

# Understanding Shoulder Injury

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**Abstract.** Discomfort, restriction of motion, pain, and injuries to the hard and soft tissues of the shoulder are a frequently reported occupational and non-work issue. Outside of trauma, shoulder-related issues often result from physical stressors in the individual's overall life, from individual and personal factors and life-style choices. This paper will discuss the ergonomic and individual/personal risk factors associated with the development of shoulder problems to improve understanding of the multitude of sources for shoulder pain and injury, and provide guidance toward reducing shoulder injury potential through effective task, tool, and work design as well as in educated injury and accident investigations.

**Keywords:** Shoulder injury · Risk factors

## 1 Introduction

The shoulder is one part of the biomechanical chain that begins with the hands and ends in the shoulder, neck/shoulder region. Loads, motions, and postures of the hands, forearm, and upper arm are balanced by the shoulder and to some extent by the region of the neck-shoulder region, so while this paper will address “shoulder” issues, the activities of the hands and arms and their impact on the shoulder and neck-shoulder region cannot be totally ignored.

Aches and pains in the shoulder region are not unusual and the overall frequency of shoulder-related disorders is second only to those for low back problems. Reported rates for shoulder problems are quite variable, depending on the definition of “problem,” with typical prevalence rates from 6% to over 26%, incidence rates of from 0.9% to over 2.6%, and with occupations, lifestyles, or sports with higher shoulder overuse having higher rates of complaints. [1–6]

## 2 Basic Shoulder Anatomy

The shoulder joint is the most complex and flexible joint in the body and is designed to allow considerable joint flexibility and motion rather than for overall strength and load bearing capacity. The shoulder consists of three bones, the scapula (shoulder blade), the humerus (upper arm bone), and the clavicle (collar bone); a large number of muscles

that support the scapula, the neck/shoulder region; and the actual shoulder joint and related supporting joints.

## **2.1 Bone Structure**

The scapula is the origin for many of the power, stability, and motion generating muscles of the shoulder joint. There is a bone projection called the acromion that goes from the back of the scapula upwards to the clavicle where it forms the acromioclavicular (AC) joint and a second projection from the front facing side of the scapula called the coracoid process that angles upwards to the AC joint region. The gap between the AC joint and the clavicle is called the subacromial gap. The AC joint and upper end of the coracoid process are connected by a strong ligament that stabilizes the AC joint and the coracoid process and also creates a strong covering over the subacromial gap that contains bursa and through which tendons and nerves pass from the scapula to the shoulder joint.

## **2.2 Shoulder Joints**

The primary joints in the shoulder are the Glenohumeral joint (GH) or the “shoulder joint” which is where the head of the humerus joins the shoulder joint on the scapula and three other shoulder supporting joints, the Acromioclavicular joint (AC), the Scapulothoracic joint, and the Sternoclavicular joint. These joints and associated muscles, tendons, and ligaments provide support and stability for the shoulder and the neck-shoulder complex. The GH joint is the primary joint involved in normal shoulder motion and the AC joint provides support and motion control of the shoulder and scapula, particularly with loads and awkward postures.

## **2.3 Shoulder Muscles and Their Actions**

The flexibility, load bearing, and control of the shoulder joint rely on a number of muscles in the scapula, shoulder, upper arm, torso, and neck-shoulder region. The muscles of the scapula, upper arm, and torso allow stabilization, elevation, and positioning of the GH joint, and the rotator cuff muscles, and the deltoid and upper arm muscles allow further posture control of the GH joint and the forearm. The GH joint itself is a loose ball and socket joint that has the rounded head of the humerus held in a shallow socket in the scapula by the long tendon of the biceps, the deltoid, and the four muscles of the rotator cuff, the Infraspinatus, Supraspinatus, Subscapularis, and the Teres Minor. Additional joint stability comes from a ring of fibrous tissue around the shoulder joint socket, the labrum that deepens the socket joint and is an attachment point for a number of the tendons of the rotator cuff.

The rotator cuff muscles connect the scapula to the humerus with their tendons passing around the head of the humerus, through and around the subacromial gap and surrounding bursa to their attachments on the head of the humerus and labrum. Additional motion and stability of the shoulder joint is provided by a number of muscles, including the Deltoid, Pectoralis Major, Infraspinatus, and Latissimus Dorsi.

### 3 Shoulder Injury

There is a wide range of shoulder problems that can range from transient not well-defined aches, pains, and soreness of the soft tissues of the shoulder often called nonspecific disorders, NSD's, to more serious conditions such as impingement, tendonitis, bursitis, arthritic changes and tears of the rotator cuff. While rates of different types of shoulder injury vary, for purpose of this paper, the most commonly reported shoulder problems are summarized next.

#### 3.1 Persistent Soreness, Pain

Persistent shoulder discomfort or NSD's are the most commonly reported shoulder problem and reflects the complexity of the shoulder and its response to overuse, aging, obesity, medical/personal issues, a more significant injury to the hard or soft tissues of the shoulder joint or, in some cases, radiating pain from a cervical spine injury. Psycho-social factors are also implicated in persistent shoulder soreness issues as stress can create static postures and loadings. NSD are of importance as they may reflect the early stage development of more significant injuries if exposures continue.

#### 3.2 Shoulder Arthritis

Arthritis generally refers to degenerative changes of the cartilage including cartilage thinning, development of holes in the cartilage as thinning progresses, bone to bone contact after cartilage loss, bone spurs, and alterations in bone form associated with these changes. Shoulder arthritis generally appears in the GH or AC joints and its development is associated with heavy physical work, a history of shoulder overuse, sports, sub-traumatic injury to the shoulder, some individual or personal conditions or more commonly, a combination of the above. The term "degenerative changes" is also used to describe these injuries or changes in the joint as well as to the changes in the tendons with overuse, aging, or trauma.

#### 3.3 Bursitis

Bursitis is the irritation and swelling of the soft lubricating sacs, the bursa, that surround the tendons and joints/bony projections. Bursa protect these structures and allow easy sliding of the tendons during shoulder and upper arm motions. Bursitis is associated with repetitive shoulder/arm motions, work with poor shoulder postures, static loadings, an impact or degenerative changes in this area, or more commonly, a combination of these factors. Age plays a role in bursitis as the lubricating power of the bursa decreases with age and with aging and overuse, the tendons also begin to wear and fray, possibly accelerating irritation of the bursa. While subacromial bursitis is most "common" due to the size of the bursa and its location in the subacromial gap, any of the other bursa can be affected.

### 3.4 Tendinitis

Tendonitis is an irritation or the damage/fraying of the tendons due to repetitive motion, outward arm rotation combined with abduction, overexertion, or static or awkward postures of the shoulder. The rotator cuff tendons and the supraspinatus tendon are particularly prone to this type of injury.

### 3.5 Impingement

Impingement (syndrome) results from the compression of the tendons of the rotator cuff, the subacromial bursa, and other soft tissues in the subacromial gap when the arms are extended overhead; with sustained or static work postures; hunched shoulders; and in tasks with the arms extended fully downwards with effort; Impingement can facilitate bursitis and arthritic changes in this joint region, bone spurs, thinning cartilage, fraying and tearing of the tendons in this region, and perhaps some types of frozen shoulder.

### 3.6 Frozen Shoulder (Adhesive Capsulitis)

This occurs when the joint capsule of the humerus head adheres to the shoulder blade, causing shoulder pain and stiffness. Static work with awkward or hunched shoulder postures and repetitive, heavy work with poor postures of the arms and shoulder and some types of bursitis are all linked to frozen shoulder syndrome.

### 3.7 Rotator Cuff Injuries

Pain, discomfort and injuries to the tendons and the muscles of the rotator cuff are a commonly reported problem and include discomfort/pain from tendonitis, changes in free movement, labrum tears, strains, degenerative changes, and tears to the rotator cuff muscles and tendons. A rotator cuff tear injury refers to the wearing, fraying, or degeneration of one of the four rotator cuff tendons, a physical tear of one of the tendons, a tear of the muscle itself or a partial or complete detachment of the tendon from its attachment point(s). Injuries to the rotator cuff result from an acute trauma to the shoulder, a fall onto an extended arm, regular or sudden rotation and abduction of the arm, a sudden heavy force on the hands when the arm is extended, exertion of effort with the hands with arms extended straight down, aging and general overuse of the shoulder. Injuries to the supraspinatus and infraspinatus are more frequently reported.

Rotator cuff tears/injuries are not always symptomatic and the rate of diagnosed non-symptomatic rotator cuff injuries is about two to three times the rate of symptomatic rotator cuff injuries. While tears are found in all age groups, individuals above 50 years of age show an increase in both symptomatic and asymptomatic [7–9].

## 4 Personal and Ergonomics Risk Factors

Personal or individual features and ergonomics stressors/risk factors are both significantly associated with an increased potential for development of shoulder problems of all types. Both types are usually present at the same time with the risk of shoulder injury related to the number of risk factors present [10].

Individual or personal factors such as age, sex, BMI, sports, and home activities can influence the development of shoulder injury but the picture is far from conclusive, clear, or consistent due to how data is collected and interpreted. It is also not clear if the same sets of individual/personal risk factors apply to both sexes, suggesting other factors may be in play. Some general or least contested examples include the following:

### 4.1 Age and Sex

While shoulder injuries appear in both sexes across all ages with males generally having a higher rate than females, there is an increase in shoulder problems, injuries, and degenerative changes of the shoulder after 50-years of age with the type of injury often highly associated with occupation, years of exposure to shoulder stressing activities/work, lifestyle, sex, and perhaps psychosocial factors [1, 2, 4, 9–13].

### 4.2 Prior Upper Extremity Injury

A prior, significant musculoskeletal injury to the upper extremity is regularly reported as increasing the potential for a later upper extremity injury, including the shoulder [13]. The exact reasons for this are not clear.

### 4.3 Obesity

This does not appear to be a singular issue independent of other medical issues, age, sex and occupation, but obesity does seem to become an issue in rotator cuff problems and “other shoulder pain and injury” as the BMI reaches 35.

### 4.4 Genetics

This is a complex and controversial issue as conclusions linking shoulder problems with genetic issues are often not well distinguished from effects of sex, age, and history of shoulder straining exposures [7, 14]. Genetics, as it applies to injury causality or association is an area beyond the scope of this paper.

### 4.5 Smoking

Smoking appears to have an adverse impact on shoulder pain, injury, and rotator cuff injury and tears, apparently due to the reduction in oxygen blood uptake in smokers that

can delay healing of injury. Other well-constructed studies of shoulder injury do not find strong support for this position [4, 13].

#### 4.6 Sports Activities

Outside of intense, shoulder straining sports, sporting activities seem to have a mixed impact on shoulder problems [15].

### 5 Ergonomics Risk Factors

Ergonomics risk factors associated with shoulder problems include posture, exertion of effort, frequency, static postures, and hand-arm vibration. Almost always, a multitude of these risk factors are present at any one time which makes determining any unique contribution more difficult outside of well-controlled field studies or in a laboratory. As noted above, there is an increasing risk of shoulder overuse/injury as the number of these risk factors present in a task/activity increases.

#### 5.1 Posture

Posture of the shoulder and the upper arm is referenced to a neutral or relaxed posture of the body where the arms are alongside the body. Motions of the arms-shoulder from this neutral posture around the body are defined in terms of abduction, adduction, flexion and extension of the shoulder-arm, and lateral or medial rotation of the arm. Awkward shoulder postures are generally considered as those activities requiring overhead work, work with hands above the shoulder, work with arms/hands behind the midline of the body, abduction of shoulders/elbow away from the body, static work in these postures.

Awkward, static, or extreme postures of the shoulder/upper arm have long been linked with the potential for development of shoulder pain and injury, particularly when other risk factors are present [4, 16]. The reviews of the scientific literature on musculoskeletal disorders, and shoulders in particular indicate there is evidence for a significant increase in shoulder problems when shoulder flexion or abduction exceeds 60°, perhaps as low as 45° [4, 12, 17–20]. From a physiological perspective, there are significant reductions in blood flow and increased tissue fatigue with arm angles as low as 30° indicating a second limiting or cautionary posture threshold to be considered, possibly explaining the large number of shoulder problems with computer based work with abducted arms/elbows, extended, abducted and externally rotated arms for mouse use [21].

#### 5.2 Repetition

Repetition is the frequency with which a shoulder/upper arm motion is repeated and may be referenced to duration of an activity, or a static posture. The various references on shoulder injury all indicate there is evidence for a general adverse effect of “high

frequency” (repetition), and for static or long duration activities but that it must be considered with other risk factors [17–19].

### 5.3 Hand Arm Vibration (HAV)

Hand-arm vibration is usually combined with tool weight and static postures from holding the tool, and HAV intensity and frequency content. Occupations with high (intensity or duration) HAV exposures have higher rates of shoulder injuries, tendinitis and arthritis in particular [11, 15, 22].

### 5.4 Heavy Work, Exertion of Effort

Work that is defined or considered as heavy, intense, or “shoulder straining” by observation, employee reports, or actual loads reports is consistently identified as a risk factor for shoulder pain and injury. While there is little clear definition on what is an acceptable load/exertion to protect the shoulder in all types of work, an upper maximum of a 10 kg load lifted/handled overhead, 25 kg for straight arm exertions with hands below knee level, and 50-kg for pushing pulling tasks are common. The various review of shoulder injury all note that load/exertion is combined with the other ergonomic risk factors as well as personal ones.

### 5.5 Psychosocial Factors

Psychosocial factors are a grouping of job and job-related interpersonal factors or conditions that were once ignored or grouped into “job stress”. These factors include, but are not limited to lack of control of work and work pace, job ambiguity, paced work, and co-worker and supervisory interpersonal issues. While these are not as clearly controlled or quantified as ergonomics or individual risk factors, they can have an impact on the development and reporting of neck- shoulder injuries.

### 5.6 Shoulder Safety Recommendations/Guides

There is a general understanding of the *outer* bounds of tolerable or least stressful shoulder straining activities and postures in work and lifestyle activities. But as discussed by a number of authors, there is a lack of consistency in defining ergonomics and personal risk factors associated with shoulder injury to allow highly specific, cross task, population and age definitions of acceptable exposures [6, 19].

However, there are a number of recommendations on task/postures and loadings that are recognized as having potential for shoulder overuse, recommendations that can be used to increase alertness and appropriate response to injuries or complaints of shoulder issues. These include the following:

- Regular, repetitive, or sustained work with hands at or above shoulder or head level.
- Work requiring frequent, long reaches in front of the body.
- Lifting loads of 10 kg or more above shoulder level.

- Work that requires regular, frequent or sustained awkward postures of the shoulders, arms.
- External rotation of the hand-arm with abduction.
- Tasks requiring regular or sustained hunched shoulders such as in computer work, hand assembly.
- Elbow-shoulder abduction of more than 20 – degrees.
- Using heavy, vibrating tools.
- Regular or frequent abduction or flexion of the upper arm of more than 60°.
- Exerting effort with arms extended below knee level.
- Pushing-pulling loads of more than 50-kg.
- Sustained work with elbows abducted more than 30° and abducted and extended more than 30°.
- Working for more than 10% of a work cycle with 90° or more of shoulder flexion or extension.

## References

1. Bodin, J., Ha, C., Le Manach, A.P., Serazin, C., Descatha, A., Leclerc, A., Goldberg, M., Roquelaure, Y.: Risk factors for incidence of rotator cuff syndrome in a large working population. *Scand. J. Work Environ. Health* **38**(5), 436–446 (2012)
2. Bodin, J., Ha, C., Serazin, C., Descatha, A., Leclerc, A., Goldberg, M., Roquelaure, Y.: Effects of individual and work-related factors on incidence of shoulder pain in a large working population. *J. Occup. Health* **54**, 278–288 (2012)
3. Gold, J.E., d'Errico, A., Katz, J.N., Gore, R., Punnett, L.: Specific and non-specific upper extremity musculoskeletal disorder syndromes in automobile manufacturing workers. *Am. J. Ind. Med.* **52**(2), 124–132 (2009)
4. NIOSH, National Institute of Occupational Health and Safety: Musculoskeletal Disorders and Workplace Factors: A critical review of the epidemiological evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back. DHHS (NIOSH) Publication, pp. 97–141 (1997)
5. Sommerich, C.M., McGlothlin, J.D., Marras, W.S.: Occupational risk factors associated with soft tissue disorders of the shoulder: a review of recent investigations in the literature. *Ergonomics* **36**(6), 697–717 (1993)
6. van der Windt, D.A.W.M., Thomas, E., Pope, P.D., de Winter, A.D., Macfarlane, G.J., Bouter, L.M., Silman, A.J.: Occupational risk factors for shoulder pain: a systematic review. *Occup. Environ. Med.* **57**, 433–442 (2000)
7. Lashgari, C., Redziniak, D.: The natural history of rotator cuff tears. *Curr. Orthop. Pract.* **23**(1), 10–13 (2012)
8. Minagawa, H., Yamamoto, N., Abe, H., et al.: Prevalence of symptomatic and asymptomatic rotator cuff tears in the general population: from mass-screening in one village. *J. Orthop.* **10**, 8–12 (2013)
9. Yamamoto, A., Takagishi, K., Osawa, T., et al.: Prevalence and risk factors of a rotator cuff tear in the general population. *J. Shoulder Elbow Surg.* **19**, 116–120 (2010)
10. Harkness, E.F., Macfarlane, G.J., Nahit, E.S., Solman, A.J.: Mcbeth: Mechanical and psychosocial factors predict new onset shoulder pain: a prospective study of newly employed workers. *Occup. Environ. Med.* **60**, 850–857 (2003)



11. Miranda, H., Punnett, L., Viikari-Juntura, E., Heliövaara, M., Knekt, P.: Physical work and chronic shoulder disorder: results of a prospective population-based study. *Annu. Rheum. Dis.* **67**, 218–223 (2008)
12. Punnett, L., Fine, L.J., Keyserling, W.M., Herrin, G.D., Chaffin, D.B.: Shoulder disorders and postural stress in automobile assembly work. *Scand. J. Work Environ. Health* **26**(4), 283–291 (2000)
13. Silverstein, B.A., Bao, S.S., Fan, Z.J., et al.: Rotator cuff syndrome: personal, work-related psychosocial and physical load factors. *J. Occup. Environ. Med.* **5**, 1062–1076 (2008)
14. Rhode, B.A., Rhode, W.S.: Occupational risk factors for shoulder tendon disorders 2015 update. *MOJ Orthop. Rheumatol.* **3**(4) (2015)
15. Miranda, H., Viikari-Juntura, E., Martikainen, R., Takala, E.-P., Riihimäki, H.: A prospective study of work related factors and physical exercise as predictors of shoulder pain. *Occup. Environ. Med.* **58**, 528–534 (2001)
16. Bjelle, A., Hagberg, M., Michaelsson, G.: Clinical and ergonomic factors in prolonged shoulder pain among industrial workers. *Scand. J. Work Environ. Health* **5**, 205–210 (1979)
17. Beach, J., Senthilselvan, A., Cherry, N.: Factors affecting work-related shoulder pain. *Occup. Med.* **62**(6), 451–454 (2012)
18. Melhorn, J.M., Almadge, J.B., Ackerman III, W.E., Hyman, M.H.: *AMA Guides to the Evaluation of Disease and Injury Causation*, 2nd edn. AMA, USA (2014)
19. Punnett, L.: Musculoskeletal disorders and occupational exposures: how should we judge the evidence concerning the causal association? *Scand. J. Pub. Hlth.* **42**(13), 49–58 (2014)
20. Svendsen, S., Bonde, J.P., Mathiassen, S.E., Stengaard-Pedersen, K., Frich, L.H.: Work related shoulder disorders: quantitative exposure-response relations with reference to arm posture. *Occup. Environ. Med.* **61**, 844–853 (2004)
21. Chaffin, D.B., Andersson, G.B.J., Martin, B.J.: *Occupational Biomechanics*, 4th edn. Wiley, New York (2006)
22. Lashgari, C., Redziniak, D.: The natural history of rotator cuff tears. *Curr. Orthop. Pract.* **23**(1), 10–13 (2012)

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