Occupational Risk Factors for Shoulder Tendon Disorders 2015 Update

Abstract

Evidence for work-related exposure as a cause of shoulder tendinopathy is updated. Previous studies indicated that forceful movements combined with hands above head increases the likelihood of shoulder disorders. Hands above the shoulder and arm flexion or abduction at greater than 60° combined with forceful or repetitious motions results in significantly increased occurrence of shoulder tendinopathy. Shoulder disease is multifactorial with genetics, age, and bodyweight correlated with increased occurrence though they are minor factors for young workers. Normal aging of the rotator cuff may underlie much of shoulder disease for individuals older than 60 thereby presenting a complication for the determination of work-related rotator cuff tears in this group. In contrast, there is sufficient evidence to support work-related musculoskeletal disorders of the shoulder in younger individuals who have not undergone the aging processes. Numerous reviews along with individual cross sectional and longitudinal studies conclude that shoulder tendinopathy can result from work-related exposures based on the odds and relative risks of occurrence in a working population compared to a group that has not been similarly exposed to comparable manual effort.

Keywords: Rotator cuff; Tendinopathy; Musculoskeletal; Worker's comp; Forceful; Repetition;

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Abbreviations: RCT: Rotator Cuff Tear; MRI: Magnetic Resonance Imaging; MSD: Musculoskeletal Disease; AMA: American Medical Society; BLS: Bureau of Labour Statics; NIOSH: National Institute of Occupational Safety And Health; OR: Odds Ratio; BMI: Body Mass Index; EMG: Electromyography; RCS: Rotator Cuff Syndrome; IME: Independent Medical Evaluation; SIS: Shoulder Impingement Syndrome

Background

Work-related upper extremity musculoskeletal disorders (WRUEMSDs) which include carpal tunnel syndrome, tendinitis and arthritis are associated with high costs to employers due to absenteeism, lost productivity, increased health care costs, along with disability and workers' compensation costs. Bureau of Labor Statistics (BLS) in 2012 reported nonfatal occupational injuries totaled 1,153,980 cases with a median 9 days away from work which is equivalent to 41,543 years of work [1].

Tendinitis or shoulder injuries constitute a significant portion of workplace injuries and are often linked to overhead work [2]. Significant time is lost along with significant expenses associated with this disability. BLS stated that shoulder injuries accounted for 13.6% of musculoskeletal disorders (MSDs) claims irrespective of occupation. Rotator cuff tendons are dependent on their structure and cellular organization for function and response to physiologic loading. Tendons have a non-linear, viscoelastic response to applied cyclic tensile loads. Overstimulation of tendon through either single or repetitive loading results in collagen fibril damage. Repetitive loading may lead to mechano-biological overstimulation and hence degenerative processes that determine cell fate. The precise loads necessary to induce degenerative processes depend on age, sex, and location.

Overhead work with arm (humeral) abduction is associated with the development of pain and injury [3-6]. Overhead work has a several-fold increased risk for shoulder disorders [7-10]. Injury severity is linked to cycle time of the overhead workload [11] along with more tissue damage due to increased exposure to overhead postures [12]. Lifting weights >10 kg above the shoulder even for short periods resulted in significant risk for shoulder pain [13].

Recently AMA undertook an exercise to update the MSD science, expand the focus and overall improve the understanding of causation of Disease which resulted in the 2nd Ed of the AMA Guides® to the Evaluation of Disease and Injury Causation [14]. The findings relating rotator cuff disease or shoulder impingement syndrome (SIS) causation are similar to those of the earlier NIOSH review [15]: First, strong evidence for sustained awkward postures with >60° of arm flexion or abduction. Second, some evidence for highly repetitive work alone or in combination with other factors such as very high job structural constraints or forceful exertions or forceful pinch. Third, insufficient evidence for an effect resulting from forceful work based on the earlier NIOSH (1997) review. In contrast, a study of physical work factors conducted in random sample of workers in France found that manual male workers had more than twice the rate of rotator cuff syndrome (RCS) than non-manual workers. The conclusion was that manual workers are at high risk for upper limb disorders [16].

Rotator cuff (RC) injuries have been classified as intrinsic when that tendon injury results from direct tendon overload, intrinsic degeneration, or other insult. RC injury mechanisms are

extrinsic when: 1) the tendon is damaged through compression against surrounding structures usually the coracoacromial arch [17]; 2) Elevation of the arm may either tear or squeeze subacromial tendon structures [18]; and 3) Microcirculation in the tendon is impaired by high intramuscular pressure resulting in inflammation (tendinitis) leading to degeneration [19]. It is not always clear which of these three injury mechanisms explains a patient's RC injury and overuse likely affects both intrinsic and extrinsic factors.

The overuse theme is common for workers in industrial occupations that perform repetitive manual tasks resulting in an increased prevalence of shoulder disorders [20,21]. For example, prevalence rate of shoulder pain among cashier workers exposed to repetitive work was 28.9% compared to 16% in an unexposed group [22]. Both repetition and force requirements contribute to increased risk of shoulder tendonitis with a 3.7% rate in a Danish population of 4162 workers [23]. Other studies reported worker shoulder tendinitis rates of 2.7% in textile workers [24], up to 10% in slaughter house workers [21], 15% in fish processing workers [25], and 32% among rock blasters [26].

Cause-effect assignment becomes increasing difficult in older workers. Tendons weaken, inflammation occurs, rotator cuffs tear with increasing age. Asymptomatic individuals older than 70 have been demonstrated to have rotator cuff tears at a rate as high as 70% [27]. The question is when shoulder tendonitis is a result of work exposure and when is it due to natural causes and therefore idiopathic [28]. Morphological aging of the shoulder versus work-related exposure has to be addressed as it is critical for worker compensation decisions. Exposure-response patterns must be analyzed to better determine clinical attribution to workplace factors with age taken into consideration.

Diagnosis

A patient's history is taken followed by a complete physical examination consisting of inspection, palpitation, range of motion, strength testing, neurological assessment, and special shoulder tests. Tests include weakness in external rotation, a positive drop-arm sign, and painful arc of motion. If a patient is > 60 years and has a positive Neer or a Hawkins-Kennedy impingement sign with weakness in abduction, there is a 98% chance of a full-thickness RCT [29]. Hawkins-Kennedy is fairly specific for diagnosing supraspinatus tears. All important in worker's comp cases is assignment of cause that often relies on a self-reported questionnaire to understand exposure which can be subject to confounding factors though it is often the only method available.

Imaging the shoulder is essential to document rotator cuff tears. Ultrasound (US) imaging is almost equally effective in detecting partial tears of the rotator cuff compared to MRI, particularly when the tear is located in the area of the supraspinatus tendon. US have significantly lower costs than MRI imaging. MRI may be reserved for doubtful or complex cases, in which delineation of adjacent structures is mandatory prior to surgical intervention [30,31].

Worker overexposure can result in shoulder tendinopathy, a progressive disease mostly defined by pain and loss of function. Overexposure can be due to repetitive cycling of arm motions,

arm flexion or abduction > 60° while performing forceful tasks. Tendons exhibit plastic deformation which can occur with repeated motions. A variety of research paths are being addressed to better understand the tendon complex in use [32].

Because there are multiple risk factors associated with shoulder disorders including trauma, overuse, inflammation, age-related tissue degeneration, and smoking, a careful history is required to sort out injury and causation [33]. Age is a significant factor in developing tendinopathy and it becomes a dominant factor for patients > 60 years old [27]. Occupational history detailing work exposure is essential. Patients complain that they cannot perform regular job duties, such as lifting overhead, pushing heavy objects, or performing tasks that require arm motion.

Because MSDs are a major cause of mobidity throughout the world there is increasing attention devoted to its multifactorial nature. In particular, the co-occurrence of physical and psychophysical risk factors are important [34-37]. For example, socio-economic position has been shown to be associated with a higher risk of MSD.

Discussion

Overhead work and shoulder tendinopathy

In the NIOSH review of 20 epidemiological studies conducted before 1997 of musculoskeletal disorders (MSDs) in the workplace, workers who had high levels of exposure to those with low levels of exposure [4]. After taking into account the issues of confounding, bias, and strengths and limitations of the studies the several conclusions were reached. First, there is evidence for an association between highly repetitive work and shoulder MSDs. Second, there is epidemiologic evidence for a relationship between repeated or sustained shoulder postures with more than 60° flexion or abduction. Third, there is evidence for a positive effect of shoulder postures combined with other factors such as holding a tool while working overhead on shoulder tendinitis.

Multiple studies concluded shoulder trauma results from working with hand(s) above the shoulder. For example, overhead welding involves heavy static loading on the supraspinatus muscle and has been shown with EMG recording that it was consistently fatigued within a minute when the arm is raised [38-40]. Height of the hands in relation to the shoulder determines the shoulder work load [7]. Mechanical pressure on the tendon from the acromion is greatest between 60° and 120° of arm elevation [41]. Upper arm elevation is a factor in the onset and intensity of fatigue in the trapezius, deltoid, and rotator cuff muscles [42]. Increased shoulder tendonitis results from repetitive work and force requirements along with lack of recovery time [23,43]. With the forearm extended the rotator cuff muscles play an important role in generating the shoulder torque. Large supraspinatus contraction forces could increase the avascularity of the tendon thereby resulting in tendonitis [44].

Overhead work that consists of working with the hands above the acromium or over 60° flexion or abduction occurs frequently in both the construction and manufacturing industries [45]. Both work capacity and joint strength are reduced when the hands are overhead along with a greater risk for injury [4,6,44]. The largest odds ratios (OR) for shoulder disorders were found for work

above acromium height [7,44]. Clinical exams, radiography and EMGs were used to evaluate the effect of heavy industrial work on welders in a shipyard [38]. They found muscle fatigue was common in the supraspinatus muscles during prolonged overhead work. Because of their work-related exposure welders seldom are able to continue working beyond the age of 60. A review of rotator cuff tendinitis in occupational groups with work at shoulder level that included shipyard welders, plate workers, and male office workers showed an odds ratio of 11 and an aetiological fraction of 0.91[46].

In addition to overhead work, handling heavy loads (>20 kg) or handheld vibration were exposure factors included in a study of 483 males with radiographically confirmed tears of the supraspinatus. Adjustment of the ORs was made for age, region, lifting/carrying heavy loads, work above the shoulder level, handheld vibration, and any sports apparatus use. After adjustment all OR increased with duration of each factor up to: OR =1.8 for cumulative lifting and carrying heavy loads, OR = 3.2 for handheld vibration over 16 years on the job, and OR = 2.0 for cumulative work above shoulder level greater than 3195 hours. The unadjusted ORs were all nearly double the adjusted. Postal workers have shoulder complaints that vary from 13 to 23% after only 5 months on the job [47].

Recent studies continue to address aspects of overhead work: the effect of cycle time on shoulder fatigue [11] and the effects of overhead work configuration on muscle activity [48]. Interactions between point of force application and direction were noted through the use of EMG recordings from shoulder muscles thereby demonstrating that this is a multidimensional environment. There was a large variability in participant strategies in performing the overhead task which contributed to variable outcomes. Not surprisingly work above the head with upward exertion and a far reach requires the highest muscle demand. Overhead work is pervasive in various industrial settings and results in upper extremity discomfort and disorders. These study results are intended to assist evidence-based approaches to overhead work environments and the reduction of muscular exposure.

The frequently cited RCS study of 733 workers conducted in Washington State worksites included electronics, automotive parts, windows, cabinets, medical and fitness equipment concluded that arm flexion with long duration and forceful exertion are the principal exposure factors. All subjects were observed by ergonomists on-site and videotaped for task evaluation. RCS was been shown to occur when upper arm flexion is >45° for a sufficient period (>9% duty cycle) with an odds ratio of 2.59 after employing multiple logistic regression models that adjusted for age, gender, and BMI [49]. While age > 60 is a significant factor in the development of RCS, 38% of workers with RCS were under the age of 40. A second exposure condition that resulted in RCS was flexion ≥ 15% AND pinch grip force ≥0% resulting in OR = 2.75. For workers that had high job strain ratio (high demands-low control) the association with frequency of high forces was significantly higher than those in other job strain categories with an OR = 3.7 vs OR = 1.48 while the results for intermediate frequency of high force was OR = 4.18 to OR = 0.57. The final conclusion was that elevated ORs were obtained when upper arm flexion was >45° combined with forceful exertion which appeared to be primarily related to forceful pinching. A caveat is that the most severely

affected workers may not be present in this sample because they were off the job due to the severity of their MSD. Workers with milder symptoms were able to continue working. Noteworthy is that arm elevation > 45° was identified as sufficient for increased RCS.

A prospective study over a 2.5 year period of 41 young adults that included 15 hair-dressers, 15 electricians and 11 others with various exposures suggested that work with prolonged arm elevation > 60° is an early work-related risk factor among women [50]. Arm elevation was measured with inclinometers during a full working day and twice in the follow-up period. Data were stratified by gender after adjusting for time, mechanical workload, work demand, physical activity, tobacco use and prior shoulder pain. Repeated shoulder pain measurements were made. Another study addressed both physical and psychosocial factors in the development of musculoskeletal pain (MSP) in a large population of 12,591 subjects [35]. Forceful effort or vibrations were associated with multisite MSPs in men while women had risk for neck/shoulder pain associated with psychological factors along with highly repetitive movements. Job stress and worker adaptability influence the development of MSP.

Shoulder joint loads

Direct measurements of gleno-humeral joint loads have recently been made [51]. The first data recorded from a shoulder implant showed forces higher than 100% bodyweight along with high moments. A shoulder endoprothesis consisting of 6 strain gauges and 9-channel telemetry measures to contact load between glenoid and humeral head was implanted in six patients. Moments and forces for forward flexion and abduction motions were measured during arm motion to 90° and return to 0°. Two important points: significant moments and forces were noted starting around 45° flexion and abduction with values approaching 50% of those at 90° and 'significant' variation among the five patients recorded [52]. The variation noted is important as it indicates that 'one size does not fit all'.

Sudden forces

Occasionally trauma can ensue due to sudden forces on the RC. This was demonstrated in a study of eight healthy young males (average age = 25 yrs) with no history of shoulder pathology that were tested in a driving simulator [53]. Exposures were quantified by applying a musculoskeletal modelling approach was in combination with the UK National Shoulder Model. High muscle activation was predicted; particularly in the supraspinatus with up to a 164 N (SD 27 N) load. The study results indicate that most driving conditions result in moderate (>30%) to high activation (>50%) of supraspinatus and deltoid. Repeated high muscle activation could lead to muscle fatigue or even overload; particularly since the supraspinatus and deltoid are potentially loaded eccentrically [54]. This level of loading is up to 72 % of mean supraspinatus failure rate and likely could be exceeded in normal driving conditions especially for truck drivers. This apparently is the case as BLS [1] statistics for 2013 indicates MSD incidence rates and counts for private sector heavy and tractor-trailer truck drivers increased. MSD incident rate for truck drivers was 322.8 cases per 10,000 full-time workers (up from 279.6 in 2012)--and was more than three times greater than the rate for all private sector workers.

Repetitive motion and MSDs

The effect of repetitive motion on a tendon has been a subject of intense research for years with a current focus on damage and repair though the etiology remains unclear. It has been shown that mechano-biological under-stimulation can induce apoptosis in tendon cells [55]. An argument has been advanced that a result of under stimulation of tendon cells, secondary to microtrauma and isolated collagen fibril damage, predisposes pathological changes reported in clinical cases or tendinopathy [56]. The loss of cells could compromise the tendon's ability to repair itself.

Prevalence of rotator cuff disease with increasing age

One clear factor that affects the prevalence of rotator cuff disease is age. Reports indicate that by the age of 70 years the rate of asymptomatic RCTs can be as high as 60 to 70% of the population [27]. A study of autopsy specimens demonstrated that there was a progressive degeneration of all the elements of the tendinous structures of the shoulder with age [57]. Due to normal degenerative tendon functioning with increasing age it has been hypothesized that this is a normal common aspect of human aging and as such makes it difficult to determine causal relations [28,58-60].

There is an increase in rotator cuff disease with age Rotator cuff tears were for the most part absent in for individuals younger than 40 while they were found in nearly 50% when individuals were over 70 years for residents on a mountain village in Japan [27]. RCTs in the elderly patients were most frequent in those engaged in heavy labour, having a history of trauma, and positive for an impingement sign. A second factor involves acromial pathology leading to impingement that increases the likelihood of RCTs. Acromial shape appears to progress from type I to III reaching as high as 93% of those over 70 years [60,61]. In a measure of increasing rotator cuff disease with age in Finland it was noted that repairs more than doubled in patients over 45 from 1998 to 2011 and few repairs in individuals < 45 [62]. Kim reported RCT rates as: 0% for < 40; 10% for 40-49; 20% 50-59; and 40.7% for >70 [63]. Tempelhof et al. [59] noted in an ultrasound study of 411 patients that in a 50 to 59 years group there was a 13% RCT rate, and that the rate increased successively with age to 51% for those over 80 [59]. It was concluded that RCTs with 'advancing age' are to a certain extent a normal condition of the 'asymptomatic' shoulder population. An important take away from these studies is that for workers < 50 years old that there is a relatively small probability that an RCT is idiopathic. One can conclude that work exposure is the principal factor in shoulder tendinopathy.

Longitudinal studies of shoulder tendinopathy.

Concern has been expressed regarding the conclusions reached for MSD causes due to reliance on cross-sectional studies which have some limitations because the population is analysed at only one instant in time. One alternative is the use of longitudinal studies that follow the population over time. Mayer et al. [64] conducted a review in 2012 of the limited longitudinal studies of work-related neck and shoulder complaints [64]. Based on their selection criteria 21 of 2203 articles were included in their review. They employed a rating system to identify articles with strong evidence. Three high-quality studies examined manual material handling effect on shoulder symptoms (lift, pull/ push carry, holding) and found a positive association (1.39 < OR < 4.86). Three additional studies reported a positive relation (1.5 <

OR < 2.36) resulting in the authors considering this association to be strong. Four high-quality longitudinal studies found shoulder disorders to be associated with repetitive work with ORs of 1.59, 2.3 and 4.34. An association between shoulder pain and vibration was also found. Compared to the NIOSH report that found insufficient evidence for a positive association between force and shoulder MSDs they found a strong positive relation that they remarked could be due to studies conducted after 1997 the time limit of the NIOSH report.

Contemporary perspective

Recently AMA undertook an exercise to update the science, expand the focus and overall improve the understanding of causation of Disease which resulted in the 2nd Ed of the AMA Guides® to the Evaluation of Disease and Injury Causation in 2014 [14]. The findings relating rotator cuff disease or shoulder impingement syndrome (SIS) causation are similar to those of the NIOSH review: 1) Strong evidence for sustained awkward postures with >60° of arm flexion or abduction. 2) Some evidence for highly repetitive work alone or in combination with other factors such as very high job structural constraints or forceful exertions or forceful pinch. 3) Insufficient evidence for forceful work based on the earlier NIOSH (1997) review while Melchior et al. [16] in a study of physical work factors in random sample of workers in France found manual male workers were more than twice the rate at risk for rotator cuff syndrome as non-manual workers [16]. They concluded that manual workers are at high risk for upper limb disorders.

In response to those who continue to debate whether MSDs are sometimes work-related, even for those performing repetitive and routinized tasks, heavy lifting, and/or with postural strain, Punnett raised the question of what should be considered the gold standard for determining the health effects of non-voluntary exposure in an occupation [65]. She points out that there have been thousands of studies documenting the relation between upper extremity MSDs and occupational exposure to repetitive motion, heavy lifting, posture, vibration and other stressors. MSDs affect a large proportion of workers in every country where studies have been performed [66]. The question arises as to whether this high rate of occurrence implies that MSDs result from factors that are not preventable, such as age and gender. While there are likely common risk factors in the population, there are likely specific risk factors in certain working groups. When differences in results arise they can arise from operational definitions of ergonomic exposure and case definitions employed in the study. Furthermore, the U.S. National Research Council concluded that "The evidence justifies … [identifying] work-related risk factors for the occurrence of MSDs of the low back and upper extremities." While Random Controlled Trials are considered the gold standard they are often not feasible or even ethical to assess the health effects of factors in the workplace to which people have been exposed. With the widespread occurrence of MSDs and consideration of the costs of preventing or compensating, it should not be the case that these factors obscure the weight of evidence implicating excessive physical workload in their etiology.

In a 2015 update of the NIOSH Quality of Work Life survey of MSD risk factors covering the 2000 year decade that there is a relationship between MSDs and physical exposure variables [67]. In addition psychosocial risk factors appear to influence outcomes and are being increasingly studied. The analysis performed in

2010 stated that the overall pattern that workplace exposure to repetitive or forceful hand movements is associated with upper extremity disorders. Another 2015 review that specifically examined the evidence for mechanical risk factors for shoulder disorders identified manual handling (heavy lifting, pushing, pulling, holding and carrying), working above shoulder height, repetitive work, vibration, and working in awkward postures [68]. The review drew on several recent articles addressing shoulder pain, shoulder disorders, and MSDs in general [6,13,43,50,69-71].

Relevance of RCTs increasing with age in the working population

Tuenis et al. [28] in reviewed 30 articles that included 1452 cuff abnormalities [28]. They noted the increasing occurrence of RCTs with age and generally repeat that rotator cuff abnormality in asymptomatic people is high enough for degeneration of rotator cuff to be considered a common aspect of normal human aging. This could present a conundrum as to the assignment of cause of rotator cuff disease. However, the review focus was on asymptomatic individuals that is not the case for the working population with clear debilitating conditions. Further, the fact that 70 years olds have a large percentage of RCTs is irrelevant to the often youthful worker with a tendinopathy that prevents continued work. Reviews of work-related RCTs and the underlying causes along with a substantial body of individual studies that have been presented here are more than adequate to support the conclusions that have been presented that repetition, forceful motions, and work with hands elevated more than 60° result in tendinopathies in often youthful workers. The tendency to extrapolate from unrelated environments or patient populations is not justified given the preponderance of agreement on underlying conditions for shoulder disease.

Genetic factor for RCTs

Rotator cuff tendon tears remain poorly understood with chronic overload of the muscle-tendon-bone unit a leading cause of tendon and enthesis degeneration. The relatively high rate of occurrence of RC pathology in the general sedentary population suggests there are factors other than work exposure that underlie RCTs. Both genetics and shoulder morphology have been identified as factors. Moor et al. [72] 2013 developed an acromial index equal to the ratio of the distance from the glenoid plane to the acromion with the distance from the glenoid plane to the lateral aspect of the humeral head [72]. Patients with degenerative RCTs demonstrated significantly higher acromion indices, smaller acromion angles, and larger critical shoulder angles than patients with intact RCs.

When siblings of patients who had undergone RCT repair where compared to a control group they had more than twice the risk of developing RCTs [73]. Notably, the average age of the study group was 62 to 64, an age when many workers have retired. In a follow-up on this study, full thickness RCTs progressed in siblings over a period of five years more than in a control population in which the mean age was over 66 years [74]. Age is a possible confounding factor as it is strongly correlated with RCT occurrence even in an asymptomatic population. In a study that used the Utah Population Database a strong genetic predisposition for rotator cuff disease was found [75]. There exists the possibility that there

may be cultural or behavioural factors that influence RC disease in the Utah population. There may also be an environmental factor and no ergonomic analysis of work-related exposures was reported.

Worker's compensation is underutilized

It is noteworthy that Workers' comp data may significantly underestimate the magnitude of the MSD problem. Under reporting of MSDs may be pervasive and a general phenomenon in US workplaces [7,76-84]. Case counts from the Bureau of Labor Statistics are often much higher than comparable Workers' Comp data [85].

Negative worker –insurer interactions include : not being listened to; physician not understanding full impact of injury on worker, unjustified denial of claim, sending worker to multiple IME, sending worker to IME out of town, questioning legitimacy, stigma, not being believed. Physician unprofessional behavior or lack of knowledge of the injured system and either avoiding responsibility or making a rash decision. Administrative deficits can include, absent or incorrect information, cost containment via service approval, unclear written communication, limiting contact with the physician. The worker is subject to the power imbalance with the system, prolonged claims and appeals processes, medical reports being used out of context, and a general lack of knowledge about rights. Claims can be manipulated by ignoring or contesting diagnoses, using confusing jargon and legalistic communication, slow payments to non-preferred physician to discourage treatment [86-98].

In a Special Issue of the American Journal of Industrial Medicine, an article by Spieler & Burton [99] in 2012 is titled "The lack of correspondence between work-related disability and receipt of workers' compensation benefits" [99]. They reported that many workers with work related disabilities do not receive workers' compensation benefits in part due to increasingly restrictive state workers' compensation programs. Higher standards of proof lead to denial of claims. When there are only population based studies it is nearly impossible to meet the higher standard. Disability caused by work is common and fewer claims are being paid due to the growing barriers to obtaining benefits. This indicates that has been little abuse of worker's comp by workers to date rather it is more likely that the system often disadvantages workers.

Conclusion

While there will remain concerns as to the work-relatedness of shoulder tendinopathy, the evidence cited here is sufficient to conclude that repetitive cycling often combined with force and forceful exertions with arms flexed or abducted > 60° are underlying causes. Highly repetitive motions combined with awkward postures especially with hands above the shoulder are major contributors to workplace injuries. Recent prospective investigations along with numerous cross sectional and longitudinal studies have addressed methodological concerns resulting in a high quality of evidence. High odds ratios and relative risks shown for several occupations clearly indicate work-related exposures underlie shoulder MSDs. There is no doubt that work exposures can result in rotator cuff disease. Future studies may identify genetic factors that predispose individuals to diseases and thus allow appropriate career choices to be made.

References

1. BLS (2014) Nonfatal Occupational Injuries and Illnesses Requiring Days Away From Work.

2. Hagberg M (2002) Neck and arm disorders. Br Med J 313: 419-422.

3. Winkel J, Westgaard R (1992) Occupational and individual risk factors for shoulder- neck complaints: Part I. Guidelines for the practitioner. Int J Ind Ergonomics 10: 79-83.

4. Bruce P, Bernard (1997) Musculoskeletal Disorders and Workplace Factors. NIOSH.

5. Grieve JR, Dickerson CR (2008) Overhead work: identification of evidence-based exposure guidelines. Occup Ergon 8(1): 53-66.

6. Van Rijn RM, Huisstede BAM, Koes BW, Burdorf A (2009) Associations between work-related factors and specific disorders at the elbow: a systematic literature review. Rheumatology 48(5): 528-536.

7. Bjelle A, Hagberg M, Michaelsson G (1979) Clinical and ergonomic factors in prolonged shoulder pain among industrial workers. Scand J Work Environ Health 5(3): 205-210.

8. Miranda H, Viikari-Juntura E, Heistaro S, Helio M, Riihima H, et al. (2005) A Population Study on Differences in the Determinants of a Specific Shoulder Disorder versus Nonspecific Shoulder Pain without Clinical Findings. Am J Epidemiol 161(9): 847-855.

9. Punnett L, Fine LJ, Keyserling WM, Herrin GD, Chaffin DB (2000) Shoulder disorders and postural stress in automobile assembly work. Scand J Work Environ Health 26(4): 283-291.

10. Wiker SF, Chaffin DB, Langolf GD (1989) Shoulder posture and localized muscle fatigue and discomfort. Ergonomics 32(2): 211-237.

11. Dickerson CR, Meszaros KA, Cudlip AC, Chopp-Hurley JN, Langenderfer JE (2015) The influence of cycle time on shoulder fatigue responses for a fixed total overhead workload. J Biomech 48(11): 2911-2918.

12. Svendsen SW, Gelineck J, Mathiassen SE, Bonde JP, Frich LH, et al. (2004) Work above the shoulder level and degenerative alterations of the rotator cuff tendons. Arth Rheumatism 50(10): 3314-3322.

13. Beach J, Senthilselvan A, Cherry N (2012) Factors affecting work-related shoulder pain. Occ Med 62(6): 451-454.

14. Melhorn JM, Talmadge JB, Ackerman III WE, Hyman MH (2014) AMA Guides to the Evaluation of Disease and Injury Causation chapter - 9. (2nd edn), American Medical Association, USA, p. 9-11.

15. Bruce P Bernard (1997) Musculoskeletal Disorders and Workplace Factors. A Critical Review of Epidemiological Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back. Chapter 3 Shoulder Musculoskeletal Disorders: Evidence for Work-relatedness. NIOSH.

16. Melchior M, Roquelaure Y, Evanoff B, Chastang J-F, Ha C, et al. (2006) Pays de la Loire Study Group (2006) Why are manual workers at high risk of upper limb disorders? The role of physical work factors in a random sample of workers in France (the Pays de la Loire study) Occup Environ Med 63(11): 754-761.

17. Fu FH, Harner MD, Klein AH (1991) Shoulder impingement syndrome-A critical review. Clin Orthop Res 269: 162-173.

18. Neer CS2nd (1972) Anterior acromioplasty for the chronic impingement syndrome in the shoulder. J Bone Joint Surg 54(1): 41-50.

19. Järvholm V, Styf J, Suurkula M, Herberts P (1988) Intramuscular pressure and muscle blood flow in the supraspinatus. Eur J App Physiol 58(3): 219-224.

20. Andersen JH, Gaardboe O (1993) Musculoskeletal disorders of the neck and upper limb among sewing machine operators: a clinical investigation. Am J Ind Med 24(6): 689-700.

21. Frost P, Andersen JH (1999) Shoulder impingement syndrome in relation to shoulder intensive work. Occup Environ Med 56(7): 494-498.

22. Niedhammer I, Landre MF, LeClerc A, Bourgeois F, Franchi P, et al. (1998) Shoulder disorders related to work organisation and other occupational factors among supermarket cashiers. Int J Occup Environ Health 4(3): 168-178.

23. Frost P, Bonde JPE, Mikkelsen S, Andersen JH, Fallentin N, et al. (2002) Risk of Shoulder Tendinitis in Relation to Shoulder Loads in Monotonous Repetitive Work. Am J Ind Med 41(1): 11-18.

24. McCormack RR, Inman RD, Wells A, Berntsen C, Imbus HR (1990) Prevalence of tendinitis and related disorders of the upper extremity in a manufacturing workforce. J Rheumatol 17(7): 958-964.

25. Ohlsson K, Attewell RG, Paêlsson B, Karlsson B, Balogh I, et al. (1995) Repetitive industrial work and neck and upper limb disorders in females. Am J Ind Med 27(5): 731-742.

26. Stenlund B, Goldie I, Hagberg M, Hogstedt C (1993) Shoulder tendinitis and its relation to heavy manual work and exposure to vibration. Scand J Work Environ Health 19(1): 43-49.

27. Yamamoto A, Takagishi K, Osawa T, Yanagawa T, Nakajima D, et al. (2010) Prevalence and risk factors of a rotator cuff tear in the general population. J Shoulder Elbow Surg 19(1): 116-120.

28. Teunis T, Lubberts B, Reilly BT, Ring D (2014) A systematic review and pooled analysis of the prevalence of rotator cuff disease with increasing age. J Shoulder Elbow Surg 23(12): 1913-1921.

29. Murrell GA, Walton JR (2001) Diagnosis of rotatotr cuff tears. Lancet 357(9258): 769-770.

30. Vlychou M, Dailiana Z, Fotiadou A, Papanagiotou M, Fezoulidis IV, et al. (2009) Symptomatic partial rotator cuff tears: diagnostic performance of ultrasound and magnetic resonance imaging with surgical correlation. Acta Radiol 50(1): 101-105.

31. Codsi MJ, Rodeo SA, Scalise JJ, Moorehead TM, Ma CB (2014) Assessment of rotator cuff repair integrity using ultrasound and magnetic resonance imaging in a multicenter study. J Shoulder Elbow Surg 23(10): 1468-1472.

32. Lavagnino M, Wall ME, Little D, Banes AJ, Guilak F, et al. (2015) Tendon mechanobiology: Current knowledge and future research opportunities. J Ortho Res 33(6): 813-822.

33. Codsi M, Howe CR (2015) Shoulder conditions: Diagnosis and treatment guideline. Phys Med Rehabil Clin N Am 26(3): 467-489.

34. Kausto J, Miranda H, Pehkonen I, Heliövaara M, Viikari-Juntura E, et al. (2011) The distribution and co-occurrence of physical and psychosocial risk factors for musculoskeletal disorders in a general working population. Int Arch Occup Environ Health 84(7): 773-788.

35. Herin F, Vézina M, Thaon I, Soulat J-M, Paris C, ESTEV group (2014) Predictive risk factors for chronic regional and multisite musculoskeletal pain: A 5-year prospective study in a working population. Pain 155(5): 937-743.

36. Bauer GF, Huber CA, Jenny GJ, Müller F, Hämmig O (2009) Socioeconomic status, working conditions and self-rated health in Switzerland: explaining the gradient in men and women. Int J Public Health 54(1): 23-30.

37. Silverstein B, Fan ZJ, Smith CK, Bao S, Howard N, et al. (2009) Gender adjustment or stratification in discerning upper extremity musculoskeletal disorder risk? Scand J Work Environ Health 35(2):113-126.

38. Herberts P, Kadefors R (1976) A study of painful shoulder in welders. Acta Orthopaedica Scan 47(4): 381-387.

39. Hagberg M (1981) Electromyographic signs of shoulder muscular fatigue in two elevated are positions. Am J Physical Med 60(2): 111-121.

40. Ebaugh DD, McClure PW, Karduna AR (2006) Effects of shoulder muscle fatigue caused by repetitive overhead activities on scapulothoracic and glenohumeral kinematics. J Electromyog Kinesiol 16(3): 224-235.

41. Levitz CL, Iannotti JP (1995) Overuse injuries of the shoulder. Gordon SL, et al. (Eds.), Repetitive motions disorders of the upper extremity, Am Acad of Orthopaedic Surg, USA.

42. Herberts P, Kadefors R, Högfors C, Sigholm G (1984) Shoulder pain and heavy manual labour. Clin Orthop 191: 166-178.

43. Leclerc A, Chastang JF, Niedhammer I, Landre MF, Roquelaure Y, et al. (2004) Incidence of shoulder pain in repetitive work. Occup Environ Med61(1): 39-44.

44. Herberts P, Kadefors R, Andersson G, Petersen I (1981) Shoulder pain in industry: An epidemiological study on welders. Acta Orthop Scan 52(3): 299-306.

45. Forde MS, Buchholz B (2004) Task content and physical ergonomic risk factors in construction ironwork. Int J Ind Ergo 34(4): 319-333.

46. Hagberg M, Wegmand H (1987) Prevalence rates and odds ratios of shoulder-neck diseases in different occupational groups. Br J Indust Med 44(9): 602-610.

47. Wells JA, Ziff JF, Schuette PT, McEleney J (1983) Musculoskeletal disorders among letter carriers. J Occ Med 25(11): 814-820.

48. Maciukiewicz JM, Cudlip AC, Chopp-Hurley JN, Dickerson CR (2016) Effects of overhead work configuration on muscle activity during a simulated drilling task. Applied Ergonom 53A: 10-16.

49. Silverstein BA, Bao SS, Fan ZJ, Howard N, Smith C, et al. (2008) Rotator Cuff Syndrome: Personal, Work-Related Psychosocial and Physical Load Factors. J Occup Environ Med 50(9): 1062-1076.

50. Hanvold TN, Waersted M, Mengshoel AM, Bjertness E, Veiersted KB (2015) Work with prolonged arm elevation as a risk factor for shoulder pain: a longitudinal study among young adults. Appl Ergon 47: 43-51.

51. Bergmann G, Graichen F, Bender A, Kääb M, Rohlmann A, et al. (2007) In vivo glenohumeral contact forces-Measurements in the first patient 7 months postoperatively. J Biomech 40(10): 2139-2149.

52. Bergmann G, Graichen F, Bender A, Rohlmann A, Halder A, et al. (2011) In vivo gleno-humeral joints loads during forward flexion and abduction. J Biomec 44(8): 1543-1552.

53. Pandis P, Prinold JAI, Bull AMJ (2015) Shoulder forces during driving: Sudden steering can load the rotator cuff beyond its repair limit. Clin Biomech (Bristol, Avon 30(8): 839-846.

54. Proske U, Morgan DL (2001) Muscle damage from eccentric exercise: mechanism, mechanical signs, adaptation and clinical applications. J Physiol 537(2): 333-345.

55. Egerbacher M, Arnoczky SP, Caballero O, Gardner KL (2007) Stress-deprivation induces apoptosis in tendon cells: a mechanistic explanation for the histologic changes seen in tendinopathy. Trans Orthop Res Soc 32: 862.

56. Arnoczky SP, Lavagnino M, Egerbacher M (2007) The mechanobiological aetiopathogenisis of tendinopathy: is it the over-stimulation of the under-stimulation of tendon cells? Int J Exp Path 88(4): 217-226.

57. Brewer BJ (1979) Aging of the rotator cuff. Am J Sports Med 7(2): 102-110.

58. Milgrom C, Shaffler M, Gilbert S, van Holsbeeck M (1995) Rotator-cuff changes in asymptomatic adults. The effect of age, hand dominance and gender. J Bone Joint Surg 77(2): 296-298.

59. Tempelhof S, Rupp S, Seil R (1999) Age-related prevalence of rotator cuff tears in asymptomatic shoulders. J Shoulder Elbow Surg 8(4): 296-299.

60. Gill TJ, McIrvin E, Kocher MS, Hama K, Mair SD, et al. (2002) the relative importance of acromial morphology and age with respect to rotator cuff pathology. J Shoul Elbow Surg 11(4): 327-330.

61. Worland RL, Lee D, Orozco CG, SozaRex F, Keenan J. (2003) Correlation of age acromial morphology and rotator cuff tear pathology diagnosed by ultrasound in asymptomatic patients. J South Orthop Assoc 12(1): 23-26.

62. Paloneva J, Lepola V, Äärimaa V, Joukainen A, Ylinen J, et al. (2015) Increasing incidence of rotator cuff repairs-A nationwide registry study in Finland. BMC Musculoskeletal Disorders 16: 189-195.

63. Kim HM, Teefey SA, Zelig A, Galatz LM, Keener JD, et al. (2009) Shoulder Strength in Asymptomatic Individuals with Intact Compared with Torn Rotator Cuffs. J Bone Joint Surg Am 91(2): 289-296.

64. Mayer J, Kraus T, Ochsmann E (2012) Longitudinal evidence for the association between work-related physical exposures and neck and/or shoulder complaints: a systematic review. Int Arch Occup Environ Health 85(6): 87-603.

65. Punnett L (2014) musculoskeletal disorders and occupational exposures: How should we judge the evidence concerning the causal association? Scan J Public Health 42(Suppl 13): 49-58.

66. Punnett L, Prüss-Üstün A, Nelson DI et al. (2005) Estimating the global burden of low back pain attributable to combined occupational exposures. Am J Industr Med 48(6): 459-469.

67. Dick RB, Lowe BD, Lu M-L, Krieg EF (2015) Further Trends in Work-Related Musculoskeletal Disorders. A Comparison of Risk Factors for Symptoms Using Quality of Work Life Data From the 2002, 2006, and 2010 General Social Survey. J Occ Environ Med 57(8): 910-928.

68. Linaker CH, Walker-Bone K (2015) Shoulder disorders and occupation. Best Pract Res Clin Rheum 29.

69. Harkness EF, Macfarlane GJ, Nahit ES, Silman AJ, McBeth J (2003) Mechanical and psychosocial factors predict new onset shoulder pain: a prospective cohort study of newly employed workers. Occup Environ Med 60(11): 850-857.

70. Andersen JH, Haahr JP, Frost P (2007) Risk factors for more severe regional musculoskeletal symptoms. A two-year prospective study of a general working population. Arth & Rheum 56(4): 1355-1364.

71. Deschata A, Chastang JF, Cyr D, Leclerc A, Roquelaure Y, et al. (2008) Do workers with self-reported symptoms have an elevated risk of developing upper extremity musculoskeletal disorders three years later? Occup Environ Med 65(3): 205-207.

72. Moor BK, Stankamenec K, Gerber C, Bouaicha S (2014) Relationship of individual scapular anatomy and degenerative rotator cuff tears. J Shoulder Elbow Surg 23(4): 536-541.

73. Harvie P, Ostlere SJ, The J, MaNally EG, Clipsham K, et al. (2004) Genetic influences in the aetiology of tears of the rotator cuff. J Bone Joint Surg 86(5): 696-700.

74. Gwilym SE, Watkins B, Cooper CD, Harvie P, Auplish S, et al. (2009) Genetic progression in the progression of tears of the rotator cuff. J Bone Joint Surg 91(7): 915-917.

75. Tashjian RZ, Farnham JM, Albright FS, Teerlink CC, Cannon-Albright LA (2009) Evidence for an inherited predisposition contributing to the risk for rotator cuff disease. J Bone Joint Surg 91(5): 1136-1142.

76. Biddle J, Roberts K, Rosenman KD, Welch EM (1998) What percentage of workers with work-related illnesses receive workers' compensation benefits? J Occup Environ Med 40(4): 325-331.

77. Morse TF, Dillon C, Warren N, Levenstein C, Warren A (1998) The economic and social consequences of work-related musculoskeletal disorders: The Connecticut Upper-extremity Surveillance Project (CUSP). Int J Occup Environ Health 4(4): 209-216.

78. Morse T, Dillon C, Weber J, Warren N, Bruneau H, et al. (2003) The Prevalence & Reporting of Occupational Illness by Company Size: Population Trends & Regulatory Implications. Am J Ind Med 45(4): 361-370.

79. Morse T, Punnett L, Warren N, Dillon C, Warren A (2003) The relationship of unions to prevalence and claim filing for work-related upper-extremity musculoskeletal disorders. Am J Ind Med 44(1): 83-93.

80. Herbert R, Janeway K, Schechter C (1999) Carpal tunnel syndrome and workers' compensation among an occupational clinic population in New York State. Am J Ind Med 35(4): 335-342.

81. Pransky G, Snyder T, Dembe A, Himmelstein J (1999) Under-reporting of work-related disorders in the workplace: A case study and review of the literature. Ergonomics 42(1): 171-182.

82. Stock S, Nicolakakis N, Raïq H, Messing K, Lippel K, et al. (2014) Underreporting Work Absences for Nontraumatic Work-Related Musculoskeletal Disorders to Workers' Compensation: Results of a 2007-2008 Survey of the Que´bec Working Population. Am J Public Health 104(3): e93-e101.

83. Azaroff LA, Levenstein C, Wegman DH (2002) Occupational Injury and Illness Surveillance: Conceptual Filters Explain Underreporting. Am J Public Health 92(9): 1421-1429.

84. Rosenman KD, Gardiner JC, Wang J, Biddle J, Hogan A, et al. (2000) Why most workers with occupational repetitive trauma do not file for workers' compensation. J Occup Environ Med 42(1): 25-34.

85. Morse T, Dillon C, Kenta-Bibi E, Weber J, Diva U, et al. (2005) Trends in Work-Related Musculoskeletal Disorder Reports by Year, Type, and Industrial Sector: A Capture-Recapture Analysis. Am J of Industrial Med 48(1): 40-49.

86. Beardwood B, Kirsh B, ClarkN (2005) Victims twice over: perceptions and experiences of injured workers. Qual Health Res 15(1): 30-48.

87. Cacciacarro L, Kirsh B (2006) Exploring the mental health needs of injured workers. Can J Occup Ther 73(3): 178-187.

88. Cromie J, Robertson V, Best M (2003) Physical therapists who claimed workers' compensation: a qualitative study. Phys Ther 83(12): 1080-1089.

89. Hubertsson J, Petersson I, Arvidsson B, Thorstensson C (2011) Sickness absence in musculoskeletal disorders-patients' experiences of interactions with the Social Insurance Agency and health care. A qualitative study. BMC Public Health 11: 107.

90. Jaye C, Fitzgerald R (2010) The lived political economy of occupational overuse syndrome among New Zealand workers. Sociol Health Illn 32(7): 1010-1025.

91. Kosny A, MacEachen E, Ferrier S, Chambers L (2011) The role of healthcare providers in long term and complicated workers' compensation claims. J Occup Rehabil 21(4): 582-590.

92. Lippel K (2007) Workers describe the effect of the workers' compensation process on their health: a Quebec study. Int J Law Psychiatry 30(4): 427-443.

93. MacEachen E, Kosny A, Ferrier S (2007) Unexpected barriers in return to work: lessons learned from injured worker peer support groups. Work 29(2): 155-164.

94. MacEachen E, Kosny A, Ferrier S, Chambers L (2010) The ''toxic dose'' of system problems: why some injured workers don't return to work as expected. J Occup Rehabil 20(3): 349-366.

95. Murray M (2007) Fish harvesters with injuries accounts of their experiences with the workers' compensation system. Work 28(1): 47-56.

96. Reid J, Ewan C, Lowy E (1991) Pilgrimage of pain: the illness experiences of women with repetition strain injury and the search for credibility. Soc Sci Med 32(5): 601-612.

97. Roberts-Yates C (2003) The concerns and issues of injured workers in relation to claims/injury management and rehabilitation: the need for new operational frameworks. Disabil Rehabil 25(16): 898-907.

98. Strunin L, Boden L (2004) The workers' compensation system: worker friend or foe? Am J Ind Med 45(4): 338-345.

99. Spieler EA, Burton JF (2012) The lack of correspondence between work-related disability and receipt of workers' compensation benefits. Am J Industr Med 55(6): 487-505.