE OR INCOMPLETE?

Is complete: Any sensory or motor function is S4-S5

Is incomplete: Any sensory or motor function is S4-S5

Zone of Partial Preservation: Greater extent of partially preserved sensory/motor

	R	L
<b>SPINAL CORD LEVEL</b>	<input type="checkbox"/>	<input type="checkbox"/>
<b>KEY MUSCLES</b>	<input type="checkbox"/>	<input type="checkbox"/>

Voluntary anal contraction ☐ (Yes/No)

Any anal sensation (Yes/No) ☐

Pin Prick Score (max. 132) ☐

Light Touch Score (max. 132) ☐

TOTALS: (S4-S5) (S4) (S5) (S6) (S7) (S8) (S9) (S10) (S11) (S12) (S13) (S14) (S15) (S16) (S17) (S18) (S19) (S20) (S21) (S22) (S23) (S24) (S25) (S26) (S27) (S28) (S29) (S30) (S31) (S32) (S33) (S34) (S35) (S36) (S37) (S38) (S39) (S40) (S41) (S42) (S43) (S44) (S45) (S46) (S47) (S48) (S49) (S50) (S51) (S52) (S53) (S54) (S55) (S56) (S57) (S58) (S59) (S60) (S61) (S62) (S63) (S64) (S65) (S66) (S67) (S68) (S69) (S70) (S71) (S72) (S73) (S74) (S75) (S76) (S77) (S78) (S79) (S80) (S81) (S82) (S83) (S84) (S85) (S86) (S87) (S88) (S89) (S90) (S91) (S92) (S93) (S94) (S95) (S96) (S97) (S98) (S99) (S100) (S101) (S102) (S103) (S104) (S105) (S106) (S107) (S108) (S109) (S110) (S111) (S112) (S113) (S114) (S115) (S116) (S117) (S118) (S119) (S120) (S121) (S122) (S123) (S124) (S125) (S126) (S127) (S128) (S129) (S130) (S131) (S132) (S133) (S134) (S135) (S136) (S137) (S138) (S139) (S140) (S141) (S142) (S143) (S144) (S145) (S146) (S147) (S148) (S149) (S150) (S151) (S152) (S153) (S154) (S155) (S156) (S157) (S158) (S159) (S160) (S161) (S162) (S163) (S164) (S165) (S166) (S167) (S168) (S169) (S170) (S171) (S172) (S173) (S174) (S175) (S176) (S177) (S178) (S179) (S180) (S181) (S182) (S183) (S184) (S185) (S186) (S187) (S188) (S189) (S190) (S191) (S192) (S193) (S194) (S195) (S196) (S197) (S198) (S199) (S200) (S201) (S202) (S203) (S204) (S205) (S206) (S207) (S208) (S209) (S210) (S211) (S212) (S213) (S214) (S215) (S216) (S217) (S218) (S219) (S220) (S221) (S222) (S223) (S224) (S225) (S226) (S227) (S228) (S229) (S230) (S231) (S232) (S233) (S234) (S235) (S236) (S237) (S238) (S239) (S240) (S241) (S242) (S243) (S244) (S245) (S246) (S247) (S248) (S249) (S250) (S251) (S252) (S253) (S254) (S255) (S256) (S257) (S258) (S259) (S260) (S261) (S262) (S263) (S264) (S265) (S266) (S267) (S268) (S269) (S270) (S271) (S272) (S273) (S274) (S275) (S276) (S277) (S278) (S279) (S280) (S281) (S282) (S283) (S284) (S285) (S286) (S287) (S288) (S289) (S290) (S291) (S292) (S293) (S294) (S295) (S296) (S297) (S298) (S299) (S300) (S301) (S302) (S303) (S304) (S305) (S306) (S307) (S308) (S309) (S310) (S311) (S312) (S313) (S314) (S315) (S316) (S317) (S318) (S319) (S320) (S321) (S322) (S323) (S324) (S325) (S326) (S327) (S328) (S329) (S330) (S331) (S332) (S333) (S334) (S335) (S336) (S337) (S338) (S339) (S340) (S341) (S342) (S343) (S344) (S345) (S346) (S347) (S348) (S349) (S350) (S351) (S352) (S353) (S354) (S355) (S356) (S357) (S358) (S359) (S360) (S361) (S362) (S363) (S364) (S365) (S366) (S367) (S368) (S369) (S370) (S371) (S372) (S373) (S374) (S375) (S376) (S377) (S378) (S379) (S380) (S381) (S382) (S383) (S384) (S385) (S386) (S387) (S388) (S389) (S390) (S391) (S392) (S393) (S394) (S395) (S396) (S397) (S398) (S399) (S400) (S401) (S402) (S403) (S404) (S405) (S406) (S407) (S408) (S409) (S410) (S411) (S412) (S413) (S414) (S415) (S416) (S417) (S418) (S419) (S420) (S421) (S422) (S423) (S424) (S425) (S426) (S427) (S428) (S429) (S430) (S431) (S432) (S433) (S434) (S435) (S436) (S437) (S438) (S439) (S440) (S441) (S442) (S443) (S444) (S445) (S446) (S447) (S448) (S449) (S450) (S451) (S452) (S453) (S454) (S455) (S456) (S457) (S458) (S459) (S460) (S461) (S462) (S463) (S464) (S465) (S466) (S467) (S468) (S469) (S470) (S471) (S472) (S473) (S474) (S475) (S476) (S477) (S478) (S479) (S480) (S481) (S482) (S483) (S484) (S485) (S486) (S487) (S488) (S489) (S490) (S491) (S492) (S493) (S494) (S495) (S496) (S497) (S498) (S499) (S500) (S501) (S502) (S503) (S504)



## Exercise Opportunities for Persons with SCI

### 1. Atypical physiological responses to acute exercise

- a. Damage to SC dissociates homeostatic mechanisms which regulate physiological responses needed to sustain exercise. Further disrupts signal integration among motor, sensory and autonomic targets and thus influences acute adjustments to activity and peak exercise capacity.
- b. Progressively higher levels of injury:
  - i. Greater muscle mass loss in those muscles that serve as prime movers and stabilizers of the trunk. Arms must simultaneously generate propulsive forces and steady the trunk during exercise.
  - ii. Greater degrees of adrenergic dysfunction, and at key spinal levels totally dissociate adrenal, cardiac, and sympathetic nervous system regulation from central command. Decreased adrenergic/noradrenergic function leads to altered cardiovascular and metabolic efficiencies achieved by individuals who exercise in the presence of an intact neuraxis.
- c. Evidence strongly supports a direct relationship among level of injury, peak workload, and peak oxygen uptake from arm crank testing.
  - i. Individuals with injuries below the level of sympathetic outflow at T6 have significantly lower resting stroke volumes and higher resting heart rates than those without disability. Increased heart rate is thought to compensate for lower SV imposed by pooling of blood in lower extremity and venous circuits, diminished venous return and cardiac end-diastolic volumes or frank circulatory insufficiency. Upregulation of intact adrenergic system after SCI may also compensate to increase HR responses during exercise→ observed in paraplegia with persons have mid thoracic injuries.
  - ii. Hypersensitivity of the supralésional spinal cord is believed to regulate the atypical adrenergic state and dynamic

# 6 Month Myth: “Rehabilitation only works for 6 months post injury” (FIND PAPERS ABOUT THIS)

From previous slide clearly this isn't true

Extra slides