



Occupational
Health Clinics
for Ontario
Workers Inc.

Centres de
santé des
travailleurs (ses)
de l'Ontario Inc.

Four E's Of Shoulder Injuries

Trevor Schell

1



Overview - Four E's Of Shoulder Injuries

- Explain the anatomy of the shoulder
- Examine common risk factors for injury
- Explore the most common shoulder injuries including Rotator Cuff Tears, Osteoarthritis, and Thoracic Outlet Syndrome
- Expand upon prevention measures

2

Shoulder Function and Anatomy



- Shoulder joint is one of the most flexible joints in the human body allowing rotation in three planes

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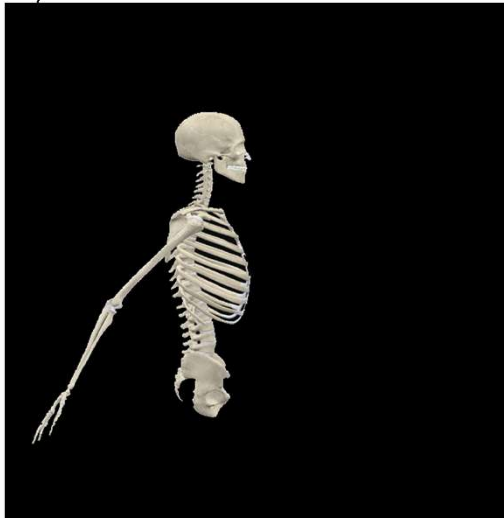
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Shoulder Function and Anatomy



- Shoulder joint is one of the most flexible joints in the human body allowing rotation in three planes

Extension



Flexion

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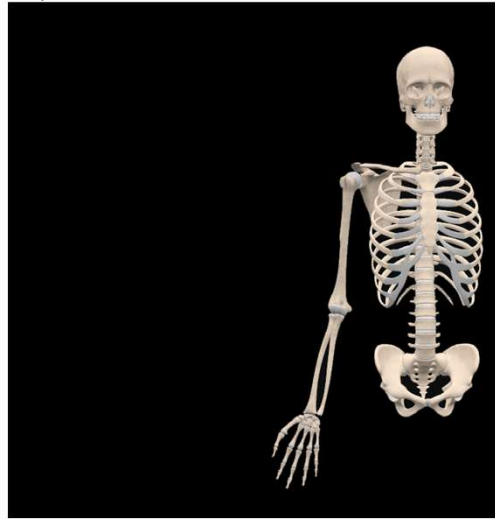
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Shoulder Function and Anatomy



- Shoulder joint is one of the most flexible joints in the human body allowing rotation in three planes

Abduction



Adduction

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Shoulder Function and Anatomy



- Shoulder joint is one of the most flexible joints in the human body allowing rotation in three planes

External
Rotation



Internal
Rotation

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Shoulder Function and Anatomy

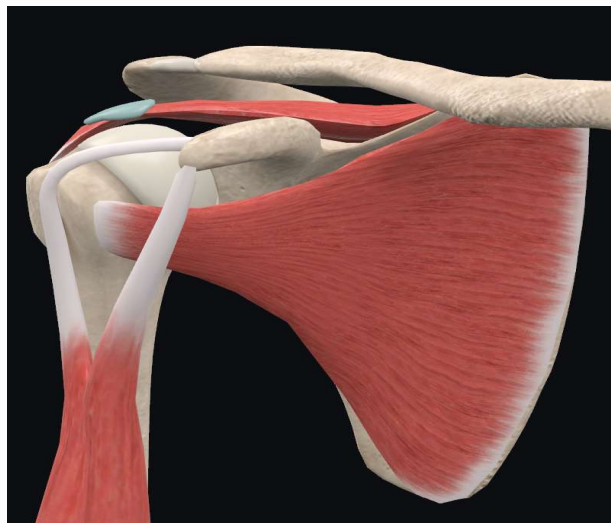


- Shoulder joint is one of the most flexible joints in the human body allowing rotation in three planes
- It is this mobility that contributes to the high incidence of injury and degeneration of the joint.
- Area of low blood flow compared to other joints in the body

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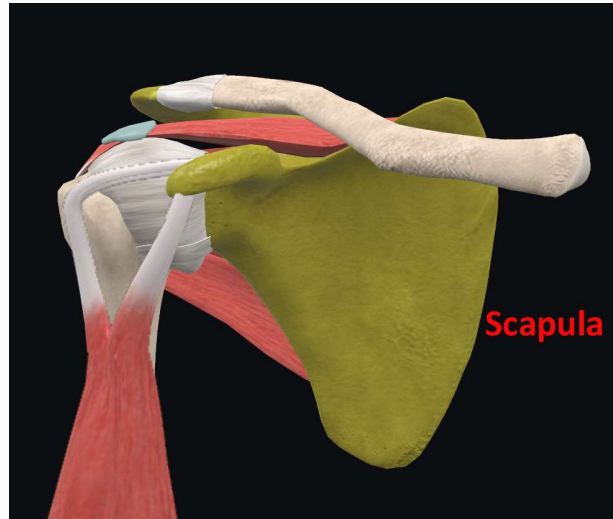
Shoulder Function and Anatomy



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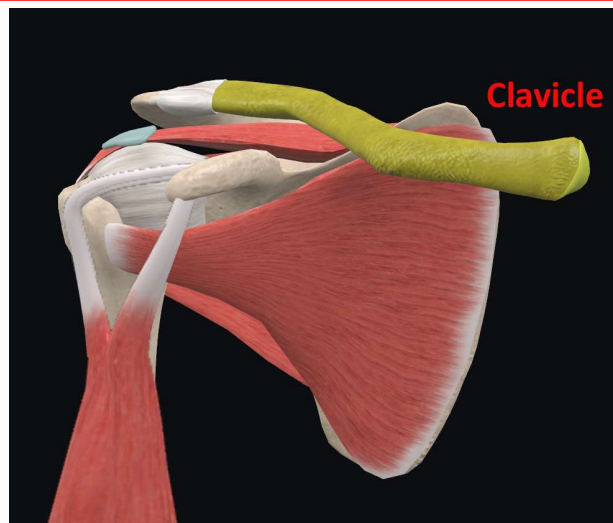
Shoulder Function and Anatomy



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9

Shoulder Function and Anatomy



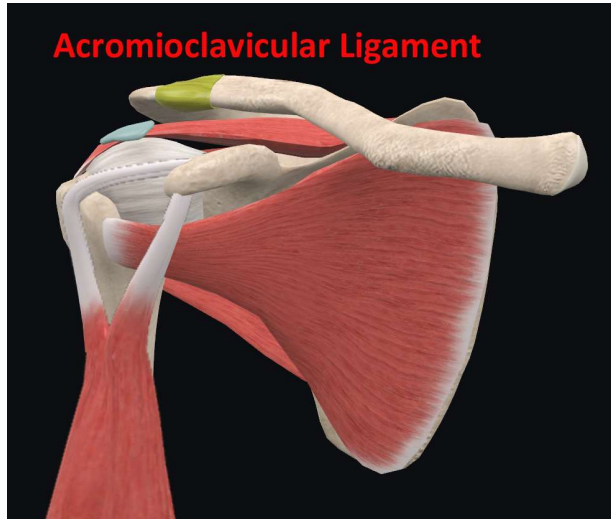
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Shoulder Function and Anatomy



Acromioclavicular Ligament



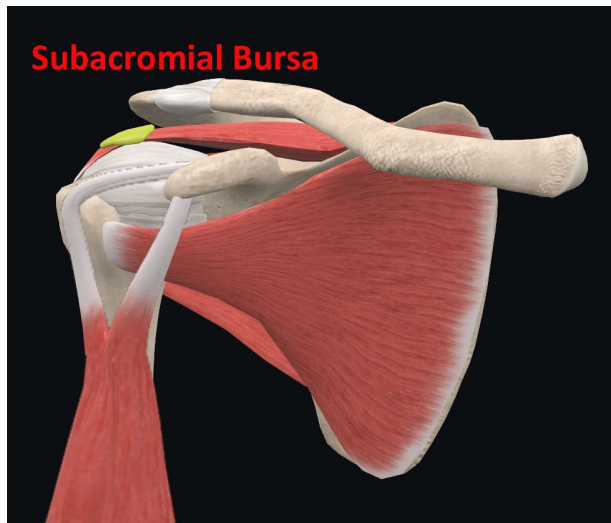
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Shoulder Function and Anatomy



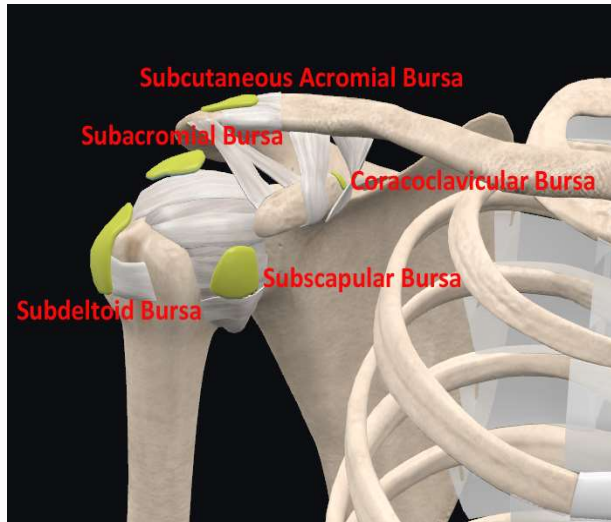
Subacromial Bursa



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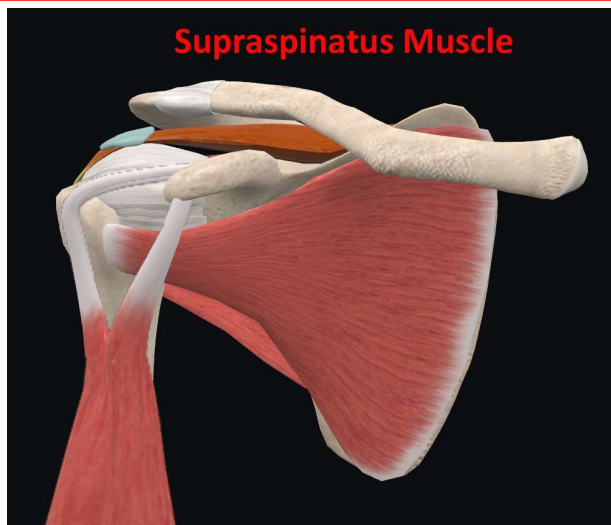
Shoulder Function and Anatomy



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13

Shoulder Function and Anatomy



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14

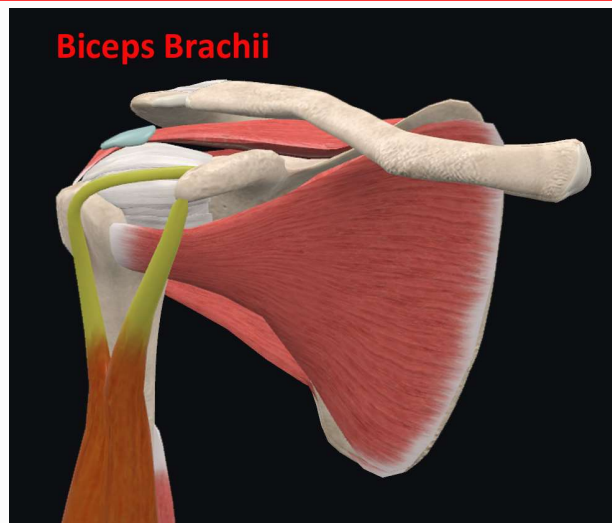
Shoulder Function and Anatomy



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15

Shoulder Function and Anatomy



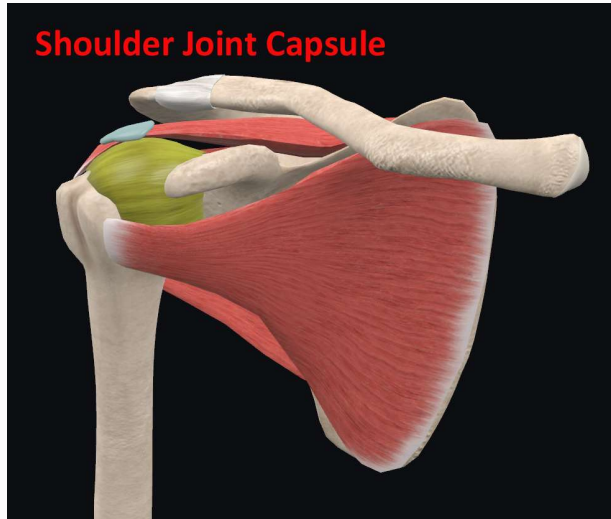
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16

Shoulder Function and Anatomy



Shoulder Joint Capsule



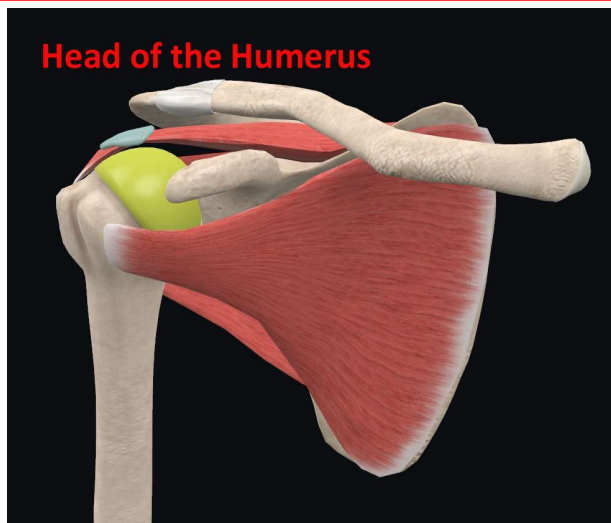
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17

Shoulder Function and Anatomy



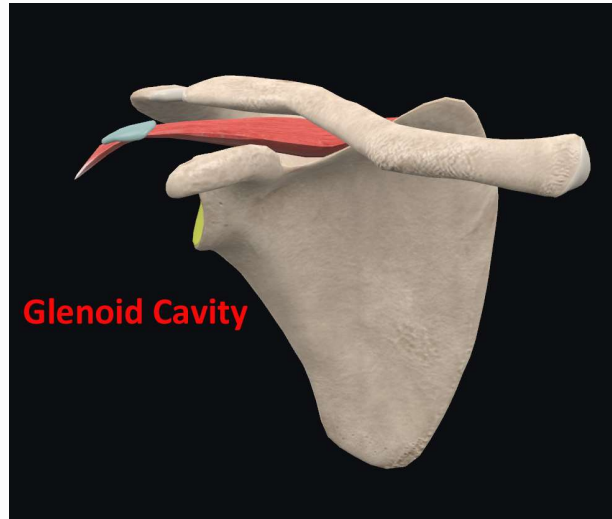
Head of the Humerus



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Shoulder Function and Anatomy



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19

Shoulder Function and Anatomy



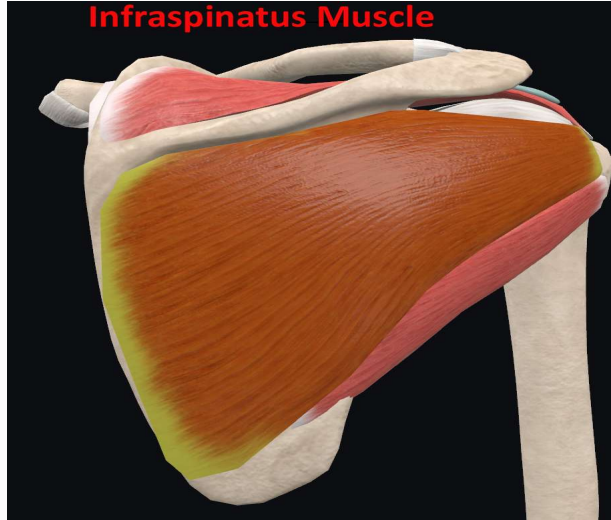
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20

Shoulder Function and Anatomy



Infraspinatus Muscle



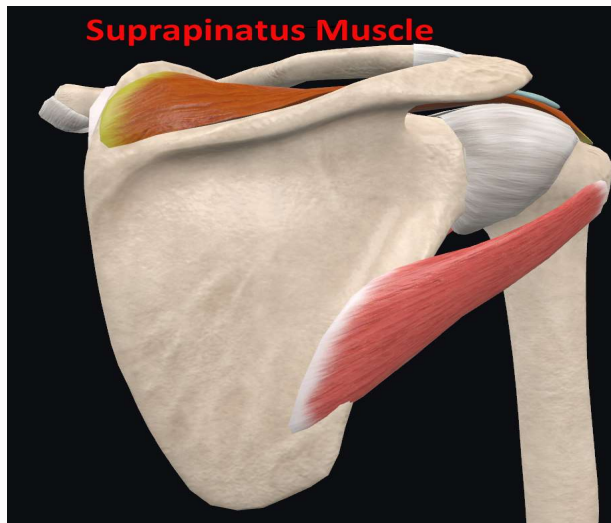
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21

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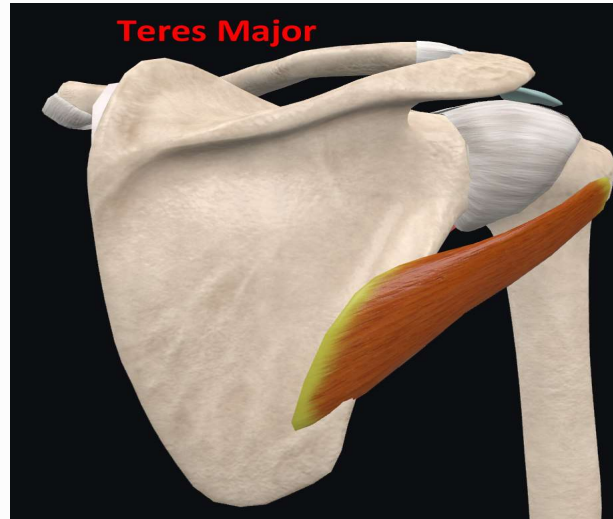
Supraspinatus Muscle



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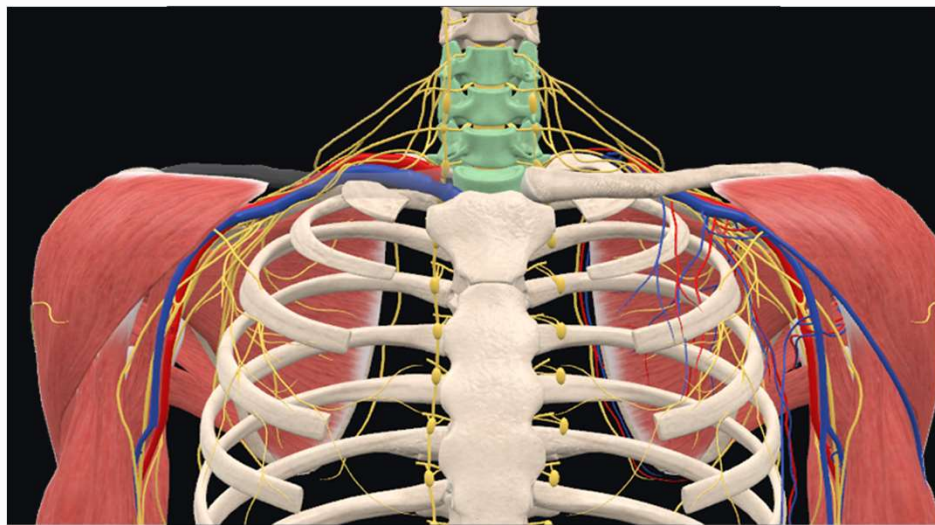
Shoulder Function and Anatomy



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23

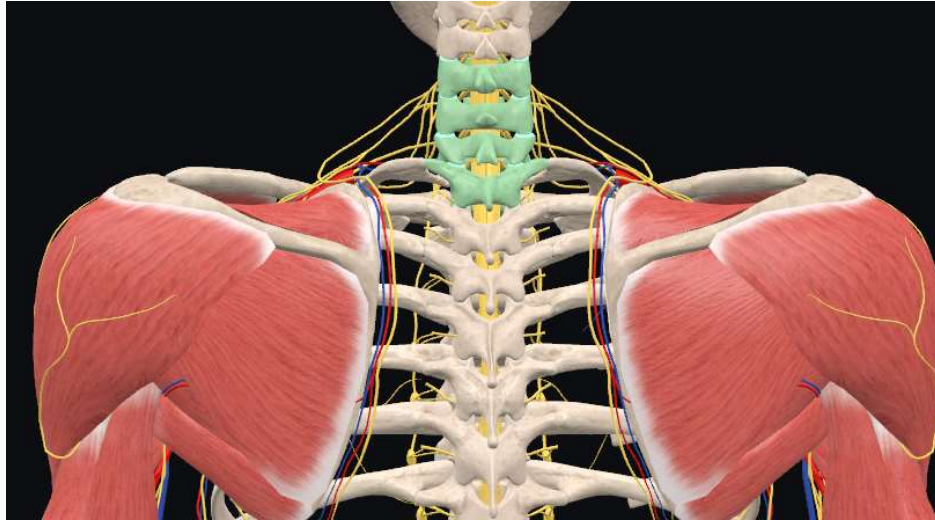
Shoulder Function and Anatomy – Nerves



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24

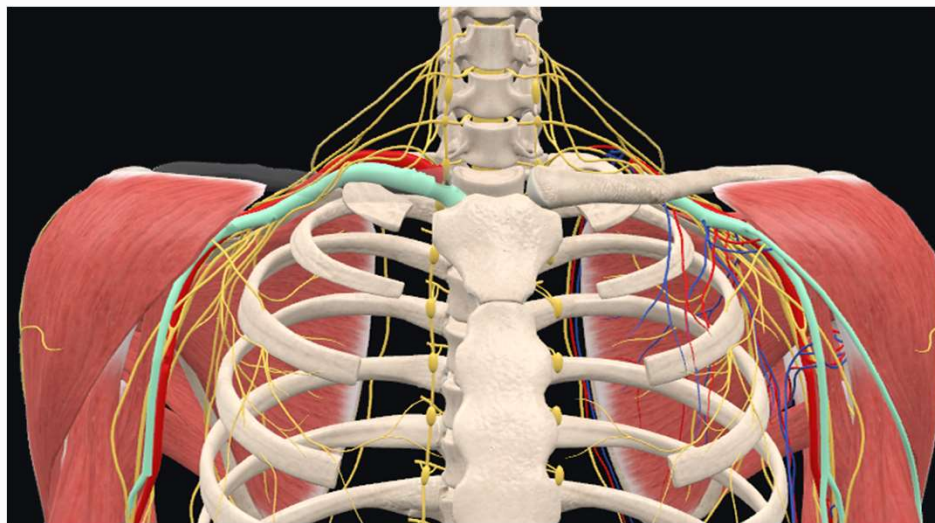
Shoulder Function and Anatomy - Nerves



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25

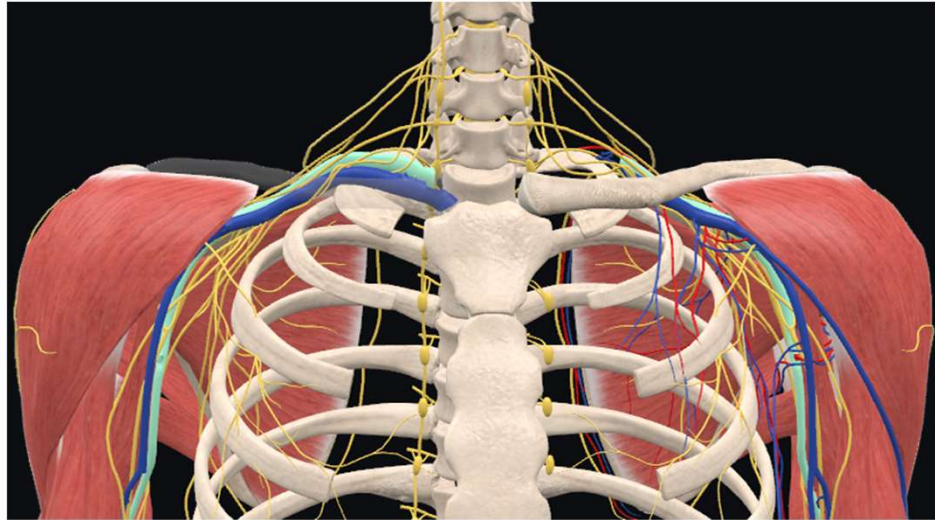
Shoulder Function and Anatomy - Veins



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26

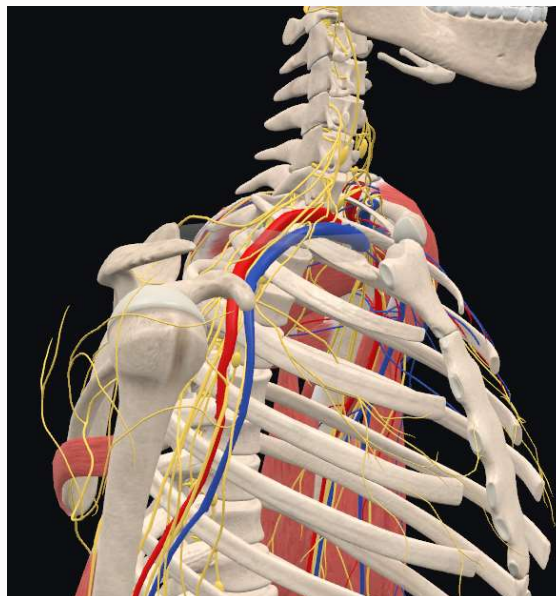
Shoulder Function and Anatomy- Arteries



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27

Shoulder Function and Anatomy



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28



Risk Factors for Injury

- Acute/Chronic Injuries
- Acute injury occurs as a result of trauma (slip, fall, impact, catching a falling object) – fairly easy to prove
- Chronic injury occurs over time (i.e. years) due to exposure to risk factors and previous injury

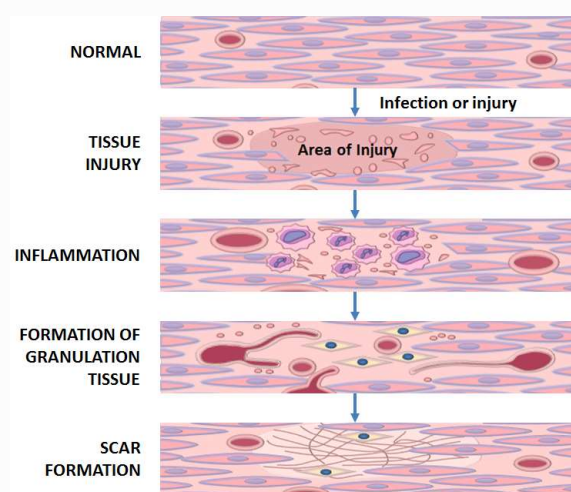
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Risk Factors for Injury

- Previous Injury
- Once tissues (muscles or tendons) have been damaged, they will never return to 100%
- Scar tissue may also develop which can result in a loss of function.
 - Adheres to muscle fibers, tendons and connective tissue preventing them from sliding back and forth properly.
 - Limits the flexibility of a muscle or joint (less range of movement) and can result in pain.
 - Weaker, less elastic, and more prone to future re-injury than normal, healthy tissue.
- Osteoarthritis



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Risk Factors for Injury



- Awkward Postures

- Punnett (1991), stated that workers who spend more than 10% of their time in non-neutral postures are at an increased risk of developing musculoskeletal disorders.
- Include working with the arms away from the body ($\sim <60^\circ$) such as overhead, abduction/adduction, flexion/extension

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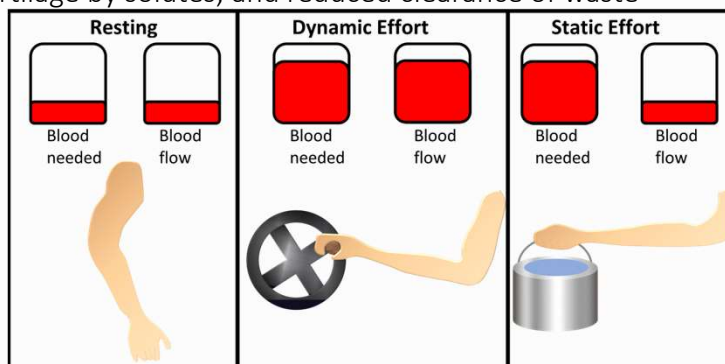
31

Risk Factors for Injury



- Static Postures

- Working with arm extended for a period of time in a static posture
- Anatomy of shoulder with static posture places pressure on the nerves and blood vessels in the area
- Reduce the blood flow to tissues; reduce synovial fluid circulation; results in reduced penetration of cartilage by solutes; and reduced clearance of waste products from the joint.
- Already an area of low blood flow



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Risk Factors for Injury

- Inadequate Recovery Time
 - Formerly repetition
 - Use of the same body part(s) to perform a task(s) without allowing the body tissues sufficient time to recover
 - Time to perform a task
 - Time spent engaged in a task i.e. arm away from body

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Risk Factors for Injury

- Force
 - Two types
 - External – what weight you are lifting
 - Internal – how hard the muscles work to move/hold external weight
 - Internal force is basically ignored by WSIB since not easily measured and requires understanding and education of biomechanics

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34

Risk Factors for Injury



- Internal Force Example (simplified)

- **Scaling rock face – simply holding the bar**
- **Force** = mass of the object (weight) multiplied by acceleration (in the case gravity) which is -9.81m/s^2 or to keep it simple 10m/s^2 (is negative since it is acting downwards opposite to the muscle).
- Force is expressed in Newtons (N) which is the weight X gravity $\text{kg} \times \text{m/s}^2$ or kgm/s^2 or 1 N.
- **Torque** (turning effect of a force) is the product of force (F) and its moment arm (MA) or $T = F \times \text{MA}$



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35

Risk Factors for Injury



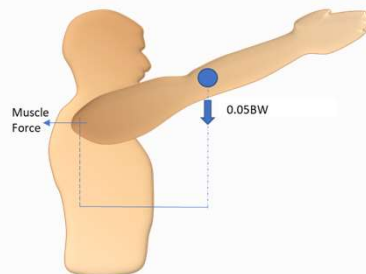
- Internal Force Example (simplified)

- Scaling rock face – holding the bar

Weight arm = $0.05 \times \text{body weight} \times 10$
= 34.5 N

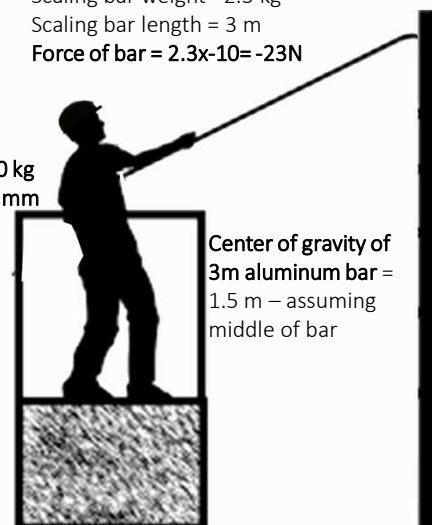
Muscle Force (FM) at shoulder = ?

Center of gravity of arm = $.467 \times \text{arm length}$



Scaling bar weight = 2.3 kg
Scaling bar length = 3 m
Force of bar = $2.3 \times 10 = -23\text{N}$

Body Weight = 180 kg
Arm Length = 796 mm



Center of gravity of 3m aluminum bar = 1.5 m – assuming middle of bar

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36

Risk Factors for Injury



- Internal Force Example (simplified)

- Scaling rock face – holding the bar

| Force | Magnitude | Moment Arm (MA) | Torque | Torque Name |
|-------|-----------|-----------------|----------|-------------|
| W_b | -23 N | 1.5 m | -34.5 Nm | T_b |
| W_A | -90 N | 0.372 m | -33.5 Nm | T_A |
| F_M | TBD | 0.0272 m | ??? | T_M |

- Torque of the muscles (**TM**) plus the torque of the bar (**TB**) plus the torque of the hand/arm segment (**TA**) must equal 0 to be in balance.
- TM + TB + TA = 0**
- TM = -TB - TA**
- TM = -(-34.5 Nm) - (-33.5 Nm) = 68.0 Nm**
- Muscles about the shoulder must create a torque of **68.0 Nm** in the opposite direction of the segment and rod to maintain balance



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37

Risk Factors for Injury



- Internal Force Example

- Scaling rock face - holding bar
- To calculate the muscle force, we use:
- TM = FM x MA**
- FM = TM/ MA**

$$FM = 68.0 \text{ Nm} / 0.0272 \text{ m}^*$$

$$FM = 2,496 \text{ N or } 249.6 \text{ kg}$$

- Therefore, just to hold the 5 lbs. (2.3 kg) bar, not the action of scaling itself would result in 249.6 kg of internal force generated to just hold the bar or **100** times the weight of the bar.



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38



Risk Factors for Injury

- Vibration
 - As length of time exposed increases (> 9001 hours - Stenlund et al., 1992) so did the risk of osteoarthritis
 - Contributes to tissue degeneration when combined with sustained static postures and inadequate recovery
 - Circulatory effects by reducing the rate of blood flow to peripheral tissues.
 - When these two factors are combined, they act synergistically to exacerbate the situation and increase the likelihood of tissue degeneration.
 - Stimulates bursts of muscle activity that results in fatigue of muscles (tired feeling).
 - Results in the muscles becoming tensed.
 - As muscle tenses, it increases the strength of the vibration transmission throughout the body thereby making the effects stronger.

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39



Risk Factors for Injury

- Cold Temperature
 - Causes a reduction in blood flow from body's core
 - Shoulder is already an area of low blood flow

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40

Risk Factors for Injury Non-occupational risk factors



- Age – muscles and joints are less hydrated and elastic – longer recovery
- Genetics- in some families there is a greater probability of developing defective connective tissue or decreased circulation.
- Infection - some infections within the bursa or tendon sheath can give rise to inflammation
- Systemic disorders - such as rheumatoid arthritis, gout, lupus, diabetes, thyroid disease
 - Causes a reduction in blood flow from body's core
 - Shoulder is already an area of low blood flow
- Smoking – reduces blood flow and healing process

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41

Osteoarthritis (OA)

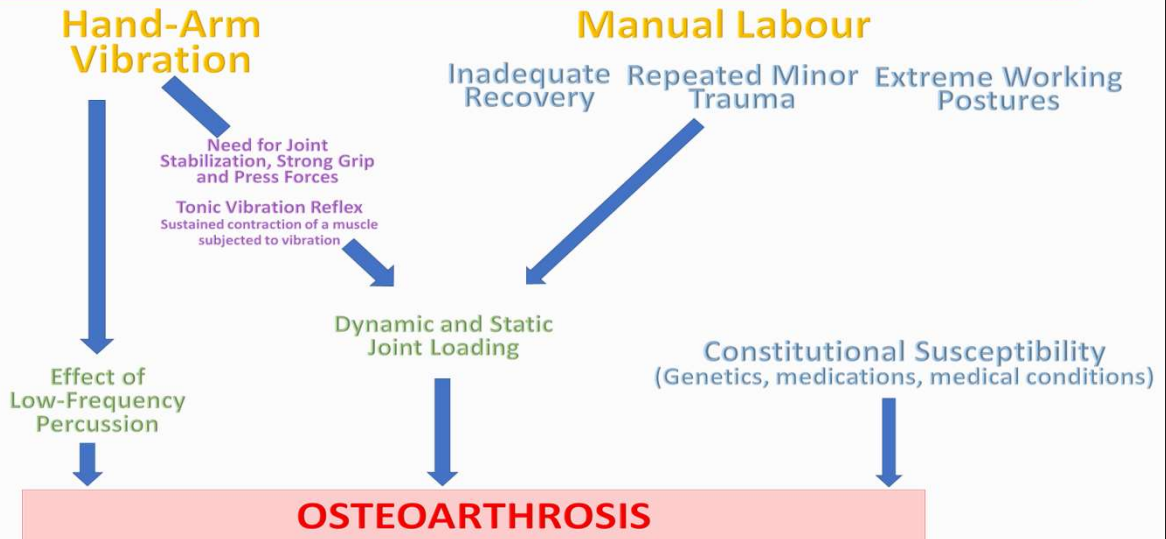


- Occurs when the protective cartilage that cushions the ends of the bones wears down over time.
- Shoulder joint is already an area of low blood flow
- Risk Factors include:
 - Awkward and static postures
 - Insufficient recovery time (repetition)
 - Force (internal and external)
 - Vibration
 - Cold temperature
- Primary effect is reduction of blood flow i.e. reduce tissues healing
- OA occurs in the acromioclavicular joint and glenohumeral joint
- When stability of the joint is compromised, tiny micro tears occur inducing the creation of osteophytes in the joint, thus starting the process of degeneration and osteoarthritis.

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42

Osteoarthritis (OA)



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Adapted from Elsner, 1995.

43

Acromioclavicular Joint Osteoarthritis



- Cartilage loss occurs between and around the acromion of the scapula and the clavicle



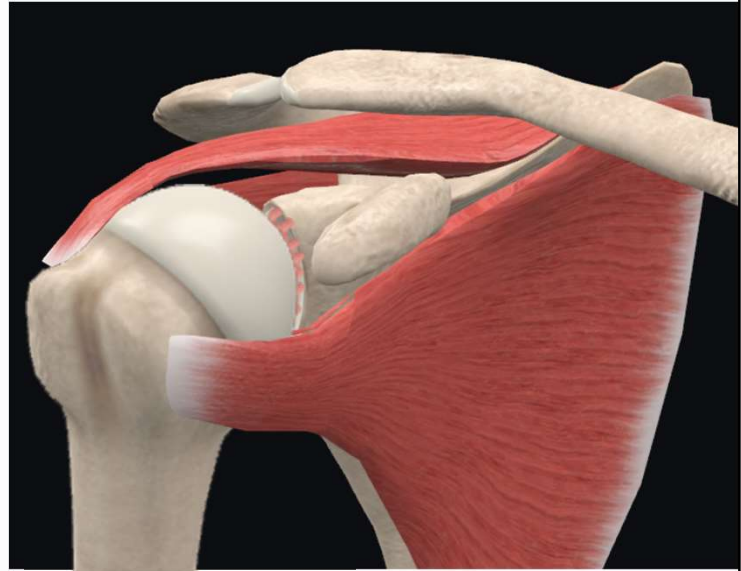
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Glenohumeral Osteoarthritis



- Cartilage loss occurs within the glenoid cavity



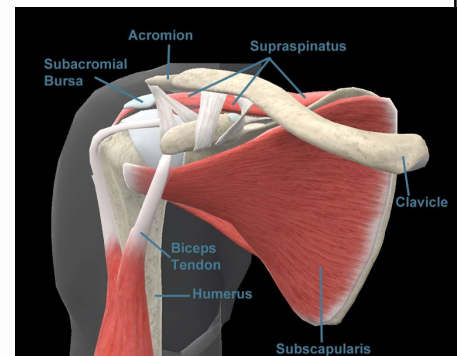
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Rotator Cuff Tears



- Rotator cuff connects the humerus (upper arm bone) to the scapula (shoulder blade).
- Formed by the tendons of four muscles the supraspinatus, infraspinatus, teres minor, and subscapularis, which attach the muscle to the bone.
- Muscles move the bones by pulling on the tendons and in this case raises and rotates the arm.
- These tendons run beneath the bony acromion or point of the shoulder.
- The rotator cuff keeps the humerus, the upper arm bone tightly in the glenoid socket of the shoulder blade



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46



Rotator Cuff Tears

- Rotator Cuff Tendons
 - very low blood supply
 - not able to repair and maintain themselves as quickly as other parts of the body
 - especially vulnerable to degeneration from aging (less elastic)
- Degeneration is accelerated by repeating the same types of shoulder motions.
- Is estimates that up to 40 percent of population may have a mild rotator cuff tear without even knowing it.
- 20% of 60-year old's have rotator cuff tears and 50% of eighty-year old's.

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47



Rotator Cuff Tears

- Two mechanism for injury
 - Trauma (slip, fall, car accident, or sports related)
 - Chronic use
 - Over time, tendons wear thin, and a tear can develop
 - Often preceded by complaints of shoulder bursitis
 - With movements, the tendons can be impinged under the bones

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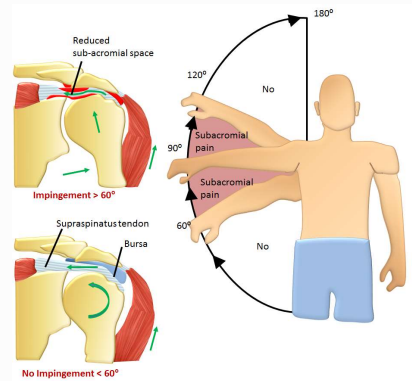
48

Rotator Cuff Tears



- Development of a tear is a multistage process

- **Stage I** includes swelling and hemorrhage and occurs mostly in young (< 25 years old) patients after overuse and is reversible with conservative treatment.
- **Stage II** involves fibrosis and tendonitis, is typically seen in patients 25-40 years old and may not respond to conservative treatment.
- **Stage III** refers to bony changes (spurs, etc.) and complete tears of the rotator cuff and/or long head of the biceps tendon.



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49

Rotator Cuff Tears



- Work Related Causes
 - Shoulder motions of abduction and flexion above chest height
 - Internal rotation of the shoulder
 - Protraction of the shoulder.
 - Prolonged work at or above shoulder level
 - Repetitive and/or heavy forceful motions involving combined abduction, forward flexion, and internal rotation (impingement position)
 - Static tensions or positions involving prolonged abduction
 - Prolonged vibration exposure from heavy handheld vibrating tools (e.g. jackhammer)
 - Previous shoulder injury

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50

Rotator Cuff Tears



- Non- Occupational Causes
 - Non work-related trauma – accident, sports etc.
 - Aging - rotator cuff pathophysiology and degeneration has an absolute association with the aging process (partial tear)
 - Anatomical variations such as hooked or curved acromion, acromioclavicular joint and coracoid process anomalies
 - Post-operative or post-traumatic scarring
 - Glenohumeral instability.
 - Smoking




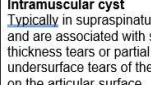

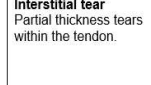
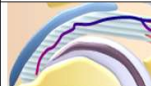

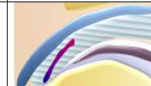



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51

Rotator Cuff Tears



- Eight different types of tears
- Partial goes only part of the way into the tendon. It's usually described in terms of how deep the tear is in the tendon and doesn't refer to length, width or other dimensions.
- Full-thickness is when the tear in the tendon goes all the way through the tendon.

| | | |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Normal rotator cuff</p>  | <p>Partial-thickness tear articular side Incomplete tear of the rotator cuff on the articular side of the joint</p>  | <p>Partial-thickness tear bursal side Incomplete tear of the rotator cuff of the joint on the bursal side of the joint</p>  |
| <p>Intramuscular cyst Typically in supraspinatus muscle and are associated with small, full-thickness tears or partial undersurface tears of the rotator cuff on the articular-surface.</p>  | <p>Partial articular supraspinatus tendon avulsion (PASTA) Incomplete tear specific to the supraspinatus tendon</p>  | <p>Interstitial tear Partial thickness tears within the tendon.</p>  |
| <p>Attritional wear Gradual process of wearing down tendons compared to an acute injury. Can be a partial or full thickness tear on any aspect of tendon.</p>  | <p>Full thickness tear with retraction Associated with full thickness tear when tendon is torn on one end. Tendon retracts due to tension of muscle.</p>  | <p>Partial thickness articular surface intra-tendinous tear (PAINIT) Separation and/or splitting of tendon layers on the articular surface</p>  |
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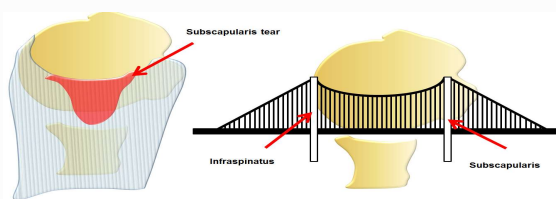
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Rotator Cuff Tears

- If 20% of the population in the age range of 50-60 have a partial tear progressing to 50% by age 80 have a tear, how can they not know it?
- Rotator Cuff works like a suspension bridge cable that connects one side of a bridge to another and carries the load from one pillar to the other across a span.
- If tear of the supraspinatus muscle (top of the bridge and if the anterior and posterior rotator cuff (the two suspension towers) are intact and functioning well, shoulder function will be maintained.



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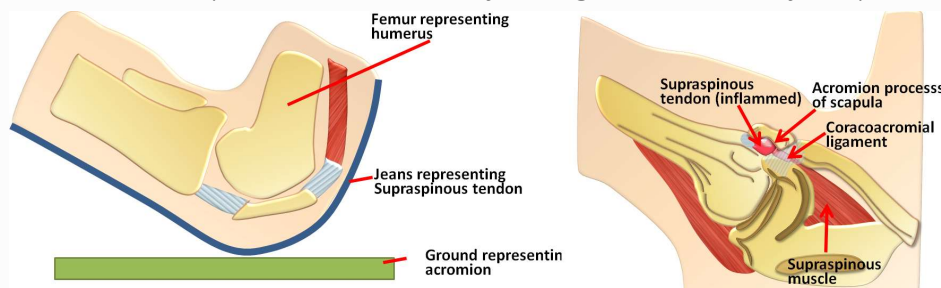
Shoulder from overhead

53



Rotator Cuff Tears – Analogy 1

- Think of the rotator cuff tendon as a pair of jeans covering a bent knee when kneeling
- Knee = Shoulder
- Jeans = Rotator cuff tendons
- Ground = Bones (acromioclavicular joint, glenohumeral joint)



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54



Rotator Cuff Tears – Analogy 1

- Ever notice on one day your jeans are fine, then the next there is a slight hole?
- Then you may have a minor fall or simply kneel, and the jeans suddenly tear.
- Over time, the jeans wear out, if you wear them long enough, they get ratty in spots and eventually a hole may form.

Until around age 45, the rotator cuff looks like a new pair of jeans



Around age 45-65 the rotator cuff begins to develop tears that will progress in size



Over age 65, the rotator cuff becomes even more worn and torn



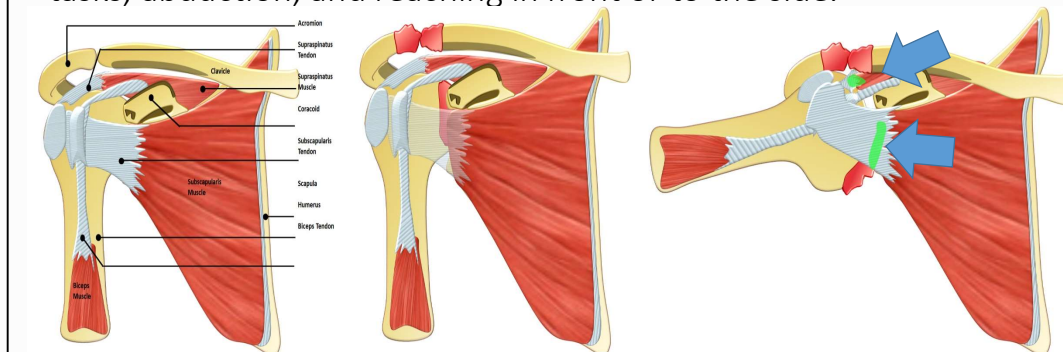
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55



Rotator Cuff Tears – OA

- Once smooth surface of bones are rough and jagged
- Tendons glide over the bones of the shoulder joint, rubbing against the roughened surfaces and producing micro tears especially with overhead tasks, abduction, and reaching in front or to the side.



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56

Rotator Cuff Tears – OA Analogy



- Fraying Rope



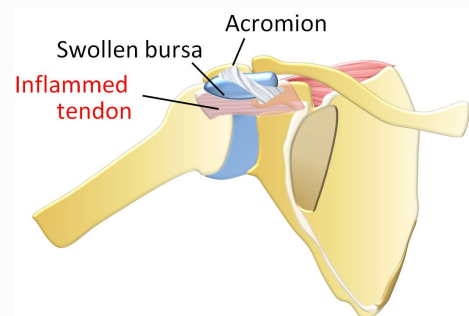
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57

Bursitis



- Inflammation of the bursa which is a sac of fluid that cushions the structures of the shoulder as they move to create a smooth, almost frictionless functional gliding surface making normal movement painless.
- With overuse, trauma as well as various medical conditions, the bursa can fill up with too much fluid, filling and squeezing the joint space.



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58

Progression of injuries



| | | | |
|--------------------------------------------------------------------------------------------------------------------------------------|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <p>Stage 1 Normal Shoulder</p> | | <p>Stage 4 Bursitis Can result from swelling due to tenosynovitis pushing it against the acromion. Can also result due to forceful actions, prolonged overhead work, impingement, and secondary conditions.</p> | |
| <p>Stage 2 Tendonitis Inflammation of tendon Can result due to forceful actions, and prolonged overhead work.</p> | | <p>Stage 5 Tendonitis, tenosynovitis, and bursitis can also worsen if there is osteoarthritis present in the shoulder due to rubbing against this rough surface.</p> | |
| <p>Stage 3a Tenosynovitis Inflammation of the synovial sheath as a protective response due to tendonitis</p> | | <p>Stage 6 Progressive micro tears of the muscles can also result due to rubbing against the rough bones and impingement.</p> | |
| <p>Stage 3d Tenosynovitis Swelling of the synovial sheath as a protective response due to tendonitis</p> | | | |

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59

What is Thoracic Outlet Syndrome (TOS)?



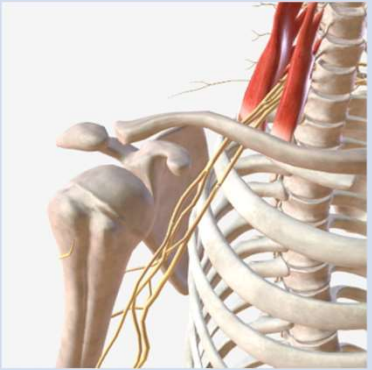
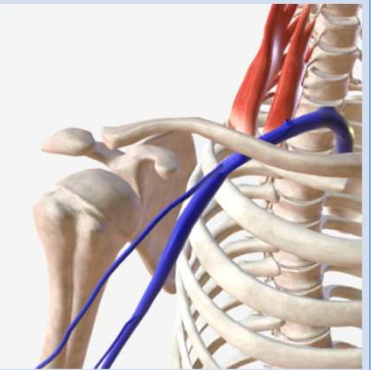
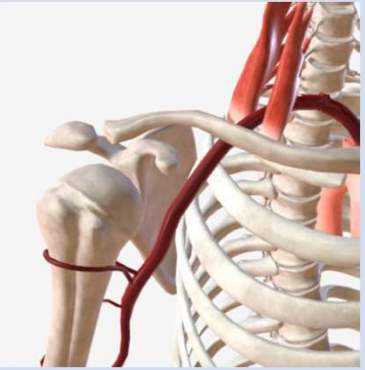
- Disorder that result in compression of one or more of the *neurovascular* structures (nerves or blood vessels) that travel through the passageway from the lower neck to the armpit (thoracic outlet)
- Compression of the nerves and blood vessels within the thoracic outlet can interrupt nerve signaling, while compression of the blood vessels can impact blood flow
- Commonly results from chronic or prolonged movements with arms elevated or overhead and from awkward and static postures of the head, neck, and shoulder girdle

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Types of TOS



| Neurogenic TOS | Venous TOS | Arterial TOS |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|  |  |  |
| 80% | 20% | < 1% |

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Images: <https://human.biodigital.com/>

61

Venous TOS



| | |
|----------------------|----------------------------------------------------|
| Incidence | Accounts for ~20% of TOS cases |
| Location | Costoclavicular space |
| Cause | Elevated/overhead arm use |
| Health Effect | Impeded circulation Oxygen/nutrient deprivation |



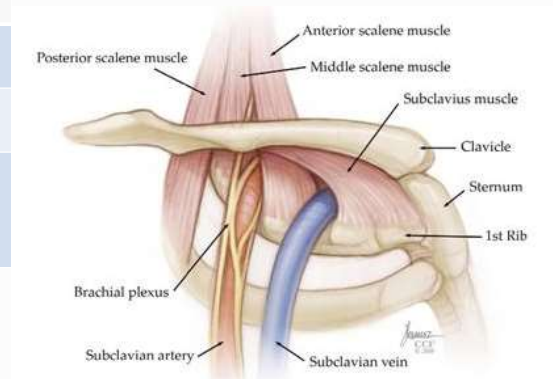
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62

Arterial TOS



| | |
|----------------------|-------------------------------|
| Incidence | Accounts for <1% of TOS cases |
| Location | Interscalene Triangle |
| Cause | Structural abnormalities |
| Health Effect | Ischemia Embolism |



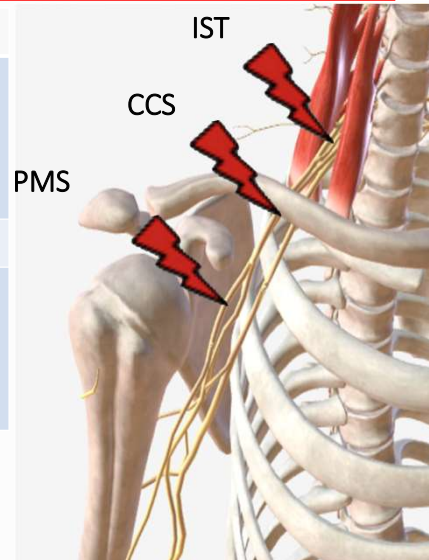
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63

Neurogenic TOS



| | |
|----------------------|-----------------------------------------------------------------------------------------------------------|
| Incidence | Accounts for ~80% of TOS cases |
| Location | IST = Interscalene Triangle CCS = Costoclavicular Space PMS = Pectoralis minor/ Retropectoral space |
| Cause | Various |
| Health Effect | Pain Numbness Tingling Cold Sensation |



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Image: <https://human.biodigital.com/>

64

Neurogenic TOS - Causes



1. Post-Traumatic Onset

- Acute Trauma
- Bone Fracture
- Whiplash



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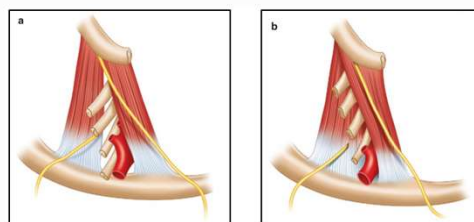
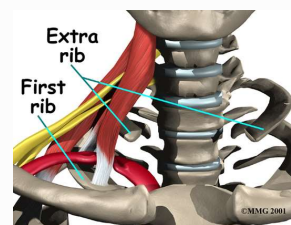
65

Neurogenic TOS - Causes



2. Structural Abnormalities

- Bone Abnormalities
 - Cervical Rib
 - Elongated C7 Transverse Process
- Muscular Abnormalities
 - Narrow Interscalene Triangle
 - Passage through anterior scalene muscle
- Fibrous Bands
 - Extra ligaments



Images: Sanders & Donahue (2021)

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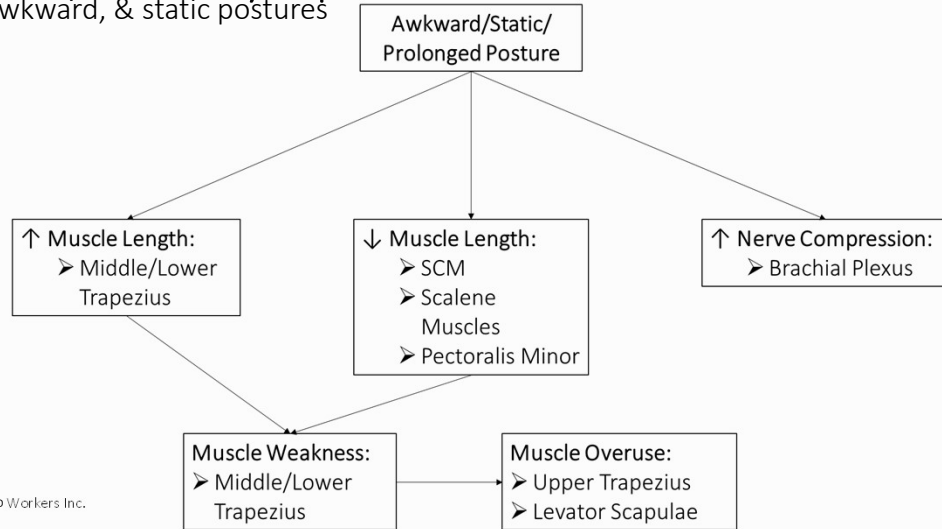
66

Neurogenic TOS - Causes



3. Work-Related/Functionally Acquired Causes

A. Prolonged, awkward, & static postures



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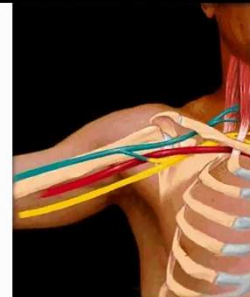
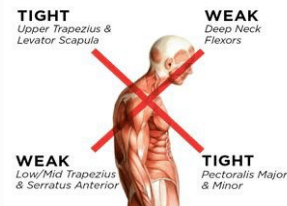
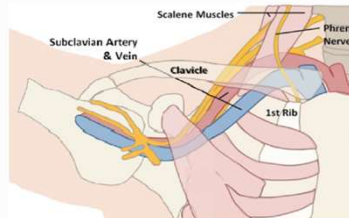
67

Neurogenic TOS - Causes



3. Work-Related/Functionally Acquired Causes

A. Prolonged, awkward, & static postures



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68



Neurogenic TOS - Causes

3. Work-Related/Functionally Acquired Causes

B. External Forces – Compression

- Ex. Carrying heavy shoulder loads, pulling shoulders back and down



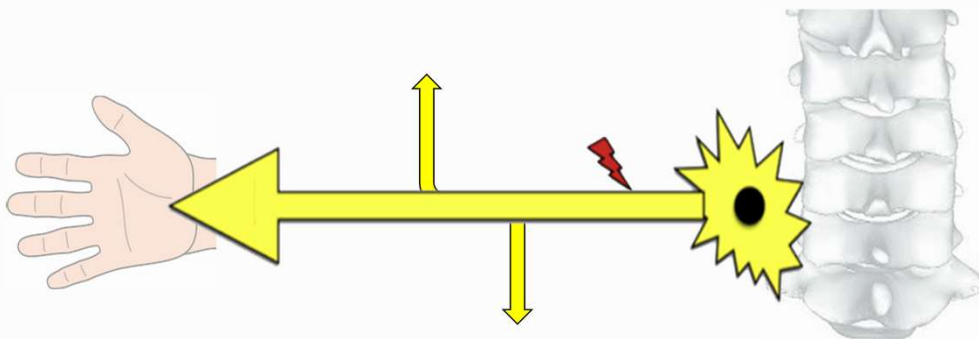
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Neurogenic TOS - Symptoms

- Symptoms can range from the neck and shoulder to the forearm and hand



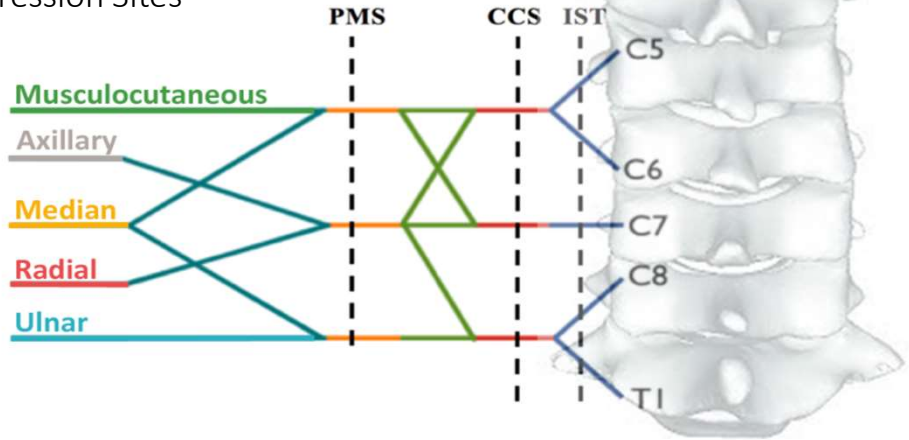
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70

Neurogenic TOS - Symptoms



Potential Compression Sites

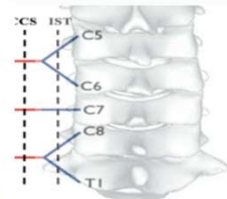
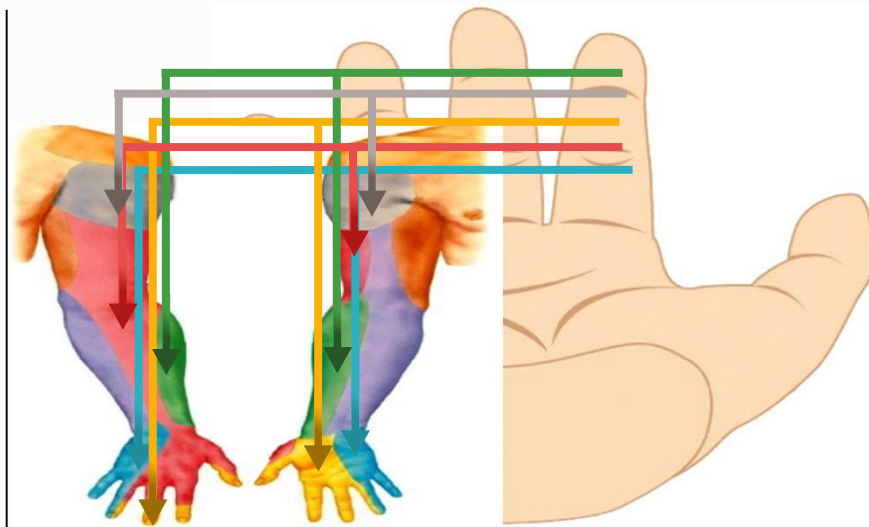


IST = Interscalene Triangle
 CCS = Costoclavicular Space
 PMS = Pectoralis Minor Space

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71

Neurogenic TOS - Symptoms



Symptoms of TOS can often manifest themselves as those similar to Carpal Tunnel Syndrome if branch to Median nerve is compressed

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72



Prevention

- Minimize Awkward Postures – Keep the upper arm below 60° of elevation.
- Minimize time spent in awkward postures
- Minimize reaching – get as close as you can
- Monitor the number of tasks that require overhead work.
- Change tools and/or equipment
 - Bit extensions for drills and screw guns that allow you to hold the tool at waist or shoulder level rather than above your head
 - Lower weight tools

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Prevention

Use a step stool, ladder, mechanical lifts or hoists to raise and position yourself closer to the work



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Prevention

- Use a tool balancer
 - Supports weights of tool



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75



Prevention

- Listen to your body. If your shoulder gets sore after any activity, don't ignore it.
- Take a break for a couple of minutes every hour. Move around and stretch.
- Avoid sleeping on your side with your arm stretched overhead. Try not to lie on your shoulder while you sleep.
- Don't smoke as it decreases blood flow to the rotator cuff.

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76

Prevention



- CRE/MSD Infographic <https://bit.ly/3ImqZio>
- CRE/MSD Video <https://bit.ly/3igXfca>

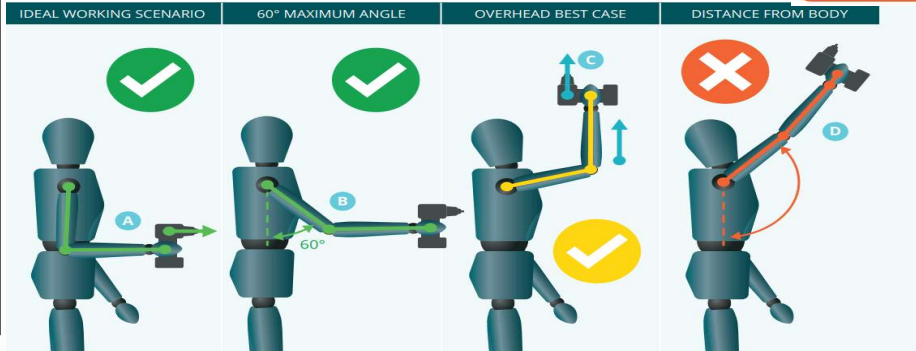
OVERHEAD WORK:

A known MSD risk strongly related to the development of shoulder and neck injuries and pain.

GREEN – No action required if tasks are not held or repeated for long periods and no MSD symptoms are reported. Continue to monitor for MSD symptoms and check after workplace or process changes.

YELLOW – Investigations and improvement needed in the longer term. Investigation and improvement needed immediately if MSD symptoms are present.

ORANGE – Further assessment or improvement needed immediately.



- A Eliminate overhead work when possible.
- B Keep the upper arm below 60° of elevation.
- C When required, design overhead work to reduce injury risk.
- D Avoid reaching far from the body.

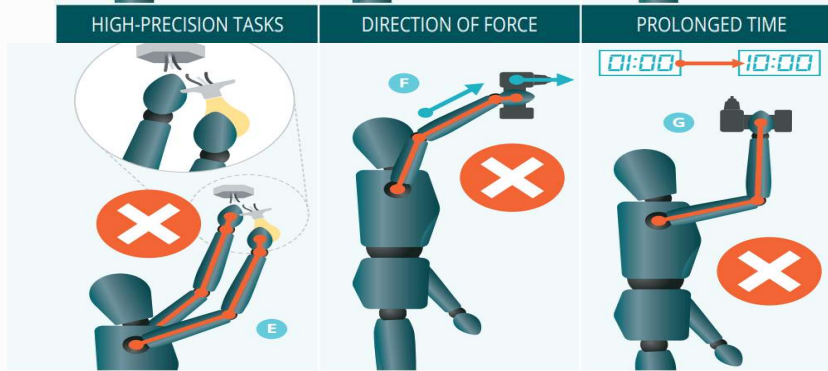
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77

Prevention



- CRE/MSD Infographic <https://bit.ly/3ImqZio>
- CRE/MSD Video <https://bit.ly/3igXfca>



- E Limit high precision overhead tasks (in frequency and duration).
- F Apply force in-line with the vertical (i.e. push straight up or pull straight down).
- G Rest often—take a 1 minute break after 10 minutes of continuous overhead work.

LEGEND

GREEN – No action required if tasks are not held or repeated for long periods and no MSD symptoms are reported. Continue to monitor for MSD symptoms and check after workplace or process changes.

YELLOW – Investigations and improvement needed in the longer term. Investigation and improvement needed immediately if MSD symptoms are present.

ORANGE – Further assessment or improvement needed immediately.

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78

Prevention

- CRE/MSD Infographic <https://bit.ly/3ImqZio>
- CRE/MSD Video <https://bit.ly/3igXfca>



Try to maintain shoulder postures in the green working range with only short bouts of work in the yellow and orange.

Ideas for Reducing Hazards when Working Overhead

- Keep arm elevations below 60° and don't elevate the arm above 90° for more than 10% of an entire work day.
- When possible, adjust tooling and/or workspace to decrease time spent working overhead.
- Perform work close to the body to avoid reaching.
- Ensure your arm is free to rotate.
- Ensure tasks completed overhead have low precision requirements.
- Keep the overhead applied force in the vertical plane.
- Use light-weight tools to reduce the load on your shoulders.
- Introduce rests to give the body time to recover.

Did you know?

- Overhead work fatigues muscles in the shoulder more quickly than non-overhead work.
- Increased exposure to overhead work is linked to increased severity of shoulder and neck injury and can include:
 - Decreased work performance.
 - Missed time from work.
 - Delayed return to work.
 - May contribute to chronic injury and inability to work.

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For more info visit: msdprevention.com

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Centre of Research Excellence for the Prevention of Musculoskeletal Disorders

Work shouldn't hurt

79

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80