The Scientific Committee of the
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Associations between work-related exposure and the occurrence of rotator cuff disease and / or biceps tendinitis
A reference document

Authors

Department of Public Health (Epidemiology Group), University of Aberdeen, UK

Dr Gareth T Jones	Senior Lecturer in Epidemiology
Dr Nirupa Pallawatte	Honorary Research Fellow in Epidemiology
Dr Ashraf El-Metwally	Lecturer in Epidemiology
Professor Gary J Macfarlane	Professor of Epidemiology

Department of Medicine and Therapeutics, University of Aberdeen, UK

Professor David M Reid	Professor of Rheumatology

Department of Environmental and Occupational Medicine, University of Aberdeen, UK

Dr Finlay D Dick	Clinical Senior Lecturer in Occupational Medicine

Address for correspondence

Professor Gary J Macfarlane
Epidemiology Group, Department of Public Health
University of Aberdeen
School of Medicine
Polwarth Building, Foresterhill
Aberdeen, AB25 2ZD, UK

Tel: +44 (0) 1224 552 495
Fax: +44 (0) 1224 550 925
E-mail: g.j.macfarlane@abdn.ac.uk

Forord

Det foreliggende referencedokument er nummer 6 af 6 referencedokumenter, som den videnskabelige komite under Dansk Selskab for Arbejds- og Miljømedicin (VK-DASAM) har bistået Arbejdsskadestyrelsen med at få udarbejdet.

Referencedokumentet vedrører spørgsmålet om det videnskabelige grundlag for at antage, at arbejdsmæssige påvirkninger kan være årsag til lidelser i skulderens rotator cuff og bicepssene. Opgavens indhold har været beskrevet af Arbejdsskadestyrelsen og opslået og finansieret gennem Arbejdsmiljøforskningsfonden.

Graden af evidens for en årsagsmæssig sammenhæng er rubriceret efter en standard, som DASAM's videnskabelig komite har udarbejdet på baggrund af internationale standarder. Den anvendte standard er vist i referencedokumentets Appendix VI.

Referencedokumentet er udarbejdet af Dr. Gareth T. Jones, Senior Lecturer in Epidemiology, Dr. Nirupa Pallawatte, Honorary Research Fellow in Epidemiology, Dr. Asraf-El-Metwally, Lecturer in Epidemiology, Professor Gary J. Macfarlane, Professor of Epidemiology, Department of Public Health (Epidemiology Group), University of Aberdeen, Professor David M. Reid, Professor of Rheumatology, Department of Medicine and Therapeutics, University of Aberdeen og Dr. Finlay D. Dick, Clinical Senior Lecturer in Occupational Medicine, Department of Environmental and Occupational Medicine, University of Aberdeen.

Fra VK-DASAM har afdelingslæge PhD Susanne Wulff Svendsen, Arbejdsmedicinsk Klinik, Århus og overlæge PhD Johan Hviid Andersen, Arbejdsmedicinsk Klinik, Herning været projektledere mhp.at sikre, at dokumentet er udfærdiget i overensstemmelse med VK-DASAM's standard for referencedokumenter. Opgaven har været uafhængigt bedømt af to særligt sagkyndige reviewere, Dr. Jens Ivar Brox, Department of Orthopedics and Physiotherapy, Rikshospitalet University Hospital and Medical Faculty University in Oslo og Dr. Alex Burdorf, Department of Public Health, Erasmus MC, University Medical Center Rotterdam. Professor PhD Staffan Skerfving, Yrkes- och Miljömedicinska Kliniken, Lund, overlæge PhD Henrik Kolstad, Arbejdsmedicinsk Klinik, Århus og forskningschef Jørgen H. Olsen, Institut for Epidemiologisk Kræftforskning, Kræftens Bekæmpelse har fungeret som kvalitetssikringsforum.

Dokumentet er efterfølgende gennemgået og drøftet på et heldags-møde i VK-DASAM med deltagelse af Dr. Gareth T. Jones, Professor Gary J. Macfarlane og Dr. Finlay D. Dick fra forfattergruppen, de eksterne reviewere og kvalitetssikringsforum, og sluttelig har forfatteren revideret referencedokumentet i forhold til de fremkomne bemærkninger.

København oktober 2007

Sigurd Mikkelsen
Formand for DASAM's Videnskabelige Komite

Dansk resume og konklusion

Det følgende er en dansk oversættelse af referencedokumentets populære resume (afsnit 11) og konklusion (afsnit 9). Oversættelsen er foretaget af Johan Hviid Andersen og Susanne Wulff Svendsen.

Dansk populært resume

Baggrund for problemstillingen

Denne gennemgang blev lavet efter en forespørgsel fra, og i samarbejde med, den videnskabelige komite under Dansk Selskab for Arbejds- og Miljømedicin (DASAM).

Skuldersmerter er almindelige. Ligesom for andre almindelige bevægeapparatssmerter stiger hyppigheden op til omkring 50-års alderen for derefter at aftage. Undersøgelser har vist, at så mange som 47% af alle voksne har haft skuldersmerter inden for den seneste måned, og op til 2/3 har oplevet smerter i skulderen inden for det seneste år. Der er flere kendte skulderlidelser, som medfører smerter - fx rotator cuff sygdom [herunder supraspinatus tendinitis], indeklemningssyndrom, betændelsesreaktion i den lange bicepssene (biceps-tendinit) og betændelsesreaktion i slimsækken under skulderhøjden (subacromial bursit) - og disse lidelser er beskrevet i en række forskellige erhvervsgrupper. Undersøgelser har fx vist, at over 25% af svejsere har supraspinatus tendinitis sammenlignet med ca. 2% i en kontrolgruppe af kontoransatte. Andre undersøgelser har vist, at blandt kvinder i fiskeindustrien har 35% nakke-/skuldersmerter sammenlignet med kun 7% blandt andre kvinder.

Forskelle mellem erhvervsgrupper giver mistanke om, at specifikke arbejdsforhold eller arbejdsopgaver medfører forøget risiko for symptomer, og der er lavet en række studier for at undersøge, hvorvidt det er tilfældet.

Formål

Formålet med dette dokument er at vurdere disse undersøgelser, opsummere resultaterne og forsøge at svare på spørgsmålet om, hvorvidt der er evidens for, at specifikke erhvervsbelastninger er årsagsmæssigt forbundet med rotator cuff sygdom og / eller biceps-tendinit.

På grund af betydelige forskellige i diagnosticeringen af disse lidelser blev det besluttet kun at inddrage undersøgelser, hvor rotator cuff sygdom blev defineret som: en sygehistorie med skuldersmerter samt smerter ved bevægelse af skulderleddet mod modstand; og / eller hvor diagnosen biceps-tendinit blev defineret som: en sygehistorie med skuldersmerter samt smerter ved bevægelse af albuen eller underarmen mod modstand.

Metoder

Der blev gennemført en litteratursøgning efter engelsksprogede medicinske artikler i to computeriserede databaser: Medline og Embase. Ved søgningen blev der brugt søgeord relateret til skulderlidelser (engelske ord for fx skulder / rotator cuff / biceps- tendinit), erhvervseksponeringer (engelske ord for fx erhverv / job / arbejdsopgave). Alle artikler, som blev identificeret ved søgningen, gennemgik en tretrins screeningsproces: 1) Artiklernes titler blev gennemgået for at finde undersøgelser, der kunne være relevante, 2) resumeerne af muligt relevante artikler blev læst for at fravælge de undersøgelser, der ikke opfyldte definitionen på sygdommene, og 3) de resterende artikler blev læst i deres fulde længde med henblik på at finde dem, der var velegnede til at indgå i dette dokument. Hvert trin blev gennemført af to uafhængige forskere, og i tilfælde af uenighed trådte en tredje forsker til.

Resultater

Ved den indledende litteratursøgning fandtes 651 artikler, hvor det blev fundet relevant at gennemgå resumeet af 327, og i alt 112 artikler blev udvalgt med henblik på gennemlæsning af hele teksten. Fra denne læsning blev 13 artikler, som er publiceret i perioden 1993 til 2006, udvalgt til at indgå i dette dokument. De fleste af undersøgelserne havde fokus på erhvervsmæssige fysiske eksponeringer (armenes stilling, kraft og repetition), men de nyeste studier undersøgte også psykosociale risikofaktorer (fx krav, indflydelse og social støtte i arbejdet).

Risikofaktorer for rotator cuff sygdom / biceps-tendinit

Sammenhængen mellem armenes stilling og rotator cuff sygdom / biceps-tendinit blev undersøgt i seks studier. Selv om der var forskelle mellem de enkelte studier, var der generelt enighed om, at arbejde med armen(e) løftet medfører en øget risiko for skulderlidelser.

Sammenhængen mellem kraftbetonede bevægelser af skuldre eller arme og rotator cuff sygdom / biceps-tendinit blev undersøgt i fem studier. Selv om resultaterne var knapt så samstemmende, var der dog rimelig enighed om, at kraftbetonet arbejde medfører en øget risiko for skulderlidelser.

Fem studier undersøgte sammenhængen mellem repetitivt arbejde og rotator cuff sygdom / biceps-tendinit. Vurderingen af resultaterne vedrørende repetitivt arbejde blev imidlertid vanskeliggjort af, at personer med repetitivt arbejde ofte samtidig har kraftbetonet arbejde, hvilket gør det svært at isolere effekten på skulderen af de to former for eksponering. Der var dog nogen evidens for, at repetitivt arbejde, uafhængigt af kraftanvendelsen, havde sammenhæng med en øget risiko for skulderlidelser. Resultaterne fra et enkelt studie pegede også på, at personer, som både havde repetitivt og kraftbetonet arbejde, løb en yderligere risiko for skulderlidelser.

Enkelte af de 13 studier så også på andre arbejdsfunktioner, såsom kørsel og arbejde med vibrerende håndværktøj, men der var for få undersøgelser til at kunne drage klare konklusioner.

I fem af studierne blev det vurderet, hvorvidt der var en sammenhæng mellem psykosociale aspekter af arbejdet og rotator cuff sygdom / biceps-tendinit. Nogle af resultaterne kunne tyde på, at personer som savner social støtte på deres arbejdsplads har en øget risiko for skulderlidelser. Der var for sparsomme resultater for andre psykosociale arbejdsfaktorer, herunder høje krav og manglede indflydelse i arbejdet.

Forskelle mellem mænd og kvinder

Der var kun to studier, som undersøgte, om der var forskel på effekten af de erhvervsmæssige belastninger mellem mænd og kvinder. Trods sparsomme data ser det ud til, at mænd og kvinder påvirkes på nogenlunde samme måde af arbejde med løftede arme, repetitivt arbejde og dårligt psykosocialt arbejdsmiljø.

Resume

Der blev gennemført en omfattende litteratursøgning med det formål at udvælge undersøgelser, som belyste, hvorvidt personer med bestemte erhvervsmæssige belastninger og dårligt psykosocialt arbejdsmiljø har en øget risiko for rotator cuff sygdom / biceps-tendinit. På baggrund af i alt 651 artikler blev 13 udvalgt som egnede og relevante for dette dokument.

Den første konklusion er, at der er en (meget) sandsynlig årsagssammenhæng mellem arbejde med armene løftet over skulderhøjde og rotator cuff sygdom / biceps-tendinit. Der er overensstemmelse på tværs af mange studier til støtte for denne konklusion. Den anden konklusion er, at der er en sandsynlig årsagssammenhæng mellem kraftbetonet arbejde med skuldre og arme og rotator cuff sygdom / biceps-tendinit. Den tredje konklusion er, at selv om en årsagssammenhæng bestemt er mulig mellem repetitivt arbejde og rotator cuff sygdom/ biceps-tendinit, er evidensen her mindre sikker. Endvidere kan der måske være en sammenhæng mellem lav social støtte i arbejdsmiljøet og risikoen for rotator cuff sygdom / biceps-tendinit.

De foreliggende undersøgelser af andre fysiske og psykosociale erhvervseksponeringer er utilstrækkelige med hensyn til kvalitet, konsistens eller statistisk styrke til at tillade konklusioner vedrørende årsagssammenhænge.

Konklusion

Denne litteraturgennemgang bygger på studier udført i almenbefolkningen og på arbejdspladser inden for forskellige typer af erhverv. I langt de fleste tilfælde har der været tale om tværsnitsstudier, hvilket indebærer problemer med at fastslå den tidsmæssige karakter af eventuelle sammenhænge mellem eksponeringer og skulderlidelser og risiko for, at studierne kan være behæftet med såvel informations- som selektionsbias. Nogle studier har kun haft adgang til begrænsede informationer om potentielle confoundere. Til vurdering af erhvervsmæssige fysiske eksponeringer er der anvendt selvrapporterede oplysninger, men flere studier har omfattet mere objektive eksponeringsestimater fx baseret på videooptagelser. De fleste studier har fokuseret på fysiske arbejdsforhold (armenes stilling, kraft og repetition), men nyere studier har inddraget måling af psykosociale arbejdsmiljøfaktorer.

Erhvervsmæssige fysiske eksponeringer

Det konkluderes, at der er moderat til stærk evidens [++(+)] for en årsagssammenhæng mellem arbejde med eleverede arme og rotator cuff sygdom / biceps-tendinit. På tværs af en række studier udført i flere forskellige arbejdsmiljøer er der fundet konsistente holdepunkter for en eksponerings-respons sammenhæng. Konklusionen er robust over for eksklusion af artikler, hvor diagnoserne kan være behæftet med unøjagtighed; selv efter udelukkelse af disse artikler, resterer der flere studier, som demonstrerer en positiv eksponerings-respons sammenhæng mellem omfanget af arbejde med eleverede arme og de relevante lidelser. Som yderligere støtte for konklusionen tyder studier af mere subjektive helbredsudfald ligeledes på en årsagssammenhæng mellem arbejdsstillinger med eleverede arme og skuldersmerter og / eller skuldersymptomer generelt.

Det konkluderes, at der er moderat evidens [++] for, at manuel håndtering / kraftbetonet arbejde er kausalt forbundet med rotator cuff sygdom / biceps-tendinit. En række studier har fundet en positiv sammenhæng mellem manuel håndtering / kraftbetonet arbejde og de nævnte lidelser, og prospektive kohortestudier giver ligeledes gode holdepunkter for en kausal relation mellem manuel håndtering og skuldersmerter og / eller skuldersymptomer generelt. Hertil kommer at resultaterne - efter eksklusion af artikler hvor diagnoserne kan være behæftet med unøjagtighed – fortsat tyder på årsagsmæssige sammenhænge. Det kan imidlertid ikke med rimelig sikkerhed udelukkes, at disse sammenhænge kan forklares med confounding på grund af den sandsynlige overlapning mellem manuel håndtering / kraftbetonet arbejde og arbejdsopgaver med repetitive bevægelser. Det konkluderes imidlertid, at der kun er begrænset evidens [+] for en årsagsmæssig sammenhæng mellem opgaver, der indebærer repetitive bevægelser (uafhængigt af kraftanvendelsen), og rotator cuff sygdom og biceps-tendinit. Selv om en række studier samstemmende tyder på en sammenhæng, og selv om en kausal sammenhæng er mulig, er det ikke usandsynligt, at sammenhængen kan forklares med tilfældigheder, bias eller confounding (især på grund af samtidig manuel håndtering eller kraftbetonede aktiviteter).

Der er utilstrækkelig evidens [0] for en årsagssammenhæng mellem andre fysiske / mekaniske eksponeringer og rotator cuff sygdom og biceps-tendinit.

For de undersøgte erhvervsmæssige fysiske eksponeringer konkluderes det ikke i noget tilfælde, at der er stærk [+++] evidens for en sammenhæng mellem en given eksponering og rotator cuff sygdom / biceps-tendinit. Denne konklusion udelukkes for det første af, at der er mangel på prospektive kohortestudier af høj kvalitet, som gør det muligt helt at forstå den tidsmæssige relation mellem eksponering og helbredsudfald.

For det andet af, at der er utilstrækkeligt grundlag for at skelne imellem eksponeringer, der medfører patologiske forandringer i rotator cuff'en eller nærliggende strukturer i skulderen, og eksponeringer, der forværrer symptomer som stammer fra forudbestående skulderpatologi. For det tredje af, at kun få studier fremlægger robuste eksponerings-respons sammenhænge, således at der i konsekvens heraf ikke er basis for velbegrundede eksponeringsstandarder eller for at identificere grænser for 'sikker' eksponering.

Erhvervsmæssige psykosociale eksponeringer

Det konkluderes, at der er begrænset evidens [+] for en sammenhæng mellem oplevet (mangel på) støtte i arbejdsmiljøet og risikoen for rotator cuff sygdom / biceps-tendinit. Om end eksponeringen kun belyses i få studier, tyder resultaterne samstemmende på en sammenhæng. Det er imidlertid ikke usandsynligt, at dette kan forklares med bias og / eller confounding med andre fysiske eller psykosociale eksponeringer, og der er fundet modstridende resultater i studier af skuldersymptomer, der kunne have bidraget med understøttende holdepunkter.

Det konkluderes, at der er utilstrækkelig evidens [0] til at drage konklusioner vedrørende sammenhængen mellem oplevede arbejdsmæssige krav og risikoen for rotator cuff sygdom / biceps-tendinit. De foreliggende studier er for få og har utilstrækkelig konsistens til at tillade en konklusion angående tilstedeværelse eller fravær af en årsagssammenhæng.

Det konkluderes, at der er utilstrækkelig evidens [0] til at drage konklusioner vedrørende sammenhængen mellem oplevelsen af manglende kontrol over arbejdet og risikoen for helbredsudfaldet rotator cuff sygdom og / eller biceps-tendinit. Kun få studier belyser sammenhængen, og de studier, der er gennemført, har givet inkonsistente resultater.

Det konkluderes, at der er utilstrækkelig evidens [0] til at drage konklusioner vedrørende sammenhængen mellem rotator cuff sygdom / biceps-tendinit og andre psykosociale faktorer, specielt arbejdspres (forstået som en kombination af høje krav og lav kontrol / indflydelse), manglende tilfredshed med arbejdet og oplevet stress.

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1. Background

The aim of this document is to provide a high-quality scientific reference resource, summarising the existing epidemiological evidence with respect to the associations between occupational-related exposures and rotator cuff disease and / or biceps tendinitis. It has been produced in collaboration with the Scientific Committee of the Danish Society of Occupational and Environmental Medicine and in response to a request from the Danish Working Environment Research Fund that allocated funds for reference documents for use by the National Board of Industrial Injuries and the Occupational Diseases Committee. Specific objectives set out in the commissioning brief were:

- To present exposure-response patterns for associations that are likely to be causal;
- To assess any impact of gender on these relations; and
- To evaluate the evidence of work-related exposures on prognosis.

This document will outline the literature search and review methodology, and will provide a discussion of the findings of the review. Further, where insufficient evidence is identified to meet these objectives, this document will provide a commentary on the limitations of present knowledge and major areas for future research will be identified.

In accordance with the guidelines set down by the Scientific Committee of the Danish Society of Occupational and Environmental Medicine, this review has a specific focus, with respect to both exposure and outcome assessment, *viz*:

- Exposure: The review will focus on mechanical exposures including, but not limited to: working with elevated arms, repetitive work, forceful exertions, and hand-arm vibration. However, this review will not consider occupational exposures related to computer terminal work, aspects of which have been covered in previous reference documents[1].
- Outcome: The review will focus on rotator cuff disease and / or biceps tendinitis. Because the International Classification of Diseases, tenth revision, is not accompanied by diagnostic guidelines for physical diseases and no consensus has been reached with respect to diagnostic criteria for shoulder disorders, this review will focus on studies where physical findings form part of the outcome definition. However, studies that use as their outcome shoulder pain and muscular palpation tenderness alone, shall not be considered to provide *prima facie* evidence of any causal association.

2. Outcome under study

Outcome definition

Anatomy of the shoulder

The shoulder girdle has the largest range of movement of any region in the body. It consists of two bones (humerus and scapula), three joints (glenohumeral, acromioclavicular and sternoclavicular) and two articulations (scapulothoracic and acromiohumeral). These components are joined together by an extensive network of soft tissue structures, which include the rotator cuff and non-rotator cuff structures. The rotator cuff consists of four muscles and their tendons: subscapularis, supraspinatus, infraspinatus, and teres minor. All these muscles take their origin from the blade of the scapula, pass over the glenohumeral joint and their tendons form a continuous cuff around the humeral head. The rotator cuff is responsible for creating all directions of shoulder motion and, together with the long head of the biceps muscle and other muscles in the shoulder (e.g. pectoralis major and serratus anterior), provide dynamic stabilisation to the humeral head in the shallow glenoid fossa (Goldstein 2004). The subacromial space (supraspinatus outlet) is the space between the coracoacromial arch, which is formed from the undersurface of the acromion, coracoacromial ligament and coracoid, and humeral head (Travis *et al*. 2000). This space contains the subacromial bursa and the tendons of the rotator cuff muscles and the long tendon of the biceps muscle. Shoulder complaints presumed to have been caused by disorders of subacromial structures are described in the literature under a variety of names, including: rotator cuff disease, rotator cuff syndrome, supraspinatus tendinitis, impingement syndrome, subacromial syndrome, entrapment syndrome and painful arc syndrome.

Symptoms suggestive of rotator cuff disease and biceps tendinitis

Pain and loss of motion are the most common presenting symptoms of rotator cuff disease. The pain of rotator cuff disease tends to be antero-laterally located and, in the case of tears, can be referred to the insertion of the deltoid. A more distal pain is rarely related to rotator cuff pathology (Tytherleigh-Strong *et al*. 2001).

Pain in the anterior aspect of the shoulder and located within the bicipital groove is the usual presenting complaint of patients with biceps tendon disorders. Such pain usually radiates toward the deltoid insertion, and can be difficult to distinguish from pain due to impingement or rotator cuff tendinitis (Selvanetti *et al*. 1997).

Physical findings suggestive of rotator cuff disease and biceps tendinitis

In rotator cuff disease, although pain is usually present during passive range of motion tests, it tends to be more pronounced during active motion (Tytherleigh-Strong *et al*. 2001). Several manoeuvres can be conducted to test rotator cuff muscles. These include Jobe's Test for supraspinatus (Jobe 1983) and Gerber's 'Lift Off' Test for subscapularis (Gerber and Krushell 1991). Assessment of the integrity of the posterior cuff – the infraspinatus and teres minor – is made by resisted external rotation with the elbow flexed at 90° and the patient's arm either at 0° or 90° of abduction. An inability to hold the arm up, the 'drop' sign, is suggestive of a complete rotator cuff tear (Willick and Sanders 2004). The physician can confirm a subacromial origin for the patient's pain by finding a positive Neer's sign and / or Hawkins' sign (Neer 1983; Hawkins and Kennedy 1980) and at least one of these tests – impingement tests – would need to be positive for diagnosis of impingement syndrome. The terms supraspinatus tendinitis and impingement syndrome are sometimes used as if they are synonymous with rotator cuff disease. However, strictly speaking, impingement syndrome can be a consequence of any disorder affecting the structures located in the subacromial space. The diagnosis of shoulder impingement syndrome requires both symptoms of pain in the shoulder and a positive impingement test. A painful arc on shoulder abduction above 80° and the exclusion of other shoulder conditions is necessary. (Silman and Newman 1996). Malhi and Khan (2005) found a strong correlation between a clinical diagnosis of shoulder impingement syndrome and arthroscopic findings.

The subacromial bursa is located between the acromial process of the clavicle and the humeral head and is therefore adjacent to, but not part of, the rotator cuff. Subacromial bursitis can be considered to come in two forms:

- A sub-acute disorder which may evolve along with a rotator cuff injury; and
- Very acute, form of calcific periarthritis where calcium apatite crystals are rapidly deposited in the burse.

This latter condition, which is acutely painful, is usually self-limiting, although steroid injection may fore-shorten the process. Calcific tendinitis (usually of the supraspinatus tendon) is generally a different process altogether, and is usually taken to indicate more long-standing supraspinatus tendinitis.

The most common finding on physical examination in the presence of a disorder of the long head of the biceps tendon is point tenderness over the bicipital groove. This tenderness is best localised by direct palpation of the bicipital groove with the arm in about 10° of internal rotation (Paynter 2004). Tenderness in this area should move laterally with external rotation of the arm if associated with the biceps tendon. This was thought by Burkhead *et al*. (1998) to be the most specific finding for biceps tendon pathology although there are a number of other provocative tests that have been proposed for evaluating disorders of the long head of the biceps, including Speed's Test (Gilcreest and Albi 1939) and Yergason's Test (Yergason 1931).

Diagnosis of rotator cuff disease / biceps tendinitis

Imaging techniques are the best available methods to diagnose rotator cuff disease and biceps tendinitis – particularly if tendon tears are suspected. However use of such methods are costly and, for reasons of practicality, are not used routinely in large epidemiological studies. Available imaging modalities in the clinical setting include x-ray, computed tomography, diagnostic ultrasound, arthrography and magnetic resonance imaging (MRI). The latter provides the best images of soft tissue anatomy, including articular cartilage, labrum, muscle, tendon, ligament, fat and bursae. Although it has been shown that, in experienced hands, shoulder ultrasound is as accurate as MRI when assessed against the gold standard of arthroscopic findings (Teefey *et al*. 2004), MRI is increasingly becoming the imaging modality of choice for the assessment of the rotator cuff. However, some authors have noted that full thickness tears of the rotator cuff may be observed with MRI in older asymptomatic individuals. (Sher 1995). This could have implications for studies employing MRI alone to diagnose shoulder disorders, as the most heavily exposed subjects might also be the oldest – thus, age might confound the exposure-outcome relationship under examination.

For superficial muscle and tendon anatomy ultrasound has many benefits: it is non-invasive and relatively inexpensive. However, it has the disadvantage of being very operator-dependent. Radiography is also helpful in diagnosing full-thickness tendon tears (Tytherleigh-Strong *et al*. 2001) but is unlikely to be helpful in diagnosing acute tendinopathy. However, where there is calcification of the supraspinatus tendon, a diagnosis of supraspinatus tendinitis is very likely.

Rotator cuff disease represents a spectrum of disorders affecting tendons of rotator cuff muscles, ranging from tendinopathy to tearing (Tytherleigh-Strong *et al*. 2001). However, in clinical practice, the diagnosis 'rotator cuff syndrome' is based on the patient's history and their clinical examination and may be made without the benefit of imaging. In fact, even in the presence of imaging, the absence of an observable tear does not preclude the diagnosis of rotator cuff syndrome.

Disorders of the long head of the biceps tendon often have been labelled as tendinitis. Technically, this would imply that there is an acute inflammatory component to the pathophysiology. However, several authors have shown that tendon degeneration is seldom associated with inflammatory cells in the tendon itself (Kannus and Jozsa 1991; Almekinders 1998). Rather, the term 'tendinopathy' is the general term recommended to describe the clinical findings in and around affected tendons (Maffulli *et al*. 1998).

Outcome definition for the current review

There is no international standard definition or agreement on shoulder disorders suitable for use in epidemiological studies, although surveillance criteria for shoulder tendinitis have been proposed (Harrington *et al*. 1998). In 1997, the experience of healthcare professionals in the field of prevention and management of upper limb disorders was combined, using Delphi technique, in order to develop consensus case definitions for several limb pain disorders, including shoulder tendinitis. Based on consensus between experts, the following criteria were proposed:

- For rotator cuff disease: history of pain in the deltoid region; plus, pain on one or more resisted active movements of the shoulder.
- For biceps tendinitis: history of anterior shoulder pain; plus, pain on resisted active flexion of elbow or supination of forearm.

For the current review, we have considered rotator cuff disease to comprise, broadly, disorders affecting one or more subacromial structures, or nearby structures, leading to shoulder complaints. Similarly, for biceps tendinitis, we have included studies that report clinical findings, in addition to pain, in and around affected tendons. Thus, specific disorders included in our review will include:

- Rotator cuff disease / syndrome;
- Impingement syndrome;
- Biceps tendinitis / tendinopathy;

- Tendinitis / tendinosis of the rotator cuff muscles;
- Subacromial bursitis;
- Non-traumatic partial or complete tear of the long head of the biceps or rotator cuff tendons;
- Primary or secondary calcifications of the rotator cuff or biceps tendons;
- Shoulder pain caused by disorders affecting the sternoclavicular or scapulothoracic articulations; and
- Osteoarthritis of the acromioclavicular joint or variations in the shape of the acromion leading to development of impingement

There are a number of other disorders that are characterised by chronic pain in the shoulder region. Where these were identified as the sole outcome of interest in a paper, they were excluded from the current review. These include the following:

- Cervical radiculopathy;
- Shoulder instability;
- Adhesive capsulitis;
- Myofascial pain;
- Complex regional pain syndromes affecting the shoulder area; and
- Isolated lesions of nerves in the shoulder region.

Where studies were identified in which the outcome under investigation was a combination of included and excluded disorders (from the above lists) the studies were included. We comment on the potential effect of the inclusion of these papers in the discussion.

Descriptive epidemiology

Shoulder pain is common. It may originate from many sites and there is currently a paucity of evidence to separate the aetiology of the many clinical conditions of the shoulder that have pain as a presenting symptom (Macfarlane *et al*. 2005). Typical of a number of other musculoskeletal pain conditions, the prevalence increases with age to around the sixth decade and decreases thereafter (Andersson *et al*. 1993). Further, it has been hypothesised that such pain may have a mechanical aetiological component – as evidenced by the decrease in occurrence beyond normal working age.

Luime *et al*. (2004) conducted a review of 19 population-based epidemiological studies of shoulder pain occurrence. They reported that the one-month prevalence of shoulder pain varied between studies from 4.7% to 46.7% and the one-year prevalence between 6.7% and 66.7%. The authors noted that prevalence varied considerably with different case definitions, with lower a occurrence being found in studies with more detailed case criteria. This is similar to the findings of van der Windt & Croft (1999) who demonstrated nearly a ten-fold difference in prevalence of shoulder pain depending on case definition: from 6.7% (clinically diagnosed subacromial shoulder pain (Jacobsson *et al*. 1989)) to 61% (self-reported pain, tenderness or stiffness in the shoulders during the past year (Westerling & Jonsson 1980)).

Some authors have reported that rotator cuff disorders are responsible for 10% of all cases of persistent shoulder pain (Meislin *et al*. 2005). The prevalence of rotator cuff disease / biceps tendinitis has seldom been recorded in general population samples. However, using epidemiologic surveillance data on the French working population, Roquelaure *et al*. (2006) reported the prevalence of rotator cuff syndrome to be 6.8% in men and 9.0% in women. Although general practitioners rarely record a specific diagnosis (Linsel *et al*. 2006), it has been estimated that, among patients presenting to primary care with shoulder pain, impingement and rotator cuff tears occur in 74% and 85% of cases, respectively (Baring *et al*. 2007). A recent population survey in Finland revealed that the prevalence of rotator cuff tendinitis and biceps tendinitis was 3.8% and 0.5% respectively (Shiri *et al*. 2007). Others, also in Finland, reported the prevalence of rotator cuff tendinitis to be 2% (Miranda *et al*. 2005) and others reported that shoulder joint impairment was present in 8.8% of the Finnish population aged $\geq$30yrs, although shoulder pain was reported by 30% (Mäkelä *et al*. 1999). These authors also reported that the prevalence of shoulder pain decreased among elderly: whereas, the prevalence of impairment increased to 20% in those aged 75-80yrs.

Among occupational populations, there have been a number of studies. Some have demonstrated a prevalence of supraspinatus tendinitis of 27% in welders, compared to less than 2% in office workers (Herberts *et al*. 1981; Herberts *et al*. 1984). Frost and Andersen (1999) reported a prevalence of 6.9% in slaughterhouse workers and 10.4% in ex-slaughterhouse workers, both groups were predominantly male. Others have reported high prevalences in fish processing workers, rock blasters and brick layers (Chiang *et al*. 1993; Stenlund *et al*. 1993). Svendsen *et al*. (2004b) reported that prevalence of supraspinatus tendinitis among house painters was 4.4% whereas among machinists and car mechanics it was 2.0% and 1.4% respectively.

Kaergaard and Andersen (2000) reported a prevalence of 5.8% among female sewing machine operators and 2.2% among a control population (supervisory jobs, office workers, *etc*). Also in women, Ohlsson *et al*. (1994) demonstrated an increase in the occurrence of neck / shoulder symptoms in women working in the fish processing industry: exposed women reported a prevalence of 35%, with only 7% in unexposed women (women from municipal work places: nurseries, offices, *etc*). Specifically, these authors demonstrated a three-fold and four-fold increase in supraspinatus tendinitis and infraspinatus tendinitis (15% versus 5%, and 12% versus 3%, respectively) (Ohlsson *et al*. 1994).

Analytical epidemiology

For more than 30yrs, occupational risk factors[2] – particularly heavy industrial work – have been associated with shoulder pain and tendinitis of the rotator cuff (Herbets and Kadefors 1976). Although the main aim of this reference document is to review the evidence on whether occupational exposures are associated with the occurrence of rotator cuff disease and biceps tendinitis, some of the exposures experienced in non-work settings may also be relevant to the assessment of workplace exposures.

[2] Strictly speaking, a 'risk factor' for disease can only be identified with a longitudinal study design. Even then, however, the decision as to whether a particular exposure is a causal risk factor is a complex one. However, the term 'risk factor' is used – by many authors – to refer to any factor that is associated with the outcome of interest. Although the term risk 'marker' is more appropriate, it is seldom used. In the current review, we have avoided the use of the term 'risk factor' unless we can be clear that this exposure preceded the outcome. However, it should be noted that, *a priori*, <u>any</u> exposure under study can be considered a <u>potential</u> risk factor.

Studies in occupational settings (rotator cuff disease / biceps tendinitis)

Most studies reported an increase in the occurrence of specific shoulder disorders with increasing age (Walker-Bone *et al*. 2006; Miranda *et al*. 2005; Svendsen *et al*. 2004b; Kaergaard and Andersen 2000) and, while some have shown an increased occurrence in women (Walker-Bone *et al*. 2006; Melchior *et al*. 2006), the evidence is not consistent, with many studies showing no difference (e.g. Miranda *et al*. 2005; Werner *et al*. 2005). The increased prevalence of rotator cuff disease in older working populations might be attributed to the following:

- Longer cumulative exposure to work-related risk factors;
- Degenerative changes that take place in the rotator cuff tendons with age (Brewer 1979; Fukuda *et al*. 1990); or
- The chronicity of the disorder – even with constant incidence one will observe an increased prevalence with age in any disease of long duration.

Four studies have investigated the role of smoking. Walker-Bone *et al*. found that current smokers had 50% higher occurrence of shoulder disorders compared to non-smokers. However occurrence of such disorders were not related to smoking habits in the other three studies (Werner *et al*. 2005; Svendsen *et al*. 2004b; Kaergaard and Andersen 2000).

Two studies have evaluated the role of physical exercise and both reported no significant association between frequency of exercise and rotator cuff disease (Werner *et al*. 2005; Andersen and Gaardboe 1993). Walker-Bone *et al*. (2006) used the vitality domain of the Short Form 36 Health Survey (SF-36) (Ware and Sherbourne 1992), which measures general mental and physical health perceptions, and found that workers who had the lowest score were more likely to have clinically diagnosed shoulder disorders. However, these factors may be consequences of rotator cuff disease, rather than risk factors for it. One study evaluated the role of height and weight and found that body mass index was not an indicator of an increased risk of rotator cuff disease (Kaergaard and Andersen 2000). Only one study examined the relationship between psychological stress and rotator cuff tendinitis and observed a significant contributory role (Kaergaard and Andersen 2000).

With respect to specific diseases, inconsistent findings have been reported with respect to the role of diabetes, with one study reporting that diabetes is strongly associated with rotator cuff disease (Miranda *et al*. 2005) and the other two finding a non-significant association (Werner *et al*. 2005; Melchior *et al*. 2006). Thyroid disease was also investigated as a possible predictor in one study (Melchior *et al*. 2006) but, similarly, no significant correlation was found. It should be noted, however, that population-based studies such as these are not best suited for studying the risk of rotator cuff disease related to diabetes and thyroid diseases due to the uncommon nature, in population terms, of the conditions.

Studies in occupational settings (neck / shoulder pain)

Malchaire *et al*. (2001) carried out a comprehensive review of approximately 40 studies which investigated potential risk factors for neck / shoulder pain[3]. The vast majority of these studies were cross-sectional, conducted in occupational settings, and used a subjective case definition of the outcome. This review concluded:

- The prevalence of neck / shoulder pain increases with age and is more commonly reported by females. However, the gender difference may be occupational-related: in studies restricted to men and women performing the same occupational tasks, female predominance was no longer significant;
- Self-report of bad health, but not chronic diseases, correlates with pain reporting in the neck / shoulder area;
- Height, weight, previous upper limb injury, hormonal factors, hobbies, and alcohol consumption seem to play no role in pain reporting;
- Leisure time physical exercise and smoking habits have a very minor effect on pain reporting; and
- There is a strong link between neck / shoulder pain symptoms and psychological stress, depression, irritability, fatigue and dizziness.

However, because of the cross-sectional design of most of these studies, the temporal nature of these relationship cannot be determined.

Studies in the general population (self-reported and non-specific neck / shoulder pain)

Many studies that have investigated demographic and environmental correlates of shoulder disorders in the general population have, firstly, used rather crude methods for collecting data about the outcome (mainly using questionnaires to evaluate subjective pain experience); and, secondly, have studied neck / shoulder pain rather than specific shoulder disorders. However, this assumption – i.e. that the risk factors of regional shoulder pain are no different from those of regional neck pain – has been inadequately explored.

Evidence from these studies suggests that non-specific shoulder and neck / shoulder pain in the general population seems to be slightly more frequent in females than in males, and that in both genders the prevalence of these symptoms in middle-aged and elderly is considerably higher than that in younger populations (Barnekow-Bergkvist *et al.* 1998; Miranda *et al*. 2005).

Barnekow-Bergkvist *et al.* (1998) conducted a population-based cross-sectional study in a middle-aged Swedish population. These authors examined whether a number of factors relating to socio-demographic factors and stress were associated with self-reported neck / shoulder pain: living alone, having children, socioeconomic status, education, feeling worried, sleeping difficulties, headache, physical activity, smoking and height. They demonstrated that, in men, only feeling worried was associated with the outcome (odds

[3] Different studies used different terminology to refer to pain in the shoulder and neck area combined. For example: some authors use 'shoulder / neck', others used 'neck-shoulder'. There are other permutations. For ease of discussion, and for continuity throughout this document, we will use the term 'neck / shoulder' throughout.

ratio (OR): 11.0; 95% confidence interval[4]: 3.1-39.6). None of these factors were significantly associated with symptoms in women.

Similarly, Miranda *et al*. (2005) conducted a population-based cross-sectional study of a middle-aged Finnish population (aged 30-64yrs) to investigate potential risk factors for non-specific shoulder pain. Data was collected on a number of psychological factors. After controlling for age, sex and work-related exposures, non-specific shoulder pain was associated with alexithymia (OR: 1.6; 1.1-2.5), mild or severe burnout (OR: 1.7; 1.4-2.5) and, in women, with severe depression (OR: 3.0; 1.6-5.6).

Studies in sports settings (rotator cuff disease / biceps tendinitis)

Overuse injuries to the rotator cuff and the long head of the biceps are commonly encountered in athletes engaged in sports disciplines characterised by overhead motion and abduction / external rotation of the arm (e.g. handball, tennis, volleyball, swimming and weight-lifting sports) (Pieper *et al*. 1993; Ticker *et al*. 1995; Sommerich and Hughes 2006). These athletes frequently place repetitive large stresses on the static and dynamic glenohumeral stabilisers, which can lead to instability of the glenohumeral joint and a decrease in supraspinatus outlet space and secondary impingement (Karzel and Pizzo 1995).

There is some data on specific sports. Shoulder pain reporting is also the most commonly reported musculoskeletal symptom in baseball pitchers, with 32% of these players reporting such complaints over a period of two seasons (Lyman *et al*. 2001). Also, Kim *et al*. (2004) reported that rotator cuff disease and subacromial impingement are among the most common problems among golfers: 93% of patients with golf injuries in the shoulder had these injuries. In an occupational group, Miranda *et al*. (2001b) examined forest industry workers to investigate the relationship between physical exercise and shoulder pain and found that workers who were actively involved in volleyball were three times more likely to report shoulder pain, compared to those who never or infrequently play this sport.

Summary

Very few studies have investigated the role of non-occupational factors on, specifically, rotator cuff disease and / or biceps tendinitis. However, the available evidence suggests that the following factors might have an important role:

- Age;
- General health;
- Psychological stress; and
- Sports characterised by overhead motion;

while the following seem to play a more minor role:

- Gender;
- Anthropometric characteristics (e.g. weight, height).
- Life style factors (smoking, alcohol, frequency of physical activity); and

[4] All confidence intervals presented in this document will be 95% confidence intervals, unless otherwise stated.

- Chronic diseases (e.g. diabetes and thyroid diseases).

3. Exposures under study

Accurate exposure assessment is central to efforts to establish an exposure-response relationship for occupational factors in the occurrence of rotator cuff syndrome. In the event of a null result, low quality exposure estimation is one possible explanation.

Physical exposures

Physical exposures studied as potential risk factors for rotator cuff syndrome include hand-transmitted vibration, repetitive movements, work without pauses, heavy loads and awkward postures. A significant proportion of the working population is exposed to these factors. For example, it is estimated that around 4.8 million UK workers are exposed to hand transmitted vibration (Palmer *et al*. 2000). However, major challenge for researchers in this field has been to determine how to deal with co-exposures – for example: users of handheld power tools may be exposed not only to hand transmitted vibration but also to awkward working postures and the handling of heavy loads.

Physical exposures in the workplace are generally assessed using job titles, self-administered questionnaires, direct observation (with or without video recording) or by instruments. All of these approaches have their advantages and limitations.

The use of job titles as a surrogate for more detailed exposure estimation assumes that an occupation has sufficiently similar exposure to ergonomic factors as to be considered a uniformly exposed group, when contrasted with a second job group deemed to have a different exposure. This approach is known to lead to non-differential exposure misclassification and, secondly, should between group differences be found, it does not identify the relevant physical exposure.

Exposure estimation in occupational epidemiology would ideally inform exposure standards (by identifying 'safe' limits for exposure) but should at least distinguish the highly exposed from the less exposed. To achieve the first generally requires some objective measurement of exposure. Where occupation is a reasonable surrogate for exposure then job title may be all that is required to distinguish between the highly exposed and the less exposed although such a study is unlikely to inform exposure standards. Job title is an adequate exposure surrogate where workers have clearly defined jobs with different levels of exposure between jobs: for example, where employees in a single, large, workplace are studied. Job title may be less informative when applied across work sites or employers owing to exposure variability within job groups – leading to exposure misclassification. Even exposure measures ascertained at individual level will have some imprecision that will result in exposure variability within individual workers but also between workers in exactly the same working conditions.

Self-administered exposure questionnaires are readily applied to large groups of workers and allow exposure assessment at low cost and, as a consequence, have been widely used. One limitation of questionnaires is that they rely on self-reports – which may be inaccurate. Subjects alerted to concerns regarding ergonomic factors in the workplace may over-report exposures leading to information bias. Similarly, workers with musculoskeletal disorders may over-report their work-load when compared with unaffected colleagues (Viikari-Juntura *et al*. 1996) leading to differential exposure misclassification and biased exposure estimates.

Direct observation of workplaces has been used to assess ergonomic factors. While direct observation might be superior to questionnaire based assessments this assumption may not be valid especially where job demands are highly variable – even though most direct observation is carried out by experts. Some studies have attempted to establish factory, job or task groups in an effort to better characterise exposures. Perhaps the best example of this approach employed a carefully designed task-based exposure assessment methodology (Fallentin *et al*. 2001). However, others have found that task based estimates can be imprecise and no better than group mean exposures derived from measurement of a sample of workers (Svendsen *et al*. 2005). Instruments to measure exposures have been employed in relatively few studies of work-related shoulder disorders.

A number of physical factors have been studied as risk factors for shoulder pain including force, mass, repetition, posture, and hand transmitted vibration. Several authors have proposed mechanisms to explain the observed associations between these physical factors and shoulder disorders. Neer's hypothesis was that the majority of cases of rotator cuff syndrome were due to elevation of the arm, tearing the sub-acromial tendons between the head of the humerus and the acromion – i.e. an extrinsic mechanism (Neer 1972). Subsequent authors have questioned this view and noted that, at least in younger people, impingement may be secondary to cumulative microtrauma to the ligaments leading to glenohumeral instability (Fu *et al*. 1992) The intrinsic mechanism has also been proposed: high pressure within the muscles of the rotator cuff leads to impaired circulation leading to inflammation and subsequent degeneration (Fu *et al*. 1992) However, the mechanism by which these physical factors operate is incompletely understood. Currently the most likely explanation is that it is multifactorial with both intrinsic and extrinsic factors operating (Mehta *et al*. 2003).

Psychosocial exposures

Psychosocial factors studied have included high job demands, low job control, poor workplace support and job insecurity. Psychosocial pressures are typically measured using self-administered questionnaires such as the widely used Job Content Questionnaire (Karasek *et al*. 1998). There is the possibility that psychosocial factors in the workplace are simply surrogates for physical factors, such as high repetition. However, the correlation between physical and psychosocial factors has been found to be less than 0.2, strongly suggesting that this is not the case (Miranda *et al*. 2005).

Psychosocial factors including high job demands, low job control, poor workplace support and job insecurity have been explored as potential risk factors for shoulder pain. How these factors might lead to chronic pain, especially rotator cuff disease, is unclear. It might be hypothesised that psychosocial factors for shoulder pain are mediated by workplace stress. However, Bonde *et al*. (2005) found that repetitive work did not lead to stress, calling this into question. An alternative explanation is that these psychosocial factors predispose to poor mental health. In one prospective cohort study, the Whitehall II study, low workplace support, low job control, high job demands and effort-reward imbalance were associated with an increased risk of psychiatric morbidity (Stansfeld *et al*. 1999). Also, anxiety has been shown to be a predictor of subsequent musculoskeletal disorders in a prospective study of offshore oil industry workers (Parkes and Carnell 2005) and a tendency to somatisation has previously been linked to an increased risk of primary care consultations with arm pain (Palmer *et al*. 2005). Whether somatisation worsens shoulder pain or leads to greater health seeking behaviour is less clear.

4. Methods

Data sources

The literature search was conducted in electronic bibliographic databases using the University of Aberdeen Ovid web gateway. The search was conducted, simultaneously, in Medline (start date: 1966) and Embase (start date: 1980). The final search to derive literature for this report was conducted on February 7th, 2007.

Identification and review of literature

The identification and review of literature was conducted in four parts:

- Bibliographic database search:
  - To identify papers relating to the appropriate outcome(s) of interest;
  - To identify papers relating to the appropriate exposure(s) of interest; and
  - To combine searches 1 and 2, and to restrict the searches by a number of pre-specified parameters.
- Review of manuscript titles;
- Review of manuscript abstracts; and
- Review of full papers

Literature search 1 – outcome(s) of interest

A number of anatomical search terms were used to identify papers relating to the appropriate outcome(s) of interest. Specific search terms included: shoulder, rotator cuff, supraspinatus, infraspinatus, teres minor, subscapularis, biceps tend$, and glenohumeral – and various alternative spellings of these – all combined using the Boolean operator 'OR'. The full search strategy can be seen in Appendix I. This search identified 56,174 papers.

Literature search 2 – exposure(s) of interest

Firstly, a number of search terms were used to identify papers relating to epidemiology and / or those presenting data relating to risk factors. Specific search terms included: epidemiolo$, aetiolo$, risk factor$, odds ratio$, risk ratio$ and relative risk$ – and various permutations and alternative spellings of these – all combined using the Boolean operator 'OR'. This search identified 1,456,900 papers.

Secondly, occupational search terms were used to identify papers relating to the appropriate occupational environment. Specific search terms included: occupation$, employment$, job$ and work$, all combined using the Boolean operator 'OR'. This search identified 1,305,486 papers.

Thereafter, these two searches were combined using the Boolean operator 'AND'. This resulted in the identification of 122,674 papers.

Literature search 3 – combination and restriction of searches

Search 1 (outcomes of interest) and Search 2 (exposures of interest) were combined using the Boolean operator 'AND'. This resulted in the identification of 1062 papers. Because the literature search had involved the simultaneous use of more than one bibliographic database, duplicates were then removed (i.e. papers identified twice, because of being listed in both databases). This resulted in the exclusion of 301 papers, leaving 761 unique articles. An additional search was conducted using the term 'impingement syndrome' and, although this resulted in a number of relevant articles, it revealed none that had not already been identified.

Thereafter, the final search was limited to papers written in English, and those indexed as 'Human'. This reduced the number of papers to 651.

Review of manuscript titles

Two persons independently reviewed all 651 titles to assess whether it was important to read the abstract of the paper. The following inclusion criteria were used:

- Evidence of pain / disability in the shoulder as an outcome measure; and
- Evidence of pain / disability in the neck / upper limb as an outcome measure.

At this stage, the exposure measurement in each paper was not considered.

The reviewers agreed in 488 (75%) of instances: 247 papers in which they agreed that the abstract should be reviewed and 241 where the paper was rejected. For the 163 papers in which there was disagreement a third person reviewed the titles to assess whether it was important to read the abstract of the paper, using the same inclusion criteria, above. This resulted in a further 80 papers being accepted and 83 being rejected. Thus, 327 abstracts were selected for review.

Review of manuscript abstracts

Two persons independently reviewed all 327 abstracts to assess whether it was important to read the full paper. The following exclusion criteria were used:

- Explicit mention that the outcome was assessed by self-report; and
- Explicit mention that only non-occupational exposures were assessed.

The reviewers agreed in 275 (84%) of instances: 97 papers in which they agreed that the full paper should be reviewed and 178 where the paper was rejected. For the 52 papers in which there was disagreement a third person reviewed the abstracts to assess whether it was important to read the full paper, using the same exclusion criteria, above. This resulted in a further 15 papers being accepted and 37 being rejected. Thus, 112 full papers were selected for full-text review.

Review of full papers

Two persons independently reviewed all 112 papers to assess eligibility for inclusion in this report. The following exclusion criteria were used:

- The study used solely a self-reported assessment of outcome;
- The study examined non-occupational exposures only; and
- There was no presentation of estimates of the magnitude of any risk effects, or data from which risk effects were computable.

The reviewers agreed in 90 (80%) of instances: 12 papers in which they agreed that the paper warranted inclusion in the final report and 78 where the paper was rejected. For the 22 papers in which there was disagreement a third person reviewed the full papers, using the same exclusion criteria, above. This resulted in 1 additional paper being accepted and 21 being rejected. Thus, 13 papers were selected for inclusion in the review.

A full flowchart of the methods, from the identification of the initial 651 titles, to the selection of the final papers, is available in Appendix II. Also, Appendix III lists the 13 papers included in the review; and Appendix IV lists the 99 papers rejected following full-text review, and gives the reasons for exclusion.

Quality assessment

The methodological rigour with which each individual study had been conducted was assessed in ten domains, each scored according to set criteria:

- Study design;
- Sample size and statistical power;
- Sampling methods;
- Participation and / or follow-up;
- Bias (inflationary bias and bias towards the null);
- Confounding;
- Blinding;
- Objective measurements of exposure;
- Exposure-response data; and
- Outcome measurement

Comprehensive details of the quality assessment can be seen in Table 1. However, in general, prospective studies – particularly those with extensive periods of follow-up – were rated higher than cross-sectional or case-control studies. Studies with large number of participants and those with high participation and / or follow-up were also rated higher, as were those with clearly stated, robust sampling methods. A higher score was given for studies in which it was deemed there was a low(er) potential for bias and where adjustment was made for potential confounding factors. A higher rating was also awarded for studies where the outcome assessment was blinded for exposure status (or *vice versa*), for objective measurement of both exposure and outcome, and where exposure-response data was defined on a ordinal or quantitative scale, rather than simply binary.

The methodological assessment for each individual study can be seen in Table 2. In accordance with the guidelines set down by the Scientific Committee of the Danish Society of Occupational and Environmental Medicine, the overall quality of a study was not based on any formal scoring system since there is no gold standard for the true validity of a study. No thresholds were imposed beyond which a study was rated as good, moderate, poor, *etc*. Thus, the overall quality of a study was assessed subjectively, but was based largely on the above scoring system.

5. Literature review

Main findings

Thirteen original articles were identified for inclusion in this review (see Appendix III). A general description of each study is shown in Table 3. Also, a comprehensive definition of the primary outcome for each study is provided in Table 4. A description of each individual study is given below, followed by a summary of the findings. In addition, Tables 5 to 9 summarise the results relating to occupational exposures and shoulder disorders from the thirteen papers, as follows:

- Table 5 – Position of upper limb;
- Table 6 – Manual handling / force requirements;
- Table 7 – Repetitive tasks;
- Table 8 – Other physical exposures; and
- Table 9 – Psychosocial exposures.

Description of individual studies

Andersen and Gaardboe 1993

Andersen and Gaardboe conducted a cross-sectional study of 90 sewing machine operators (identified from a previous epidemiological survey) and compared the prevalence of musculoskeletal disorders (including rotator cuff disease) with that in a group of 30 age-matched auxiliary nurses and home-helpers. Sewing machinists are involved in a job characterised by repetitive arm movements, static loading of the shoulders and prolonged neck flexion, while job tasks of auxiliary nurses and home-helpers, assumed by the researchers to share a similar social background as sewing operators, were considered to be different with respect to neck / shoulder exposures. Both groups were invited to undergo a physical examination which included a comprehensive assessment of the neck, shoulder and arm. There were seven refusals to undertake the examination and six exclusions because of other disease. Rotator cuff syndrome was diagnosed if the worker reported chronic shoulder pain and had all the following signs: positive pain arc or impingement sign, and tenderness at the tuberculum majus. Both groups were also interviewed and data was collected about work history. The physical examination, which preceded the interview, was performed blind, with respect to the occupation of the study subject. 'Number-of-years' in the job was used as an index of the level of exposure. Only 1 out of 25 (4%) in the non-exposed groups (nurses and home helps) was diagnosed with rotator cuff syndrome compared to 6 out of 25 (24%) in those who worked as sewing operators for 8-15yrs, and 11 out of 36 (31%) in those who were involved in that job for more than 15yrs ($p<0.01$).

Although the fact that the assessment of the outcome was blind to the exposure status is a strength of this study, the exposure was defined crudely, based on occupation (sewing machine operator, home help, or auxiliary nurse). In addition, estimates were not controlled for any potential confounding factors, including age. This is particularly important as persons with the longest exposure are likely to be older.

Chiang et al. 1993

Chiang *et al*. conducted a cross-sectional study of 207 employees in eight fish-processing factories in Taiwan (size of source population and level of participation not provided). Data on upper limb and shoulder pain was collected using a standardised questionnaire and clinical examination. 'Shoulder girdle pain', was determined by a standardised questionnaire and clinical screening carried out by an experienced occupational physician and included all patients diagnosed with any disorder involving the upper limb, shoulder and neck (e.g. cervical brachial syndrome). The workers were classified into three groups according to their job tasks.

- Group 1 – Tasks of low repetitiveness and low forceful movement of the upper limbs;
- Group 2 – Tasks of high repetitiveness <u>or</u> high forceful movement of the upper limbs; and
- Group 3 – Tasks of high repetitiveness <u>and</u> high forceful movement of the upper limbs.

The biomechanic movements of one worker in each group was observed and recorded. The highly repetitive jobs were those with a cycle time of less than 30 seconds or more than 50% of the cycle time involved in performing the same type of cycles. The hand-force requirements of the jobs were estimated by electromyographic recording from forearm flexor muscles. Occurrence of shoulder girdle pain was more commonly reported in groups 2 and 3 compared to group 1 in employees who had been in their current job during the previous twelve months (p=0.04). A statistically significant difference was also found in workers who had been working in the same industry during the previous 12-60 months, although, no difference was found in those who had more than 60 months of employment duration. No other statistical analyses were conducted to explore this association further. The assessment of the outcome in this study was not blinded to the exposure status and, therefore, may be prone to observer bias.

Only one worker in each of the three task groups was evaluated for biomechanical movements at the work place and, thus, the authors are assuming a large degree of homogeneity in exposures. Also, only current exposure has been considered in assigning to the exposure groups. In addition, the nature of the study – and, in particular, the fact that there was no effect of ergonomic factors in those employed for the longest time – may suggest the possibility of the Healthy Worker Effect.

Stenlund et al. 1993

Stenlund *et al*. conducted a cross-sectional study of bricklayers, rock blasters and foremen drawn from construction workers in the Stockholm region of Sweden. It was assumed that these three occupations represent different workloads in the same trade. A total of 260 workers were invited to participate in the study, of whom 207 agreed to take part and their exposure status was assessed using an interviewer-administered questionnaire. The outcome (shoulder tendinitis) was diagnosed by either pronounced palpable pain of the shoulder muscle attachments, or a pronounced pain reaction to isometric contraction in any of the four rotator cuff muscles or the biceps muscles. The only statistically significant work-related physical factor associated with shoulder tendinitis was exposure to vibration ($OR_{right\ side}$: 1.7; 1.1-2.6; OR_{left}

$_{side}$:1.8; 1.1-3.1). However, lack of variability in the other exposures may have limited the ability of the study to detect differences in the other exposures.

In this study, assessment of the outcome was blinded for the exposure and the significant effect estimates were controlled for age, right- or left-handedness, and smoking. However, exposure variables in this study were only measured subjectively. This might have led to differential misclassification if workers with shoulder tendinitis have overestimated their level or duration of exposure compared to those without the condition.

Frost and Andersen 1999

Frost and Andersen (1999) performed a cross-sectional analysis of a historical cohort of 1591 current and former slaughterhouse and chemical factory workers. Their objective was to determine whether workers who performed slaughtering or meat processing tasks were at increased risk for shoulder impingement syndrome when compared with workers who had never performed that work. The intensity of shoulder work was assessed by video-based observations. Clinical status was determined by questionnaire followed by physical examination. The prevalence of impingement syndrome in current and former slaughterhouse workers exceeded those for referents more than five-fold. When corrected for age, impingement syndrome prevalence ratios increased with years of exposure to slaughterhouse work, particularly within the first 6yrs. The statistical model presented also was consistent with an increase in risk after more than 28yrs of exposure although the confidence intervals were very wide.

The exposures in this study were video recorded in a sub-group of subjects. Exposure-response information is available: potential risk factors were defined on three-class ordinal scale and, while the definition of shoulder impingement syndrome was made un-blinded to the employing company, investigators were blinded to cumulative exposure. The authors have attempted to partially address the Healthy Worker Effect by having former slaughterhouse workers included in the exposed group. Effect estimates presented in this report were not controlled for potential confounding factors, including psychological and psychosocial variables, although the authors reported that age- and sex-adjusted figures were not different from those in the tables.

Kaergaard and Andersen 2000

Kaergaard and Andersen conducted a cross-sectional study of 243 female sewing machine operators. The presence of rotator cuff tendinitis and myofascial pain was determined by questionnaire and physical examination using diagnostic criteria, which are specified by the authors. Information was collected with respect to work-related psychosocial factors (based on Karasek's model). The sewing machine operators were assumed to be highly exposed to repetitive work, and were classified according to the duration of work into four exposure categories. The prevalence of the shoulder disorders in each exposure category was compared with the prevalence of the same disorder in 357 women with non-repetitive work. A U-shaped relationship was observed overall for neck / shoulder disorders with duration of exposure, however this was mainly a result of the relationship with myofascial pain syndrome. For rotator cuff tendonitis the prevalence of rotator cuff tendonitis amongst the sewing machine operators increased with increasing duration of exposure from 0% (from 32 subjects) in those exposed less than two years, 1% (from 80 subjects) in those exposed 2-10yrs, 6% (from 67 subjects) for 10-20yrs of exposure, to 15% (from 59 subjects) for those exposed more than 20yrs.

All further analyses in this study were presented combining myofascial pain and rotator cuff tendinitis cases and should be interpreted with caution given that there were approximately three times the number of the former, compared to the latter. An increased risk of having rotator cuff tendinitis / myofascial pain was significantly associated with high stress (prevalence ratio (PR): 2.54; 1.28-5.05). This association was adjusted for duration of exposure, age, smoking, BMI, job strain, low social support and whether individuals were living alone with children. In a sub-analysis comparing the prevalence of the outcome in sewing machine operators exposed to different levels of exposure (estimated by the number of years of work), a clear trend of increased prevalence was observed with duration of exposure ($p<0.001$).

Participants were then followed-up over two years to identify predictors of new onset shoulder disorder in subjects who were free of these conditions at baseline. Low social support was significantly associated with future development of shoulder disorders at two-year follow-up (PR: 3.72; 1.22-11.30).

The case-definition of rotator-cuff tendinitis, used in this study, was explicit and relevant, although the outcome definition for the multivariable analysis did not distinguish between rotator-cuff tendinitis and myofascial pain syndrome. Mechanical exposures were defined on a four-class ordinal scale, thus exposure-response information is available. However, work-related exposures in the main study group were not measured objectively and job title (based on self-report of being a sewing machine operator) was used as a surrogate for repetitive work. However, the control group comprised women from 15 different industrial plants who were considered (by observation and discussion with the workers and employees) to have non-repetitive job tasks. The longitudinal aspect of part of the study is useful in terms of assessing the temporality of the association with psychosocial factors.

Punnett et al. 2000

Punnett *et al*. conducted a case-control study in automobile assembly plant workers to evaluate the relationship between shoulder disorders and arm flexion / abduction during work. Forty-two cases with shoulder disorders (shoulder pain on more than three occasions, or for more than one week during the past year and, on examination, with physical findings during at least one manoeuvre) were identified prospectively over a ten-month period from workers who reported to the plant medical department with neck / shoulder pain. A total of 124 controls, who were free of neck / shoulder pain, were selected randomly from the rosters of the 4 production departments of the same plant at the beginning of the study. For each of the cases and controls, one job was videotaped and analysed for postural and biomechanical demands by an analyst blind to the case-control status. Strong and statistically significant associations were found between shoulder disorders and occupational exposure to shoulder flexion or abduction of at least 90° (for the right shoulder: $OR_{0\text{-}<10\% \text{ of work cycle}}$: 2.0 and $OR_{\geq 10\% \text{ of work cycle}}$: 3.9; and for the left shoulder: OR: 2.5 and 6.1 respectively[5]).

[5] No confidence intervals were presented in the paper for this analysis, although the authors noted that both sets of results were significant: p=0.007 and p=0.0004, respectively.

This study had a well-defined objective. There was a clear case-definition and the study had an objective measure of exposure. However, for the cases, the study job[6] was the job held at the onset or aggravation of pain; whereas, for controls, this was the current job. This selection of jobs would tend to inflate the effect measures. Also, 43% of cases and 19% of controls were unable to be videotaped and, thus, recordings were made of proxy workers.

Work-related mechanical exposures were defined in tertiles and there was evidence of an exposure-response relationship. These authors also demonstrated no difference between cases and controls in frequency of handling loads of $\geq$4.5kg (OR: 1.1; 0.4-3.4). Further, these findings were robust to restriction by gender and stratification by a number of other potential confounding variables.

Frost et al. 2002

Frost *et al*. (2002) conducted a cross-sectional study of 1961 workers in repetitive work and 782 referents to evaluate the hypothesis that shoulder loads in repetitive work might be a risk factor of shoulder tendinitis. To assess work-related mechanical exposures, ergonomists visited 19 company sites and work tasks were classified as either repetitive (e.g. packing, shop cashier, machine feeding) or control (internal transportation, supervision), forming 5-6 task groups in each company. The number of shoulder movements per minute, lack of micro-pauses and force requirements (which was scored by the observer on a five unit ordinal scale as described by Moore and Garg (1995)) were quantified on repeated reviews of video recordings of a sample from each task group. Physical exposure quantification was based on these task groups on the assumption that exposure profiles would be similar within groups, but different between groups. Such assumptions were tested by variance analyses, which found that the grouping strategy was successful to establish homogenous exposure levels within the task groups for repetition, lack of micro-pauses and force requirement, but failed to establish such similarity with respect to shoulder postures.

Perceived psychosocial work characteristics were assessed using the Job Content Questionnaire (Karasek *et al*. 1998). The diagnosis of shoulder tendinitis was made according to stated criteria which were determined by a questionnaire about shoulder pain and impairment, followed by physical examination using a defined protocol. The prevalence of shoulder tendinitis was significantly higher among workers classified as performing repetitive tasks (OR: 3.1; 1.3-7.3). A similar significant association was also observed, amongst all subjects, when a quantitative measurement of repetitive tasks was used: high repetition compared to no repetition (OR: 3.1; 1.3-8.1); high versus minimum force requirements (OR: 4.2; 1.7-10.4); and work without micro-pauses (OR: 3.3; 1.4-8.1). When the analysis was restricted to workers in repetitive work tasks, the only significant relationship found was with force requirement (OR: 1.6; 1.0-2.6, per unit increase across somewhat hard, hard, and very hard).

This study had a clearly stated and valid sampling frame. The exposure was measured objectively and defined on a continuous scale (exposure-response information available). In addition, assessment of outcome was objective, reproducible and blinded to exposure status. Effect estimates for physical

[6] The job that was video-taped for exposure assessment.

exposures were controlled for most important confounding factors (age, sex, injury, physical activity and psychosocial factors).

Svendsen et al. 2004a

Svendsen *et al*. conducted two cross-sectional studies in a subset of a Danish historical cohort of 2,053 male machinists, car mechanics and house painters. The aim of the first study (Svendsen *et al*. 2004a) was to determine whether work performed with the arms in a highly elevated position or requiring high force was associated with MRI-assessed supraspinatus tendinopathy and acromioclavicular joint degeneration. Technically this study does not meet the inclusion criteria for our review since shoulder pain was not part of the outcome definition – however it is an important study to consider, given the detail of the exposure assessment, but particularly in relation to its use of MRI. Out of 304 men who met specific inclusion criteria (including being aged 40-50yrs, right handed and employed in their trade for 10yrs), a random sample of 214 men were contacted by phone, of whom 192 were eligible and 136 (71%) participated in the study. Data on upper limb elevation was collected by whole-day inclinometer measurements for four consecutive working days in a random sample of workers from each trade to give an average percentage of daily working hours spent with an elevated arm >90°.

Lifetime upper arm elevation for each worker was calculated by multiplying the daily measured average exposure of each job with the duration of employment (in months). Force requirement was assessed by a torque index for the glenohumeral joint. A significant exposure-response relationship was only found between lifetime upper arm elevation and supraspinatus tendinopathy ($OR_{\text{per 5-month increment of working months}}$: 1.27; 1.02-1.60). Although the exposure duration for each participant was measured objectively (from the list of previous jobs on the Register of the Danish Labour Market Supplementary Pension Scheme) errors may have been introduced if the random sample of workers for each trade were non-representative of the trade as a whole. However, assuming such errors were random, any bias introduced would be towards the null.

This relatively small study had a clearly stated aim and used a valid sampling frame. Exposures were defined on a continuous scale and on a five-class ordinal scale (exposure-response is information available and complete). Case definition of outcome (using MRI) was reproducible and its assessment was blind to exposure status although pain, as noted above, was not a requirement of the outcome definition. The potential confounding effect of gender was controlled for by restricting the study population to males. In addition, effect estimates were adjusted for age and the inclusion of psychosocial factors to the final model did not influence the conclusions.

Svendsen et al. 2004b

In their second cross-sectional study from the same historical cohort population, Svendsen *et al*. (2004b) examined the relationship between work-related physical and psychosocial factors and clinically verified supraspinatus tendinitis in machinists, car mechanics and house painters. Data on arm elevation was collected using objective measurements that were described above (lifetime exposure and current-work exposure). Data on psychosocial factors (job demands, control and support) were collected using the

Copenhagen Psychosocial Questionnaire (Kristensen *et al*. 2002). Diagnosis of supraspinatus tendinitis was performed by physical examination with assessors blind to exposure and symptoms. The percentage of current working hours with arm elevated >90° was significantly associated with supraspinatus tendinitis ($OR_{\text{per 1\% increment of working hours}}$: 1.23; 1.10-1.39). An elevated odds, albeit not statistically significant, was found when dominant arm elevation was measured as the number of months of lifetime exposure. A significant association was also found between tendinitis and the report of high job demands (OR: 3.19; 1.62-6.31); a lesser, and non-significant, association was found with the report of low job control (OR: 1.83; 0.93-3.60).

Unlike the previously mentioned report published by the same authors, which only measured work-related physical exposures (Svendsen *et al*. 2004b), this study examined the relative contribution of both physical and psychosocial factors. However, evaluation of the outcome was performed with physical examination, without radiological confirmation.

Miranda et al. 2005

In a cross-sectional study, Miranda *et al*. used data from the Finnish 'Health 2000' survey which was carried out in 2000-2001 on a population sample of 8,028 adults. This nationwide survey, which consisted of questionnaires, interview and clinical examination, collected data on chronic rotator cuff tendinitis which was diagnosed with physical examination by a trained physician. Information was also collected on work-related physical loading (using interview, and deriving a cumulative sum index for the number of years of exposure to each factor) and work-related psychosocial / organisational factors (using Karasek's Job Content Questionnaire) (Karasek *et al*. 1998). Of the working subjects aged between 30-64yrs (n=5,871), 88% participated in the interview and 83% attended the health examination. Authors restricted their analysis to 4,071 subjects who, at the time of the survey, were of working age and had held a job during the preceding twelve months. The prevalence of chronic rotator cuff tendinitis was 2.0% with little difference between men (2.1%) and women (1.9%). There was some evidence to suggest that the following work-related physical factors may be associated with chronic rotator cuff tendinitis: driving a motor vehicle, heavy lifting, working with a hand above shoulder level, work requiring high hand force, work requiring repetitive motion of the hand or wrist, and working with a vibrating tool. However, only working with hands above shoulder level was significant in the final multivariable model ($OR_{1\text{-}3yrs}$: 2.4; 1.0-5.9; $OR_{4\text{-}13yrs}$: 3.2; 1.6-6.5; $OR_{14\text{-}23yrs}$: 4.7; 2.4-9.1; $OR_{>23yrs}$: 2.3; 1.1-4.9). The authors also conduced separate analyses for men and women: in women, the number of years of work with heavy lifting was also important ($OR_{1\text{-}3yrs}$: 1.4; 0.3-6.6; $OR_{4\text{-}13yrs}$: 5.0; 2.0-12.2; $OR_{14\text{-}23yrs}$: 1.2; 0.3-5.4; $OR_{>23yrs}$: 1.9; 0.4-8.6).

In men, even relatively short-term exposure (1-3yrs) to working with a hand above shoulder level increased the odds of chronic rotator cuff tendinitis more than threefold, whereas in the women, the odds started to increase after a longer exposure time. Ordinarily, with a cross-sectional study, one would be concerned that the population exhibited the Healthy Worker Effect. However, without detailed knowledge about exposures over time (for example: changing job, leaving work altogether), the difference between men and women cannot be interpreted.

Of the work-related psychosocial and organisational factors, high psychological demands of work were associated with chronic rotator cuff tendinitis. A similar result, but of borderline significance, was observed with the threat of bullying / mental abuse; however, neither of these factors remained in the final multivariable model.

This is a large study, with good participation, from an original target population representing the whole Finnish population aged $\geq$30yrs. The methods used to measure the outcome were valid and to a great extent reproducible. Also, most exposures were defined on five-class ordinal scale, so exposure-response information is available. However, restricting the outcome to chronic cases means that it is not possible to distinguish between factors associated with the onset, or the chronicity, of rotator cuff tendinitis. Also it is unclear whether or not the physicians who conducted the physical examination were blind to exposure status. Failure so to do might have led to differential misclassification of the outcome status.

Werner et al. 2005

Werner *et al*. conducted a cohort study of 985 working subjects from seven industrial and clerical work sites. At baseline, information was gathered about workers' experience of shoulder pain and other pain symptoms in the upper limb. In addition, data on the following factors were collected:

- Ergonomic factors, where each job was rated according to published threshold limit values for hand activity (hand repetition level and peak force) (ACGIH 2002); and
- Psychosocial variables based on a questionnaire developed by Karasek *et al*. (1998).

At the follow-up assessment, an average of 5.4yrs later, a total of 501 workers (51%) were found, completed a symptom questionnaire, and underwent a physical examination of the upper extremities. Subjects were diagnosed with shoulder tendinitis at follow-up in one of two ways: either (a) the worker reported that a physician had diagnosed him / her with shoulder tendinitis any time during the follow-up period; or (b) he / she was clinically diagnosed on physical examination at the follow-up screening. Data from subjects who were free of upper extremity tendinitis at baseline physical examination and did not report a history of such condition (n=388) was analysed to identify potential work-related ergonomic, physical and psychological factors predictive of incident shoulder tendinitis (n=43). Significant univariate associations were found for two baseline variables: low co-worker support (p=0.02) and low supervisor support (p<0.001). No multivariable analysis was performed. However, no difference was found between persons with / without incident shoulder tendinitis in terms of perceived stress at baseline, job (in)security and other psychosocial variables.

This is the only published cohort study that aimed to investigate the relationship between work-related exposures and physically diagnosed shoulder tendinitis. However, it has a number of limitations. Although the cases are referred to as 'incident cases' no data is available on the timing of disease onset. Not all subjects who were categorised as having shoulder tendinitis were physically examined (diagnosis of some cases – the actual proportion is not provided – was based on subjects' recall of a physician diagnosis during the follow-up period). The proportion of baseline subjects who attended the follow-up evaluation was low and no data was presented on subjects lost-to follow-up. Results from cohort studies with low levels of follow-up, as in this study, may be subject to selection bias. Baseline workers who were not found at follow-up might have left or changed their job as a consequence of shoulder tendinitis: this might lead to an underestimate of the new onset rate and may lead to an underestimation of any risk relationships. There is no information on whether or not investigators who collected data on the outcome were blinded to the exposure status. With respect to categorisation of independent variables and statistical analysis, most relevant exposures were defined on a nominal scale (thus, no exposure-response information is available) and the analysis was not controlled for any potentially important confounding factors.

Melchior et al. 2006

Melchior *et al*. made use of data collected by the French National Institute of Health Surveillance and conducted a cross-sectional study to investigate the role pf physical factors on specific upper limb disorders. Initially, 460 occupational physicians were invited to participate in the study of whom 80 agreed to take part and were trained to perform a standard physical examination. On randomly selected days, these doctors were asked to enrol every tenth worker undergoing a regular annual health examination. The study population was 2685 workers employed across multiple companies and industries of the private sector. Fewer than 10% of selected workers failed to participate and 2656 workers provided complete data. Participants were asked to fill in a questionnaire about demographics, occupational grade, health characteristics and physical work exposures. Workers who reported pain in the upper limb during the previous year underwent a physical examination. The examination was based on the international protocol for the evaluation of work-related upper limb disorders (SALTSA[7]) which led to the diagnosis of six principal upper limb disorders, including rotator cuff syndrome. Cases were defined as those with symptoms at the time of examination or during at least four days in the preceding week and physician observed physical abnormalities on clinical examination. Manual and non-manual workers were compared with respect to the prevalence of the disease. Cox regression models were used to identify work-related factors contributing to the increased occurrence of rotator cuff tendinitis among manual workers (PR: 2.1; 1.4-3.1 and 1.9; 1.3-2.8 in men and women respectively). The excess prevalence of rotator cuff syndrome among manual workers was partly explained by repetitive movements at work (with or without breaks), working with arms above shoulders for at least 2hrs per day, working with arms away from the body for at least 2hrs per day, working with hands behind trunk posture (women only). When these factors were adjusted for, in addition to some other work tasks and health-related conditions, there remained a 30-40% excess prevalence, albeit non-significant, (PR: 1.4; 0.9-2.1; and 1.3; 0.9-2.0, in men and women respectively).

This study used a unique analytic approach to identify the relative contribution of physical factors on the occurrence of rotator cuff tendinitis. This study had a clear definition of outcome. Despite the very low participation of physicians, selection bias is not a major concern because of the high level of participation amongst the randomly selected workers, whose visits to the physicians were mandatory. However, the physicians were not blinded to exposure status and exposure characterisation was limited to subjective reporting by the workers.

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[7] In 2000, the European consensus on upper-limb work-related musculoskeletal disorders organized by the 'SALTSA' group proposed a general score on work exposure, based on published literature on risk factors (Sluiter *et al*. 2001).

Walker-Bone et al. 2006

Walker-Bone *et al*. conducted a cross-sectional study among 10,264 adults aged 25-64 registered with two general practices in Southampton, UK. The survey questionnaire asked about shoulder pain in the past week, feeling of well-being and, for those in employment, about physical and psychological aspects of their work. A total of 6038 subjects responded (59%), of whom 4625 were in current employment. Of those currently employed subjects, who reported shoulder pain and still reported the same symptoms in the interview, 152 were classified as having a specific disorder of the shoulder, of whom 103 had rotator cuff tendinitis (other diagnoses included adhesive capsulitis, biceps tendinitis, subacromial bursitis or acromioclavicular joint dysfunction). These diagnoses were based on the detailed physical assessment conducted within four weeks of returning the postal questionnaire. The physical examination included palpation, measuring of range of movements and clinical provocation tests of the shoulder region. The study investigated the relationship between 'specific shoulder disorders' and the following work-related mechanical and psychosocial factors:

- Type of work (blue-collar versus white collar);
- Working with hand held above shoulder;
- Carrying weights on one shoulder or carrying weights of >5kg in one hand;
- Job demands;
- Control over work; and
- Support at work.

Information on both mechanical and psychosocial factors were collected solely by the survey questionnaire. Psychosocial aspects of work were based on the Karasek model of job demands, job support and control over work (Karasek *et al*. 1979). Significant age- and sex-adjusted associations were found between specific shoulder disorders and blue collar work (OR: 1.6; 1.1-2.4), and carrying weights on one side (OR: 1.8; 1.2-2.8). Working with hand held above shoulder for >1hr per day (OR: 1.6; 0.9-2.9) was associated with an increase in the odds of shoulder disorders of similar magnitude, although this did not reach statistical significance. These authors also demonstrated that a lack of support at work played an important role (OR: 1.8; 1.1-3.0).

Strengths of this study lie in its large sample size, its population sampling frame and blinded assessment of the outcome. However, an important drawback of this study is the mixture of diagnoses. There were no objective measurements for work-related exposures and all potential risk factors were defined mainly on a binary scale (exposure above a certain duration or not), so no exposure-response information was available.

Summary of evidence

The strongest evidence in relation to shoulder disorders relates to posture. This has been defined differently in different studies but the essential feature is working with arms in an elevated position. Several studies present evidence of an increased occurrence of shoulder disorders associated with this exposure (Walker-Bone *et al*. 2006; Miranda *et al*. 2005; Svendsen *et al*. 2004a and 2004b; Punnett *et al*. 2000; Melchior *et al*.

2006). It should be noted however that all these studies are cross-sectional and most included self-reported occupational physical exposures – although some also incorporated quantification of mechanical exposure by measurement or observation. There is some evidence also in relation to repetitive work (mainly inferred from job characteristics) (Kaergaard and Andersen 2000; Frost *et al*. 2002; Andersen and Gaardboe 1993), and mechanical load (Walker-Bone *et al*. 2006; Miranda *et al*. 2005), in increasing the likelihood of shoulder disorders. In relation to psychosocial factors at work, while several aspects have been reported to be linked with shoulder disorders the most frequent observation is in relation to lack of support at work, with Walker-Bone *et al*. (2006) and Werner *et al*. (2005) reporting a significant association and Kaergaard and Andersen (2000) demonstrating a substantial (~70%) association, but of borderline significance. The latter two observations have been from prospective studies which provide stronger evidence that these reports are not changed perceptions of work after having developed a shoulder disorder but, rather, are associated with its future development.

It is important to make some comments around methodology of the studies conducted. The studies conducted have used different populations (e.g. general population samples, working populations) and amongst working populations have studied diverse types of employment. Nearly all have been cross-sectional in design which leads to problems in establishing the temporal nature of any association and makes many of the studies liable to the Healthy Worker Effect. In addition, some have had limited information available on potential confounding factors. Evaluation of physical work exposures have used self-report but many studies have incorporated more objective estimates of exposure such as the use of video recordings. The focus of most studies has been on physical aspects of work (posture, force, repetition and load) but more recent studies have incorporated measurement of psychosocial aspects of the workplace.

The outcome varied between studies, and not all are explicit on the definition used. However, for the purposes of this review however all include shoulder pain with physical findings as a minimum, with the exception of Svendsen *et al*. (2004a) who relied solely on MRI findings. Finally, with respect to evaluating the evidence, rather than conclude that one study is methodologically stronger or more informative than another, as we amalgamate the evidence we have put greatest emphasis on consistency across studies. Individual studies will have both strong and weak aspects, and all studies will be prone to biases. These biases are principally around the subjects studied and the information gathered and it is difficult to determine the precise extent of biases from the reports of studies. Thus the strongest evidence often comes from repeated observations of an association – particularly if this is made across different types of populations, different study designs and using different methods of ascertaining exposures.

6. Other relevant data

Contributory evidence

Studies with a focus on clinically diagnosed rotator cuff tendinitis are scarce compared to those that investigate risk factors for self-reported shoulder pain. However, evidence with respect to determinants of subjectively measured shoulder pain may be useful: it is important to place the main findings in the context of the wider literature.

Because of limitations in the cross-sectional design in terms of establishing temporality, we limited our search for contributory evidence to prospective cohort studies, which allow conclusions to be drawn with respect to the temporal relationship between an exposure and outcome. Our literature search (described in the Chapter 4) identified seven cohort studies relevant for consideration under contributory evidence. The studies investigated occupational risk factors for shoulder pain alone, or shoulder pain with neck and / or upper limb pain – i.e. painful conditions affecting the shoulder region but which did not meet the more stringent case-definitions of rotator cuff disease and / or biceps tendinitis, as assessed using physical examination. Two of these articles restricted their outcome to pain involving the shoulder region; the remainder used a wider case definition.

A general description of each study is shown in Table 10. In addition, Tables 11 and 12 summarise the results relating to occupational exposures and pain involving the shoulder region, as follows:

- Table 11 – Physical exposures; and
- Table 12 – Psychological exposures.

Studies focusing on self-reported shoulder pain

Miranda *et al*. (2001b) conducted a one-year cohort study of Finnish forestry company workers, aiming to explore the predictive role of occupational exposures and physical exercise on the incidence of shoulder pain. In 1994, a baseline questionnaire was sent to 7000 employees, and those who responded were again contacted one-year later. 77% of these workers responded to the questionnaire and, of those who provided complete baseline data, 90% agreed to participate at follow-up. The questionnaire evaluated new episodes of shoulder pain during the previous year, and collected information on age, sex, mental stress, weight, smoking physical activity and, more importantly, gathered data on the following work related factors: repetitive work; hand-arm vibration; daily lifting of loads; amount of twisting movements during working day; working with the trunk flexed; working with the hand above shoulder level; working with rotated neck; working in sitting position; and physical strenuousness of work.

On multivariable analysis, older persons were found to be at increased risk: persons who reported that their work was 'rather or very strenuous' experienced a doubling in the odds of new episodes of shoulder pain (OR: 2.0; 1.3-3.1). Whereas, working with the hand above shoulder level for >1hr per day, and working with the trunk flexed forwards for >2hrs per day, were associated with more modest, and non-significant, increases in odds (OR: 1.3; 0.8-1.9 and 1.6; 0.9-2.6, respectively). Similarly, persons who reported mental stress experienced an increase in occurrence (OR: 1.9; 1.1-3.3).

Harkness *et al*. (2003) used a similar study design to study work-related risk factors for incident shoulder pain in newly employed workers. However, the follow-up period was longer (two years) and in addition to studying the predictive role of work-related mechanical / physical factors, this study investigated the relative contribution of psychosocial factors. The study population, a heterogonous group of workers recruited from twelve diverse occupational groups, were asked to fill in a questionnaire which assessed shoulder pain and various aspects of work-related factors. Subjects who were pain-free at baseline were re-contacted twice, at one-year intervals, to identify those who developed shoulder pain. At each follow-up, 79% and 88% of subjects participated, respectively. From the final multivariable analysis, lifting heavy weights with one or both hands (OR: 1.7; 0.9-3.0), pushing or pulling heavy weights (OR: 1.9; 1.1-3.3) and working with hands above shoulder level (OR: 1.6; 0.98-2.5) were important markers for the onset of shoulder pain. Persons reporting that their jobs were monotonous ‘at least half the time’ (OR: 1.7; 1.1-2.8) and those who reported other body pains (OR: 1.6; 0.9-1.9) also experienced an increase in odds. Although there was evidence that other mechanical and postural factors (carrying weights on one shoulder; lifting at or above shoulder level; occupational driving; and stretching below knee level) may be important on univariable analysis, these factors did not remain in the final multivariable model.

Results from these two prospective studies, which investigated work-related risk factors for self-reported shoulder pain provide contributory evidence of various exposures may place workers at risk of rotator cuff syndrome and / or biceps tendinitis. In both studies the significant predictive role of work posture, and in particular working with arms in an elevated position, support findings of studies that used pain plus physical examination in the assessment of the outcome (Walker-Bone *et al*. 2006; Miranda *et al*. 2005; Svendsen *et al*. 2004b; and Punnett *et al*. 2000). In addition, the findings of Harkness *et al*. (2003) findings relating to the independent predictive effect of pushing and / or pulling is in accordance with that reported by Walker-Bone *et al*. (2006) and Miranda *et al*. (2005) when they investigated the role of mechanical load on rotator cuff disease.

Harkness *et al*. (2003) also found that repetitive arm / wrist movements were not predictive of new-onset non-specific shoulder pain. However, this does not support the findings of Kaergaard and Andersen (2000) and Frost *et al*. (2002) who gave indirect indication of a possible relationship between such movements and rotator cuff disease. However, in the two latter studies, the amount of hand / wrist repetitive movements was only inferred by the job characteristics of the workers.

Finally, although the precise exposures varied between Walker-Bone *et al*. (2006), Werner *et al*. (2005), Svendsen *et al*. (2004b); and Kaergaard and Andersen (2000), the findings of Harkness *et al*. (2003) also identified the important role of psychosocial factors.

Studies focusing on self-reported pain involving shoulder / neck / upper limb

Feveile *et al*. (2002) conducted a five-year follow-up study of 5,940 employees aged between 18 and 59yrs in Denmark. 1,895 subjects were included, who were free of neck / shoulder pain at baseline and completed a pain questionnaire five years later. The following work-related factors were assessed at baseline: repetitive work tasks; physically hard work; working with hand raised; twisting / bending of trunk; sedentary tasks; heavy lifting; high psychological demands; low skill discretion; low decision authority and low social support. The level of participation was high at both the baseline evaluation (90%) and at follow-up (86%). In women, no occupational factors independently predicted the development of neck / shoulder pain at follow-up. Whereas, in men, twisting or bending of trunk (OR: 1.51; 1.01-2.26) and low social support at work (OR: 1.76; 1.24-2.50) were found as independent predictors. In addition, these authors demonstrated, in men, an interaction between heavy lifting and sedentary work. However, the wide confidence intervals of this latter analysis suggest that the results may not be very robust. Also, it is clear that there is some colinearity between these two variables which may cause instability in the models.

Also in Denmark, and using a similar study design, Andersen *et al*. (2003) conducted a four-year prospective study of 3123 industrial and service workers. At baseline, these workers were assessed for neck / shoulder pain by a questionnaire and physical examination. They were also assessed for physical (repetitive work, forceful work and neck flexion) and psychosocial (job demand, control and support) exposures using a combination of subjective and objective methods. Similar data was collected at the three subsequent occasions and a total of 1546 subjects (49.5%) provided complete data at all follow-up time points. Repetitive movement of the shoulder was the strongest risk factor for both subjective reporting and clinical diagnosis of shoulder and / or neck pain (OR: 3.0; 1.5-5.8). Also, greater time spent with the neck flexed more than 20° was associated with an increased risk of neck / shoulder pain. This association was also observed when regional shoulder pain was the outcome of concern (OR: 1.8; 1.4-2.3). In terms of psychosocial exposures, high job demands and low job control were associated with the onset of neck / shoulder symptoms and future clinical cases. In the multivariable analysis, high level of physical exposure and high job demands independently predicted both neck / shoulder pain symptoms and clinical cases.

Östergren *et al*. (2005) conducted a one-year prospective cohort study of 4919 workers aged 45-65 living in Malmo, Sweden. At baseline, neck / shoulder pain experienced during the previous twelve months was determined by the standardised Nordic questionnaire. Data was also collected on mechanical exposures and an index – mainly comprising of body posture at work – was constructed. In addition, work-related psychosocial factors were measured by the Karasek and Theorell demand-control instrument. At one-year follow-up, 87% of the baseline population were found, and information was gathered about the new-onset of neck / shoulder pain. High mechanical exposure was associated with an increased odds for development of neck / shoulder pain among men (OR: 2.17; 1.65-2.85) and women (OR: 1.59; 1.22-2.06). In addition, the report of job strain was associated with heightened odds in females (OR: 1.73; 1.29-2.31).

A prospective cohort study of office workers in the Netherlands aimed to investigate the relationship between physical and psychosocial work factors, and neck / upper limb symptoms (van den Heuvel *et al*. 2005; van den Heuvel *et al*. 2006). At baseline, these workers were assessed, by questionnaire, for neck / shoulder pain and for a number of work-related psychosocial factors using the Job Content Questionnaire (Karasek *et al*. 1998). In addition, data on some physical characteristics of their work (flexion or rotation of the neck, lifting, flexion or rotation of wrists, prolonged sitting) were obtained using questionnaires and video observations. Of the baseline study population, 787 workers (77%) had complete follow-up data about neck / shoulder / upper limb pain at three-year follow-up. Self-reported neck extension (OR 2.42; 1.22-4.80) and rotation (OR: 1.43; 1.02-2.01) at baseline was associated with neck-shoulder symptoms at follow-up. In addition, observed exposures (taken on 25% of the participants and extrapolated to others in the same working groups) also demonstrated a similar relationship (OR: 1.57; 0.99-2.50). However, unfortunately, observed measurements are not available for every self-reported exposure. After adjustment for physical factors, personal characteristics and stress symptoms, two psychosocial factors significantly predicted development of neck / shoulder pain: high job demands (risk ratio (RR): 2.1; 1.2-3.6) and high job strain (RR: 1.7; 1.1-2.6).

Overall, results of these studies suggest that neck / shoulder / upper limb pain in occupational settings is a result of many factors, including physical load and the psychosocial work environment. These results support the findings of studies that have investigated the relative contribution of physical and psychosocial factors on rotator cuff disease and / or biceps tendinitis (Walker-Bone *et al*. 2006; Werner *et al*. 2005; Svendsen *et al*. 2004b; Kaergaard and Andersen 2000), which have found that both physical and psychosocial factors are independently associated with these shoulder disorders in different occupational populations.

The impact of gender

Although several studies presented data separately for men and women, with respect to the association between occupational exposures and rotator cuff disease / biceps tendinitis, none set out explicitly to examine these differences. As a result, studies, in general, have been underpowered to detect any statistically significant differences and the results should be interpreted accordingly.

Mechanical exposures

Only two studies were identified that examined gender differences in the relationship between occupational mechanical exposures and rotator cuff disease and / or biceps tendinitis, using physical findings as part of the outcome definition.

Miranda *et al*. (2005) examined the role of mechanical determinants of chronic rotator cuff tendinitis in men and women separately. For some exposures (e.g. frequent lifting / work requiring high hand force) men experienced a greater age-adjusted risk than women; for others (e.g. heavy lifting) women experienced a greater risk than in men; and for others the increase in risk associated with exposure was the same in both sexes (e.g. working with hands above shoulder level).

These authors also constructed multivariable models separately for men and women. This latter analysis revealed that the duration of working with hands above shoulder level was independently associated with chronic rotator cuff tendinitis and the effect was of similar magnitude in both men and women ($OR_{>23yrs\ versus\ none}$: 2.3; 0.7-7.0 and 2.5; 0.8-7.9, respectively). However, in women, heavy lifting was also independently associated with the outcome ($OR_{>23yrs\ versus\ none}$: 1.9; 0.4-8.6).

In the second study (Melchior *et al*. 2006) it was shown, firstly, that having a manual occupation was associated with a similar increase in symptoms compared to a non-manual occupation, in both men and women, after adjusting for age, obesity and a number of health variables and occupational characteristics (PR: 1.35; 0.86-2.12, and 1.34; 0.88-2.03, respectively). Regarding specific mechanical exposures, the evidence was inconsistent. The increase in the likelihood of rotator cuff disease / biceps tendinitis associated with working with arms held away from the body was greater in men than it was in women ($PR_{>2hrs\ versus\ <2hrs\ per\ day}$: 1.49; 0.96-2.30, and 1.23; 0.69-2.09, respectively). Women experienced an increase in occurrence associated with working with hands behind the trunk whereas men did not ($PR_{>2hrs\ versus\ <2hrs\ per\ day}$: 1.43; 0.88-2.32, and 1.07; 0.68-1.68, respectively). For other occupational exposures – e.g. working with repetitive movements – the increase in likelihood was similar for men and women (PR: 2.12; 1.43-3.15, and 1.83; 1.21-2.74, respectively). However, like the findings of Miranda *et al*. (2005), it should be noted that these differences between men and women do not reach statistical significance.

Using a self-reported outcome, Feveile *et al*. (2002) also reported results separately for men and women. These authors report that the baseline report of working twisting or bending was significantly more common in men who reported neck / shoulder symptoms at five-year follow-up, than in men who did not. Further, this exposure remained independently predictive of the outcome after adjusting for heavy lifting, sedentary work and social support. In women, no significant associations were found between baseline mechanical exposures and symptom status at follow-up.

Psychosocial exposures

Only one study was identified that examined gender differences in the relationship between occupational psychosocial exposures and risk factors for rotator cuff disease and / or biceps tendinitis, which used physical findings as part of the outcome definition. Miranda *et al*. (2005) examined the relationship between high psychological demands of work and chronic rotator cuff tendinitis and found an effect of similar magnitude in men and women (OR: 1.6; 0.8-3.6 and 1.8; 0.8-3.8, respectively). Similar results were found for persons who reported the threat of being bullied / mentally abused in the workplace (OR: 2.0; 0.8-5.1 and 1.6; 0.7-3.9 for men and women respectively). However, a difference was observed with burnout. Men who reported 'mild of severe' burnout , versus none, experienced nearly a doubling in the odds of chronic rotator cuff tendinitis (OR: 1.8; 0.8-3.9), whereas women experienced a decreased likelihood of symptoms (OR: 0.5; 0.2-1.3). However, these results are not statistically different – either from each other, or from the null – so should be interpreted with caution.

Two studies were identified that examined gender differences associated with psychosocial exposures and the risk of shoulder disorders using a self-reported outcome (Östergren *et al*. 2005 and Feveile *et al*. 2002).

There was little consistent evidence to suggest a difference between men and women, with respect to risk between occupational psychosocial factors and the risk of neck / shoulder pain onset. However, there was some evidence that women experienced an increase in the risk of symptoms associated with job strain (OR: 1.49; 1.10-2.03) compared to men (OR: 0.94; 0.63-1.40) (Östergren *et al*. 2005). In contrast, Feveile *et al*. (2002) reported that men who reported low social support were significantly more likely to report neck / shoulder symptoms at five-year follow-up than those who reported 'rather high' levels of support (OR: 1.76; 1.24-2.50). Interestingly, however, men who reported 'high' – versus 'rather high' – levels of support also experienced an increased occurrence in neck / shoulder pain at follow-up (OR: 1.45; 1.00-2.09).

Time frame of exposure

According to prevailing hypotheses on pathogenesis, damage to the rotator cuff and / or biceps tendon may result from cumulative or repetitive micro-damage over an extended period of time. However, the relevant time frame for cumulative deleterious effects is not known – lifetime / years / months. Further, it is unknown whether the length of the time window depends on the character and intensity of the exposure.

It is important in epidemiological studies to estimate the empirical induction time (latency period) of the disease under investigation. Strictly speaking, latency period is a characteristic, not of disease, but of the relationship between a specific aetiological agent and a disease. Latency period can further be divided into two stages: firstly, the induction time, the period between the first exposure to the aetiological factor under investigation and the induction of the disease; and secondly, the latency interval, the period between the induction of the disease and its diagnosis.

The majority of studies included in the current review were cross-sectional. A major limitation of such studies is that they identify only existing cases and, thus, miss individuals who are still in latent period of the disease. Another limitation – particularly in occupational environments – is the Healthy Worker Effect, where individuals who change job, or job tasks, may be removed from the workforce under investigation. These pitfalls make the cross-sectional study design inappropriate to estimate the time relation between occupational exposures and the onset of rotator cuff disease / biceps tendinitis.

In most of the studies included in the current review, cumulative exposure was used as a summary measure of the level of exposure. Some of these studies report a clear exposure-response relationship between occupational exposures and shoulder disorders – Svendsen *et al*. (2004a), for example, report a linear relationship between lifetime upper arm elevation and supraspinatus tendinopathy (OR: 1.27; 1.02-1.60 for every five-month increment in exposure). Others demonstrate non-linear relationships – Miranda *et al*. (2005), for example, report an increase in the occurrence of chronic rotator cuff tendinitis with increasing years of working with the hand above the shoulder level, up to 14-23yrs, whereas, in individuals exposed for longer than this the likelihood of the outcome decreases. However, the nature of the exposure-response relationship presented in these studies might only provide clues of a possible causal role for the observed association between the exposure and the outcome, but does not give information on the time relationship (i.e. the latency period) between the exposure and the onset of the disease. Such information can only be derived from longitudinal studies.

Two cohort studies are included in the current review. Werner *et al*. (2005) conducted a single follow-up assessment of a group of workers, who were all free of shoulder disorders, after an average of 5.4yrs from baseline. However, the exact time of onset of pain following exposure was not presented in the report and, hence, information on the latency period (and the induction time) between work-related exposures and development of shoulder disorders is unavailable. The second cohort (Kaergaard and Andersen 2000) consisted of an initial cross-sectional study, with two-year follow-up. However, only cross-sectional analysis is presented concerning the categorisation of the level of exposure (number of years) to different occupational factors.

A literature search (Appendix V) was conducted to identify studies that specifically examined the time relationship between work-related potential risk factors and occurrence of shoulder disorders. This search identified 82 articles and, after abstract review, one study was identified that investigated the influence on neck / shoulder pain of exposure time in a work environment (Fredriksson *et al*. 2002). In this study, 210 women and 100 men who had sought medical care or treatment for neck / shoulder pain were recruited to the study, of whom 43% and 31% had signs of shoulder tendinitis, respectively. These individuals were compared to 1277 age- and sex-matched controls with respect to current and historical (5yrs ago) occupational exposures by self-administered questionnaire. Exposures included: physical / mechanical factors (working with hands above shoulder level, work with a vibrating tool, lifting and carrying; and psychosocial factors) support from colleagues, participation in work planning, and opportunities to acquire or use new knowledge. This study found that several current exposures, particularly among women, were significantly associated with an increase in the odds of neck / shoulder pain. On the other hand, none of the historical exposures showed a statistically significant association with neck / shoulder pain in men, and very few in women. These results suggest that the induction time for neck or shoulder pain due to work related conditions is relatively short. However, the case definition (seeking care) is not synonymous with pain experience. This might have contributed to the observed differences between long and short exposures: for example: individuals with long exposures might have not consulted a care-giver during the study period because of previously given advice and training instructions.

Further longitudinal studies are required – in particular, cohort studies of newly employed workers – to be able to estimate the induction time for shoulder disorders (particularly rotator cuff disease) due to different work related risk factors.

7. Factors associated with prognosis

Search strategy

The literature search was conducted in electronic bibliographic databases using the University of Aberdeen Ovid web gateway. The search was conducted, simultaneously, in Medline (start date: 1966) and Embase (start date: 1988) to the 8th week of 2007.

Mirroring the sequence of the literature search for the main review, firstly, a number of anatomical search terms were used to identify papers relating to the appropriate outcome(s) of interest. Specific search terms included: shoulder, rotator cuff, supraspinatus, infraspinatus, teres minor, subscapularis, biceps tend$, and glenohumeral – and various alternative spellings of these – all combined using the Boolean operator 'OR'.

Secondly, a search was carried out for the terms: prognosis, disability, recovery, sickness absence, and consequences, and were combined using the Boolean operator 'OR'. Thirdly, occupational search terms were used to identify papers relating to the appropriate to the occupational environment. Specific search terms included: occupation$, employment$, job$ and work$, all combined using the Boolean operator 'OR'.

Fourthly, all three steps were combined using the Boolean operator 'AND'. Thereafter, the search was limited to articles published on humans and in English language. In total, 364 articles were identified. The titles of these articles were screened by one reviewer to assess whether it was important to read the abstract of the paper. Thereafter, the abstracts were screened, followed by the full papers.

Findings

Three relevant articles were identified. A description of individual studies is given below followed by a summary of the findings. A more detailed description of study findings is found in Tables 13 (occupational factors) and 14 (non-occupational factors).

Chard et al. 1988

Over a two-year period, 153 patients attending a shoulder clinic in the United Kingdom with rotator cuff tendinitis (on the criteria of Cyriax) were recruited to this study and followed-up at least six months after their first attendance (mean follow-up time between 16-19 months according to outcome group). All patients were treated conservatively and 137 patients were successfully followed-up. Patients' symptoms were categorised at follow-up as 'no significant symptoms' (resolved: 39%), 'mild symptoms' (residual pain: 29%) or 'severe symptoms' (active tendinitis: 26%). The authors report that the following differed significantly between the three groups: mean duration of symptoms before attending hospital (resolved: mean 6.9 months; residual pain: 8.8 months, active tendinitis: 11.1 months) ($p<0.01$); overuse or strain unrelated to employment (resolved: 22%; residual pain: 23%; active tendinitis: 0%).

This study followed-up subjects at variable times after presentation, had relatively limited information on predictive factors, the definition of symptom outcome is not clear from the text and there is only a crude analysis presented in the paper with no estimation of the magnitude of any risk effects.

Brox and Brevik 1996

This study included 125 patients with the clinical diagnosis of rotator tendinosis who had been randomised to active treatment (supervised exercise regimen or arthroscopic acromion resection with post-operative physiotherapy) or placebo laser. After six months follow-up, outcome was assessed by the Neer shoulder score. This score has four parts: pain in the previous week, clinical testing of function, testing of active range of motion, radiological evaluation. Eleven patients were lost to follow-up. Predictors of outcome were based on the study questionnaire and clinical examination. Those who at six months follow-up had a low Neer score (<80) – i.e. were categorised as treatment failure, were more likely (at baseline) to have taken sick-leave (OR: 4.3; 1.4-12.9) to be on regular medication (OR: 4.2; 1.5-11.1), and to have received the inactive treatment (OR: 5.4; 1.7-14.2). All of these remained significant after adjustment for age, gender and pre-treatment Neer score. In particular there was no association between isometric endurance, working with hands above head, emotional distress and outcome.

This manuscript represents further analysis of a clinical trial. The initial level of participation in the trial is not mentioned in the manuscript although a high follow-up was achieved. No further details are provided of how the diagnosis (rotator tendinosis) was made. Most of the information collected is by self-report (including workplace exposure) but does cover a range of domains.

Bonde et al. 2003

In total, 3073 employees within 19 Danish companies participated in a cross-sectional study and clinical examination and three follow-up examinations at intervals between 6-18 months. From these, 167 subjects provided a history of shoulder pain and disability combined with clinical signs of shoulder tendinitis. 113 provided full clinical follow-up data. Clinical signs of shoulder tendinitis were direct tenderness (i.e. tenderness on palpation of the major tubercle, or pain on passive internal rotation of the abducted arm) or indirect tenderness (i.e. pain in front of the shoulder on active resisted abduction). Nine medical doctors undertook the examinations according to a detailed clinical protocol. If neither symptoms nor signs were present at follow-up, the subject was considered to have recovered. Factors at the time of diagnosis associated with non-recovery were: age ($OR_{>55yrs\ versus\ <45yrs}$: 3.8; 1.4-4.7), high perceived job demands ($OR_{>75th\ versus\ \leq 25th\ percentile}$: 4.1; 1.1-19.2) and low perceived social support at work ($OR_{\leq 25th\ versus\ >75th\ percentile}$: 6.8; 2.0-23.0). Aspects of job tasks (such as repetitiveness, forcefulness and duration of task) were estimated from video recordings but none were related to outcome.

This study sampled workers from a large survey of Danish workers which achieved reasonable levels of participation (73%). Diagnosis was clear and, although carried out by nine doctors, a detailed clinical protocol with comprehensive description of all procedures was used. Follow-up times were variable and this is likely to attenuate the strength of associations found. There was good exposure assessment which covered both physical and psychosocial aspects of the work and workplace.

Natural history / expected outcome with treatment

Two studies have reported on the natural course of rotator cuff disease in occupational settings. Bonde *et al*. (2003) reported that only 25% had persistent symptoms beyond the 18-month follow-up period. Similar outcome figures were reported more recently by Silverstein *et al*. (2006). At baseline, 53 manufacturing workers were diagnosed with rotator cuff tendinitis in the right shoulder, by physical examination. At one-year follow-up, persistence of clinical stage of the disease was found in 11 workers (33% of those successfully followed up). Incomplete recovery was found in 10 workers (30%), while 13 workers (39%) showed complete recovery. In this study, a better outcome was found for those who were diagnosed with rotator cuff tendinitis in their left shoulder, with 52% showing complete recovery at follow-up.

Conservative (non-surgical) treatments are the initial management choice for rotator cuff disease and biceps tendinitis. These treatment modalities include rest, avoiding aggravating activities, analgesics, physiotherapy and corticosteroid injections. Typically, surgical treatment is considered after failure of at least six months of conservative treatment (Chiang *et al*. 1993; Karzel and Pizzo 1995; Cohen and Williams 1998). If not treated or inadequately managed, rotator cuff disease can progress to rotator cuff degeneration and tear (Chiang *et al*. 1993). Other complications of impingement include frozen shoulder, rupture of shoulder tendons and reflex sympathetic dystrophy (Canoso 1997). Complications of conservative therapy are rare, but may include damage to the deltoid tendon or muscle and nerve injury.

Summary

The few studies that have been conducted suggest that a favourable outcome is usually achieved in a large proportion of patients with rotator cuff disease. With only three eligible studies of predictors of outcome, measuring different types of predictors, using different instruments, and which do not produce any consistency across their results, few conclusions can be drawn. However, there is some evidence that markers of severity may be associated with a poor outcome.

8. Discussion

Occupation

We identified six studies that examined the role of occupation; all reported an increase in the occurrence of shoulder disorders associated with at least one of the specific occupations under study. Svendsen *et al*. (2004b) showed an association between house painting and supraspinatus tendinitis; others demonstrated an association between sewing machine operation and rotator cuff symptoms (Kaergaard and Andersen 2000; Andersen and Gaardboe 1993) and Frost and Andersen (1999) reported an association between slaughter house work and shoulder impingement syndrome. Melchior *et al*. (2006) did not look at specific occupations but found that, in both men and women, a manual occupation was associated with an increased occurrence of rotator cuff disease. Stenlund *et al*. (1993) also reported that long duration of manual work was associated with an increase in shoulder tendinitis – although this latter association was only shown in the left shoulder, not in the right.

Three studies examined length of exposure. There was some evidence of an exposure-response relationship with duration of exposure to sewing machine operation (Kaergaard and Andersen 2000; Andersen and Gaardboe 1993). The former study demonstrated that persons employed as sewing machine operators for >20yrs experienced a four-fold increase in the odds of rotator cuff symptoms (OR: 4.44; 1.54-12.78). Whereas, the latter study revealed a ten-fold increase in likelihood, associated with job duration of >15yrs (OR: 10.56; 1.26-88.19). Svendsen *et al*. (2004b) reported a decrease in the occurrence of symptoms associated with increased job duration as a house painter, machinist or mechanic: for each 10yr increase in job duration these individuals experienced a 26% decrease in the odds of rotator cuff disease, albeit not statistically significant (OR: 0.74; 0.52-1.06). However, because of the design of this study, it is not possible to rule out the Healthy Worker Effect – where persons who remain symptom-free are retained in the workforce for longer duration than those who develop symptoms.

Causation

Rather than being risk factors for rotator cuff disease *per se*, the occupations discussed above are merely risk markers for the outcome of interest. However, rather than identify which occupations are associated with an increase in risk, it is more important to identify which specific exposures within these (and other) occupations may be causally related to rotator cuff disease. In accordance with the guidelines from the Scientific Committee of the Danish Society of Occupational and Environmental Medicine, the degree of evidence of a causal association between a specific exposure and a specific outcome has been graded as follows:

- Strong evidence of a causal association [+++]
- Moderate evidence of a causal association [++]
- Limited evidence of a causal association [+]
- Insufficient evidence of a causal association [0]
- Evidence suggesting lack of a causal association [–]

The specific criteria for the above grading of evidence, as set down by the Committee, can be seen in Appendix VI. For the categories of 'limited', 'moderate' and 'strong' evidence a positive relationship between the exposure and outcome must have been observed in several epidemiological studies. The difference between categories is based, essentially, on the confidence with which one can conclude whether or not the observed relationship may be due to chance, bias or confounding. It should be noted, however, that even where there may be conditions of strong evidence [+++], this not mean that there is no doubt, just that a causal relationship is 'very likely'.

All studies presented in this review are limited in that they are unable, by design, to distinguish whether a particular exposure contributes to the occurrence, or aggravation, of disease. However, whether an exposure contributes directly to a pathology, or hastens the presentation of symptoms, is somewhat academic: whether a pre-existing pathology is required or not, where there is evidence that an exposure increases the likelihood of symptom reporting, this exposure may be considered at least a component cause of the disease in question. The question of disease occurrence or disease aggravation is an important one, although is not answerable given the current state of knowledge.

Sensitivity analysis

The criteria for the definition of outcome in the studies to be included in this review was stringent: studies were included only if physical findings, other than pain on palpation alone, formed part of the outcome definition. A number of studies, while adhering to these criteria, had outcome definitions which would also allow the inclusion of persons with conditions other than rotator cuff disease and / or biceps tendinitis – *viz*:

- Chiang *et al*. 1993 – case definition may have identified persons with neck or upper arm pain only;
- Stenlund *et al*. 1993 – case definition may have identified persons with pain on palpation alone;
- Kaergaard and Andersen 2000 – case definition may have identified persons with myofascial pain syndrome;
- Svendsen *et al*. 2004a – case definition may have identified persons with pathology, but without pain;
- Miranda *et al*. 2005 – case definition required chronicity of symptoms;
- Werner *et al*. 2005 – case definition may have identified persons with pain on palpation alone; and
- Walker-Bone *et al*. 2006 – case definition may have identified persons with adhesive capsulitis.

Diagnostic inaccuracy would, ordinarily, bias findings towards the null. However, in certain conditions – for example, where an exposure is a risk factor for a shoulder disorder other than those of specific interest – risk estimates may be augmented by the inclusion of persons with competing diagnoses. For this reason, in assessing the degree of evidence of a causal association between specific exposures and the outcome of interest, we will firstly draw conclusions based on the whole available data and, secondly, comment on the nature of the evidence after exclusion of the above studies.

Occupational physical / mechanical exposures

Working with arm in elevated position

We identified six studies that examined the relationship between working with the arm(s) in an elevated position and risk of shoulder disorders. Walker-Bone *et al*. (2006) examined the association, simply, with a two category exposure: whether participants did, or did not, work with their arm elevated for >1hr per day. These authors found a 60% increase in the odds of specific shoulder disorders (including rotator cuff disease and biceps tendinitis) among those who did work with arm elevation, although this association was not statistically significant (OR: 1.6; 0.9-2.9). In contrast, Miranda *et al*. (2005) investigated the risk of chronic rotator cuff tendinitis associated with cumulative exposure: duration, in years, of working with the arm elevated for >1hr per day. These authors provided some evidence of an exposure-response relationship ($OR_{1\text{-}3yrs}$: 2.4; 1.0-5.9, increasing to $OR_{14\text{-}23yrs}$: 4.7; 2.4-9.1) although this should be interpreted with caution: firstly, the exposure was based on self-report; and, secondly, persons with the greatest exposure (>23yrs) did not experience the highest risk (OR: 2.3; 1.1-4.9), although this may just reflect the Healthy Worker Effect. Punnett *et al*. (2000) examined shoulder flexion and abduction as a percentage of job cycle. These authors also demonstrated an exposure-response relationship such that the greater the proportion of the job cycle was spent with elevated arms, the greater the likelihood of shoulder disorders – defined, in this study, as shoulder pain with physical findings.

Rather than basing the exposure measure solely on self-report, Svendsen *et al*. (2004a) used objective measures of physical exposures in a sub-sample of study participants and extrapolated this to other individuals, based on occupational history. These authors demonstrated that $\geq$20 months lifetime duration of upper arm elevation was associated with more than a doubling in the odds of supraspinatus tendinopathy of borderline significance (OR: 2.33; 0.93-5.84); a finding supported by a second study of supraspinatus tendinitis, which showed a stronger, and statistically significant, association ($OR_{\geq 24\text{ months lifetime exposure}}$: 4.70; 2.07-10.68) (Svendsen *et al*. 2004b). These authors also examined exposure separately for dominant and non-dominant shoulder. Although the effect was present in the dominant shoulder ($OR_{\geq 24\text{ months lifetime exposure}}$: 1.87; 0.79-4.44), the data for the non-dominant shoulder is unclear. Firstly, there is less variability in exposure, necessitating the collapse of exposure measurement into fewer categories; and, secondly, there are very few outcome events per category meaning that the final model may be unstable. In fact, this is illustrated by the fact that – compared to the dominant arm, where statistical adjustment for age and smoking resulted in a modest reduction in the odds ratio – in the non-dominant arm adjustment for confounders results in a swing from a 46% increase, to a 46% decrease in odds of tendinitis, associated with the exposure of interest.

Two studies examined the relationship between arm posture and shoulder disorders in men and women separately (Miranda *et al*. 2005; Melchior *et al*. 2006). In the former study, Miranda *et al*. (2005) demonstrated similar increased in the odds of chronic rotator cuff tendinitis in men and women associated with most mechanical exposures. In the latter, Melchior *et al*. (2006) found that working with arms above shoulder level was associated with similar increase in the likelihood of rotator cuff syndrome in men and women (PR: 2.57; 1.67-3.87 and 1.75; 1.09-2.83, respectively). Whereas, working with the arms held away from the body, and working with the hands behind the trunk, was significantly associated with the outcome in women (PR: 2.13; 1.36-3.33 and 2.11; 1.13-3.93, respectively) but not in men (PR: 1.42; 0.87-2.31 and 1.02; 0.44-2.36).

The contributory evidence supports these findings. Harkness *et al*. (2003) reported that working with hands above shoulder level and lifting heavy weights above shoulder level were both associated with an increase in the likelihood of new onset shoulder pain. Similarly, Miranda *et al*. (2001a) demonstrated that persons who work with their arms above shoulder level for 1hr per day experience an increase in the onset of 'mild or severe' should pain over a twelve-month period. In contrast, van den Heuvel *et al*. (2006) reported that increasing proportion of job time with arms elevated to 30-60° was not associated with any increase in neck / upper arm symptoms three years after baseline assessment.

We conclude that there is moderate to strong evidence [++(+)] to suggest a causal relationship between working with arms in an elevated position and rotator cuff disease / biceps tendinitis. There is consistent evidence across a number of studies in a number of different occupational environments suggesting a positive risk-relationship. Prohibiting the conclusion of 'strong' evidence of a causal relationship, there are insufficient studies presenting robust exposure-response data and it is not possible, therefore, to inform exposure standards – for example, by identifying 'safe' limits for exposure, either in terms of the degree of arm elevation, or in terms of duration of exposure. Also, the evidence is insufficient to be able to distinguish between exposures that lead to pathological changes in the rotator cuff or related shoulder structures, and exposures which aggravate symptoms that originate from pre-existing shoulder pathology. However, further supporting our conclusion, the evidence from studies examining more subjective outcomes also suggest a causal association between working with arms in an elevated position and shoulder pain and / or shoulder symptoms generally. Furthermore, our conclusions are robust to the exclusion of papers which may have included cases of diagnostic inaccuracy: even after this exclusion there are still several studies which demonstrate a positive risk-relationship between increasing exposure to work involving elevated arms and the outcome of interest.

Manual handling / force requirements

The majority of studies that examined manual handing / force requirements measured exposures subjectively. Walker-Bone *et al*. (2006) reported an 80% increase in the odds of specific shoulder disorders associated with the self-report of lifting / carrying >5kg weights in one hand, or carrying weights on one shoulder (OR: 1.8; 1.2-2.8). Similarly, Stenlund *et al*. (1993) reported an excess of shoulder tendinitis with heavy mechanical load. Miranda *et al*. (2005) reported an increase in chronic rotator cuff tendinitis with increased cumulative exposure to frequent lifting, heavy lifting and work requiring high hand force. However, evidence of an exposure-response relationship was less clear. Frost *et al*. (2002) reported increasing odds of shoulder tendinitis with increasing force requirements, as measured as percentage of maximum voluntary contraction assessed by subjective estimate of video recordings ($OR_{<10\%}$: 2.17; 0.84-5.59, and $OR_{>10\%}$: 4.21; 1.71-10.40); and Chiang *et al*. (1993) reported an increase in risk of shoulder girdle pain associated with forceful upper limb movements (yes versus no), based on worker observation (OR: 1.8; 1.2-2.5). In contrast, Svendsen *et al*. (2004a) reported no significant associations between lifetime shoulder force requirements and supraspinatus tendinopathy or acromioclavicular joint degeneration.

Melchior *et al*. (2006) demonstrated that men who perform forceful movements for $\geq$2hrs per day experienced an increased occurrence of rotator cuff syndrome (OR: 1.65; 1.03-2.31); whereas, the same was not true for women (OR: 1.03; 0.53-2.00). In contrast, Miranda *et al*. (2005) examined work requiring high hand force and showed some effect in both men and women.

Evidence from other studies, however, would support an association. Harkness *et al*. (2003) reported an association between shoulder pain onset and lifting with one or two hands, carrying weights on one shoulder, and with pushing / pulling heavy weights, and other authors also reported an increased likelihood of shoulder pain onset associated with physical strenuousness (Miranda *et al*. 2001a) and with force requirements, measured as percentage of maximum voluntary contraction, assessed by subjective estimate of video recordings (Andersen *et al*. 2003).

We conclude that there is moderate evidence [++] to suggest that manual handling / occupational force requirements are causally associated with rotator cuff disease / biceps tendinitis. A number of studies have observed a positive relationship between this exposure and outcome and there is also good evidence from prospective cohort studies to suggest a causal association between manual handing and shoulder pain and / or shoulder symptoms generally. Further, the results, after exclusion of papers which may have included cases of diagnostic inaccuracy, still suggest a causal association.

Repetitive tasks

A number of studies have examined repetitive work tasks and their relationship with rotator cuff disease / biceps tendinitis. Werner *et al*. (2005) reported no difference between persons with and without shoulder tendinitis and job rating according to the US Government threshold limit values for hand activity level based, in part, on hand repetition. Miranda *et al*. (2005) demonstrated that long-term work requiring repetitive motion of the hand or wrist, as assessed by interview and questionnaire, was associated with an increased occurrence of chronic rotator cuff tendinitis ($OR_{14\text{-}23yrs\ versus\ none}$: 2.4; 1.3-4.3 and $OR_{>23yrs}$: 2.6; 1.4-4.9). Frost *et al*. (2002) assessed the exposure by making observations of workers and found that persons exposed to repetitive manual handing experienced a three-fold increase in the likelihood of shoulder tendinitis (OR: 3.12; 1.33-7.34). These latter authors also characterised repetitive movements in terms of motions per minute and demonstrated an exposure-response relationship with increasing repetitive movements and risk of shoulder tendinitis ($OR_{1\text{-}14\ movements\ per\ minute,\ versus\ none}$: 2.93; 1.17-7.36 and $OR_{15\text{-}36\ movements\ per\ minute}$: 3.29; 1.34-8.11).

Other studies with more subjective outcomes have provided inconsistent evidence. Andersen *et al*. (2003) assessed shoulder repetition using a review of video recordings of worker. These authors demonstrated an exposure-response relationship with increasing repetition and incident neck / shoulder pain ($OR_{low\ repetition}$: 1.3; 0.7-2.6, and $OR_{high\ repetition}$: 3.0; 1.5-5.8). Whereas, Harkness *et al*. (2003) using a self-report measurement of both exposure (repetitive arm / wrist movements in past working day: none, <15mins and

≥15mins) and outcome (one-month period prevalence of shoulder pain at follow-up) reported no relationship whatsoever (OR: 1.0; 0.6-1.6 and 1.0; 0.6-1.6 for <15mins and ≥15mins, respectively).

Although there is some evidence that repetitive work tasks are associated with shoulder symptoms, it cannot be ruled out with any confidence that this relationship is explained by confounding, because of the likely overlap in different occupational exposures. It seems intuitive that the excess risk reported in some occupational environments – for example: the association between slaughter house work and shoulder impingement syndrome reported by Frost and Andersen (1999) – might stem from a combination of high task repetition and high force requirements. One way to inform this is to examine how often these two exposures co-occur. However, only Frost *et al*. (2002) provide such data. These authors report that, in banks, supermarkets, food processing companies and other light industries, 34% of workers experienced a high frequency of shoulder movements (defined as 15-36 movements per minute) and half of these individuals also experienced high force requirements (defined as >10% of estimated maximum voluntary contraction). It is important, therefore, to examine the role of task repetition independent of, or adjusting for, the effects of force.

Chiang *et al*. (1993) observed workers for at least 30 minutes or three work cycles. They found that, after adjusting for forceful movements of the upper limb, persons who are exposed to repetitive upper limb movements experience a 60% increase in the odds of shoulder girdle pain (OR: 1.6; 1.1-2.5). In contrast, Frost *et al*. (2002) report a non-significant increase in the odds of shoulder tendinitis among persons with high frequency tasks, but of low force (OR: 1.73; 0.56-5.53). Melchior et al. (2006) examined the relationship between repetitive tasks and shoulder symptoms separately for men and women, assessing the exposure using a self-administered questionnaire, based on the SALTSA criteria, and statistically adjusting for both force exertion and manual occupation. They reported that repetitive movements with breaks were associated with an increase in the likelihood of rotator cuff disease in both men and women (PR: 2.12; 1.43-3.15 and PR: 1.83; 1.21-2.74, respectively). Further, they found that repetitive movements without breaks was associated with an increase in occurrence of similar magnitude in men (PR: 1.97; 0.83-4.17), but an augmentation of the relationship in women (PR: 2.57; 1.50-4.41).

Focusing on a subjectively measured outcome, Andersen *et al*. (2003) also examined task frequency and force independently. They demonstrated that, compared to persons with low repetition and low force, persons exposed to high repetition and high force experienced more than a 150% increase in the odds of new onset neck / shoulder pain (OR: 2.6; 1.4-4.8). However, those exposed to highly repetitive but low force tasks also experienced an increase in odds (OR: 2.4; 1.3-4.5), demonstrating the independent effect of task frequency.

We conclude that there is limited evidence [+] of a causal relationship between repetitive tasks and rotator cuff disease / biceps tendinitis: we identified only two studies that demonstrated significant associations, independent of the effects of force. One of these two papers may have included cases of diagnostic inaccuracy, thus further limiting the conclusions. However, there is one paper of contributory evidence that supports these conclusions.

Combined effect of task force and task frequency

There is moderate evidence [++] to suggest that manual handling / occupational force requirements are causally associated with rotator cuff disease / biceps tendinitis, and limited evidence [+] to suggest that repetitive movements of the shoulder are causally associated with the same outcome. By definition, therefore, persons who are exposed to both high force and high task frequency will experience an increased risk of symptoms. It is important to understand, however, whether there is an additional effect[8] of the combination of these two exposures, over and above the effect of the two exposures individually.

Only one study was identified that examined the interaction between force requirements and repetitive tasks. Chiang *et al*. (1993) reported a 40% increase in odds of shoulder girdle pain (OR: 1.4; 1.0-2.0) over and above the effect of repetition and force alone (OR: 1.6; 1.1-2.5 and 1.8; 1.2-2.5, respectively).

Data in this area is scarce. We conclude, therefore, that there is insufficient evidence [0] to be able to draw conclusions with respect to a potential interaction between occupational task frequency and force requirements.

Other physical / mechanical exposures

There were few studies investigating the relationship between rotator cuff disease and biceps tendinitis and other physical / mechanical exposures. Stenlund *et al*. (1993) examined the association between the use of vibratory tools and shoulder tendinitis. Weighted lifetime exposure to vibration was assessed as the product of (self-reported) hours of exposure and a published constant, reflecting the recognised vibration energy emitted by the tool. The study found that an increase in lifetime exposure was associated with an increase in the odds of shoulder tendinitis in either shoulder. Miranda *et al*. (2005) also reported an association with working with a vibrating tool. These authors demonstrated that, compared to no years of exposure, persons exposed for 14-23yrs experienced a 3.5-fold increase in the odds of chronic rotator cuff tendinitis (OR: 3.5 ; 1.5-7.8). This study also revealed an association with many years of occupational driving ($OR_{14\text{-}23yrs}$: 2.7; 1.1-6.4).

Several other studies – with self-reported outcomes – examined the association between a number of different physical / mechanical exposures and shoulder pain onset. Andersen *et al*. (2003) reported that neck flexion (OR: 2.6; 1.3-5.1), particularly when associated with high force requirements (OR: 3.0; 1.1-8.6), was associated with an increase in the odds of shoulder pain. Similarly, Miranda *et al*. (2001a) reported that persons who work for >60mins per day with a rotated neck experience an increase in the likelihood of 'mild or severe' shoulder pain (OR: 1.6; 1.2-2.2). In contrast, ven den Heuvel *et al*. (2006) reported no association between neck flexion and the occurrence of neck / upper limb pain. However, these authors did demonstrate an association with neck rotation: persons working with the neck rotated by $\geq 45°$ for >14% of the time experienced more than a 50% increase in the odds of symptoms (OR: 1.57; 0.99-2.50).

[8] Statistically, a supra-multiplicative effect.

Others have suggested the importance of stretching below knee level (Harkness *et al*. 2003), working with a twisted or flexed trunk (Feveile *et al*. 2002; Miranda *et al*. 2001a) and occupational driving (Harkness *et al*. 2003)

Although one or two studies do suggest that there may be a relationship, there are too few to draw meaningful conclusions. Thus, we conclude that there is insufficient evidence [0] to suggest a causal association between occupational vibration and rotator cuff disease / biceps tendinitis. However, there is some evidence that working in a twisted or rotated posture is associated with an increase in shoulder pain and / or shoulder symptoms generally. However, there is insufficient data regarding which specific postures are particularly deleterious.

Occupational psychosocial exposures

Perceived work demands

We identified two studies that examined the relationship between perceived job demands and the outcome of interest, with conflicting results. Walker-Bone *et al*. (2006) reported no increase in the risk of specific shoulder disorders associated with work demands as assessed using a questionnaire based on the Karasek model (Karasek *et al*. 1979) (OR: 1.0; 0.7-1.5), whereas Svendsen *et al*. (2004b), using the Copenhagen Psychosocial Questionnaire (Kristensen *et al*. 2002) reported a considerable excess risk (OR: 3.19; 1.62-6.31).

Literature investigating more subjective outcomes was similarly inconsistent. Andersen *et al*. (2003) and van den Heuvel *et al*. (2005) reported an increased risk of neck / shoulder pain and upper limb symptom onset, respectively; whereas Östergren *et al*. (2005) demonstrated no such relationship. Harkness *et al*. (2003) examined job demands, separately, in terms of stressful work, hectic work and monotonous work. Using a self-completion questionnaire based on the Karasek model, these authors demonstrated that persons who perceive their work to be stressful or hectic were no more likely to report shoulder pain onset than other individuals (OR: 0.9; 0.6-1.4, and 0.9; 0.6-1.4, respectively). However, those who report monotonous work experienced nearly a doubling in the risk of future symptoms (OR: 1.9; 1.2-3.1).

In summary, we conclude that there is insufficient evidence [0] to be able to draw conclusions with respect to the relationship between perceived occupational demands and the risk of the rotator cuff disease / biceps tendinitis – the available studies are of insufficient number and consistency to permit a conclusion regarding the presence or absence of a causal association.

Perceived (lack of) control over working environment

We identified three studies that examined the relationship between the outcome of interest and job control and, again, results were conflicting. While Svendsen *et al*. (2004b) reported an increase in the odds of supraspinatus tendinitis associated with lack of job control (OR: 1.83; 0.93-3.60) this result was not statistically significant. Walker-Bone *et al*. (2006) also reported a small, non-significant, effect (OR: 1.2; 0.7-2.6) and Werner *et al*. (2005) reported no significant difference between cases with incident shoulder tendinitis and controls in terms of skill discretion and decision authority.

A number of studies with more subjective outcomes examined the relationship between shoulder pain and job control / decision latitude (Östergren *et al*. 2005; Andersen *et al*. 2003; van den Heuvel *et al*. 2005; Harkness *et al*. 2003). In general, authors reported either no effect (Harkness *et al*. 2003) or an effect of only modest, non-significant, magnitude.

In summary, there are few studies examining the relationship between perceived (lack of) control over the working environment and the risk of the rotator cuff disease / biceps tendinitis and those that have been conducted have provided inconsistent results. Thus, we conclude that there is insufficient evidence [0] to be able to draw conclusions with respect to the relationship this exposure and outcome.

Perceived (lack of) support

We identified four studies that investigated the role of perceived occupational support. Kaergaard and Andersen (2000) reported a non-significant 70% increase in the odds of shoulder rotator cuff tendinitis / myofascial pain syndrome associated with low levels of social support as assessed using Karasek's Job Content Questionnaire (Karasek *et al*. 1998) (OR: 1.66; 0.86-3.23). Others, using similar instruments based on Karasek's model have reported similar findings (Walker-Bone *et al*. 2006; Werner *et al*. 2005). Svendsen *et al*. (2004b), however, using the Copenhagen Psychosocial Questionnaire (Kristensen *et al*. 2002), reported no such effect in their study of supraspinatus tendinitis (OR: 0.91; 0.46-1.71).

In terms of contributory evidence, conflicting results have also been found in studies with a more subjective outcome. Andersen *et al*. (2003) reported a modest increase in the odds of incident shoulder pain associated with self-reported lack of job support (OR: 1.3; 0.8-2.1); Feveile *et al*. (2002) reported a modest effect in men only (OR: 1.45; 1.00-2.09) and Östergren *et al*. (2005) demonstrated a small and non-significant effect in men and women separately (OR: 1.14; 0.86-1.51 and 1.13; 0.87-1.47, respectively). In contrast. Harkness *et al*. (2003) report no increase in the likelihood of shoulder pain onset with lack of support from colleagues (OR: 1.0; 0.3-3.1), and van den Heuvel *et al*. (2005) demonstrate similar findings with respect to the onset of neck / upper limb symptoms (OR: 0.98; 0.51-1.92).

In summary, although not completely consistent, a number of different studies have demonstrated a positive relationship between perceived (lack of) support in the working environment and the risk of the rotator cuff disease / biceps tendinitis. Thus, we conclude that there is limited evidence [+] to suggest that this exposure is causally associated with the outcome of interest.

Other psychosocial exposures

Few studies were identified that examined other occupational psychosocial exposures, and which met the desired outcome criteria. Kaergaard and Andersen (2000) examined job strain, using Job Content

Questionnaire (Karasek *et al*. 1998). They demonstrated that persons who reported high job strain did not experience an increase in the risk of rotator cuff tendinitis / myofascial pain syndrome, compared to persons with low job strain (OR: 0.88; 0.45-1.71). Likewise, Werner *et al*. (2005) reported no difference between cases (persons with incident shoulder tendinitis) and controls in terms of perceived stress or job satisfaction. This latter finding was supported by Harkness *et al*. (2003) who reported no association between job dissatisfaction and shoulder pain onset over a two-year period (OR: 0.7; 0.2-2.1).

A number of other studies also examined the relationship between more subjective shoulder outcomes and occupational psychosocial exposures. Östergren *et al*. (2005) demonstrated a 50% increase in the odds of neck / shoulder pain associated with job strain, although this relationship was evident in women only (OR: 1.49; 1.10-2.03 and 0.94; 0.63-1.40, in women and men, respectively). van den Heuvel *et al*. (2005) examined job strain in more detail and categorised respondents into low, active, passive or high. Compared to low, those categorised as high experienced a 50% increase in the risk of onset of upper limb symptoms (RR: 1.54; 0.97-2.44). Persons categorised as active or passive experienced no increase in risk (RR: 1.10; 0.67-1.80 and 1.12; 0.67-1.86, respectively).

Only one study was identified that examined the relationship between mental stress and shoulder pain (Miranda *et al*. 2001a). In this study, the exposure measurement of mental stress was graded from 'not at all' to 'much' and the authors demonstrated an exposure-response relationship such that the higher the level of perceived mental stress, the higher the likelihood of new onset 'mild or severe' shoulder pain over a twelve-month period ($OR_{\text{not at all}}$: 1.0, $OR_{\text{only a little}}$: 1.3; 0.8-2.0, $OR_{\text{to some extent}}$: 1.5; 1.0-2.4, and $OR_{\text{rather much / much}}$: 1.9; 1.1-3.3).

In summary, there is insufficient evidence [0] to be able to draw conclusions with respect to the relationship between rotator cuff disease / biceps tendinitis and job strain or job (dis)satisfaction. Further, there is insufficient evidence [0] to be able to draw conclusions with respect to the relationship between perceived stress and the outcome of interest.

Gender differences

Mechanical exposures

Very few studies examined the impact of gender the relationship between occupational exposures and rotator cuff disease / biceps tendinitis and those that have done so as a secondary research question and, accordingly, have been inadequately powered for this purpose. However, there is evidence from two studies (Miranda *et al*. 2005; Melchior *et al*. 2006) to suggest that men and women experience an increase in the likelihood of rotator cuff symptoms, of similar magnitude, associated with (a) working with arms in an elevated position or (b) repetitive tasks. In the case of the latter exposure, Melchior *et al*. (2006) adjusted the analysis for manual occupation and force requirements, whereas Miranda *et al*. (2005) did not take these additional exposures into account. In terms of manual handling / forceful movements *per se*, the evidence between the studies is inconsistent: Melchior *et al*. (2006) demonstrated an increase in the odds of symptoms in men but not in women; whereas Miranda *et al*. (2005) demonstrated an effect of similar magnitude in men and women, associated with frequent or heavy lifting. There were no studies in the contributory evidence that examined the impact of gender the relationship between occupational mechanical exposures and shoulder pain and / or shoulder symptoms generally.

In summary, because of the paucity of data in this area, we conclude that there is insufficient evidence [0] to suggest that these exposures play a different role in men and women separately, with respect to the aetiology of rotator cuff disease / biceps tendinitis.

Psychosocial exposures

Of the studies in the main review only Miranda *et al*. (2005) examined the difference between men and women, with respect to the relationship between psychosocial exposures and shoulder disorders. These authors demonstrated that the association between psychological demands at work and chronic rotator cuff tendinitis was similar in men and women albeit non-significant ($OR_{\text{high versus low demands}}$: 1.6; 0.8-3.6 and 1.8; 0.8-3.8, respectively). The same was true of the perceived threat of being bullied or mentally abused ($OR_{\text{(very) much versus none / little}}$: 2.0; 0.8-5.1 and 1.6; 0.7-3.9).

Of the studies with a more subjective outcome, only one reported the association for men and women separately (Östergren *et al*. 2005). These authors reported that job strain was associated with an increase in the odds of neck / shoulder pain in women (OR: 1.49; 1.10-2.03) but not in men (OR: 0.84; 1.63-1.40). All other psychosocial constructs examined (psychological demands, decision latitude and job support) revealed no difference between men and women.

In summary, because of the paucity of data in this area, we conclude that there is insufficient evidence [0] to suggest that occupational psychosocial exposures play a different role in men and women separately, with respect to the aetiology of rotator cuff disease / biceps tendinitis.

Methodological issues

There are a number of methodological issues that should be considered.

The majority of studies considered in this review were cross-sectional or retrospective (case-control) in design: there are a number of disadvantages of this. Due to the Healthy Worker Effect, studies may have underestimated the true occurrence of disease in the occupational environments under study. This would diminish any risk associations under investigation and, thus, the true risk estimates may – if anything – be greater than are reported. Also, it is not possible from cross-sectional or case-control studies to determine the temporal nature of any exposure-outcome relationships. However, it is improbable that persons with shoulder pathology would seek out, or be selectively recruited to, occupational tasks that aggravate their symptoms (and certainly not to the extent that would explain some of the excesses seen in the reviewed literature). Therefore, we consider it most likely – although are unable to test it formally – that where associations have been observed, the exposure will have preceded the outcome. Prospective cohort studies would be better able to disentangle these issues although, at present, there are few.

Notwithstanding the above argument, we cannot be certain of the mechanism(s) leading from exposure to outcome – i.e. whether the exposure 'causes' the outcome, or whether it aggravates a pre-existing pathology. It is possible, for example, that the underlying pathology is equally prevalent in persons who do and do not work in environments that require upper arm elevation, but that it is only in the former group that this exposure causes painful symptoms. To date, there are no studies that fully address this issue: Svendsen *et al*. (2004a) report an excess of MRI-identifiable pathology associated with lifetime upper arm elevation and shoulder force requirements; however, no data is presented on pain.

We have attempted to examine the risk of rotator cuff disease / biceps tendinitis associated with different occupational exposures. However, it is highly likely that many of the exposures discussed in this review are correlated. It may be, for example, that working with elevated arms is not a risk factor *per se*, although it is harmful when combined with forceful movements. However, there are no studies with large comprehensive multivariable analyses. Consequently, it is possible that many of the exposure-outcome associations presented in the original articles (and summarised in this review) are confounded by other occupational exposures.

Where they have been examined, we have reported differences between men and women they are in the original articles. In each instance these results were derived from analyses stratified by sex. No studies were found that examined an interaction of occupational exposure and sex, thus allowing direct statistical comparison.

Finally, ideally, an occupational epidemiological review would inform exposure standards by distinguishing between 'safe' and 'harmful' limits for exposure. To date, there is insufficient exposure-response data to allow such conclusions to be drawn. Given the literature, all we have been able to conclude is that certain exposures are risk factors (or, more correctly, risk markers) for rotator cuff disease / biceps tendinitis.

9. Conclusion

The studies which have provided evidence for this review have been conducted on general populations and in the workplace amongst diverse types of employment. Nearly all studies have been cross-sectional in design which leads to problems in establishing the temporal nature of any relationship between exposures and shoulder disorders and makes them liable both to information and selection bias. Some studies have had limited information available on potential confounding factors. Evaluation of physical work exposures have used self-report but many studies have incorporated more objective estimates of exposure such as the use of video recordings. The focus of most studies has been on physical aspects of work (postural factors, force and task frequency) but more recent studies have incorporated measurement of psychosocial aspects of the workplace.

Physical workplace exposures

<u>We conclude that there is moderate to strong evidence [++(+)] to suggest a causal relationship between working with arms in an elevated position and rotator cuff disease / biceps tendinitis.</u> There is consistent evidence across a number of studies in a number of different occupational environments suggesting a positive risk-relationship. These conclusions are robust to the exclusion of papers which may have included cases of diagnostic inaccuracy: even after this exclusion there are still several studies which demonstrate a positive risk-relationship between increasing exposure to work involved elevated arms and the likelihood pf the outcome of interest. Further supporting this conclusion, the evidence from studies examining more subjective outcomes also suggest a causal association between working with arms in an elevated position and shoulder pain and / or shoulder symptoms generally.

<u>We conclude that there is moderate evidence [++] to suggest that manual handling / occupational force requirements are causally associated with rotator cuff disease / biceps tendinitis.</u> A number of studies have observed a positive relationship between manual handling, occupational force and the outcomes considered, and there is also good evidence from prospective cohort studies to suggest a causal association between manual handing and shoulder pain and / or shoulder symptoms generally. Further, the results, after exclusion of papers which may have included cases of diagnostic inaccuracy, still suggest causal associations. However, it cannot be ruled out with reasonable confidence that these relationships are explained by confounding, because of the likely overlap in exposure prevalence between manual handing / force requirements and repetitive job tasks. <u>However, we conclude that there is only limited evidence [+] of a causal relationship between repetitive tasks (independent of force) and rotator cuff disease / biceps tendonitis.</u> Although there is evidence across a number of studies suggesting a positive relationship and a causal relationship is possible, it is not unlikely that this relationship is explained by chance bias or confounding (particularly by manual handling or force activities).

<u>There is insufficient evidence [0] of a causal association between other physical / mechanical exposures and rotator cuff disease and biceps tendonitis.</u>

In none of the physical workplace exposures examined, have we concluded that there is strong [+++] evidence of a causal association between the exposure in question and rotator cuff disease / biceps tendinitis. Prohibiting this conclusion: firstly, there is a paucity of high quality prospective cohort studies from which it is possible to fully understand the temporal relationship between exposure and outcome. Secondly, the evidence is insufficient to be able to distinguish between exposures that lead to pathological changes in the rotator cuff or related shoulder structures, and exposures which aggravate symptoms that originate from pre-existing shoulder pathology. And thirdly, studies that present robust exposure-response data are scarce and it is not possible, therefore, to inform exposure standards and to identify 'safe' limits for exposure.

In addition, while we conclude that there is at least moderate evidence to suggest a causal association between rotator cuff disease / biceps tendinitis and both (a) working with the arms in an elevated position, and (b) manual handling / occupational force requirements, we cannot be certain about the mechanism behind this associations.

Psychosocial workplace exposures

<u>We conclude that there is limited evidence [+] to suggest that there is a positive relationship between perceived (lack of) support in the working environment and the risk of the rotator cuff disease / biceps tendinitis.</u> Although only a small number of studies have examined this exposure they provide consistent evidence of an association. However it is not unlikely that this could be explained by bias and / or confounding by other physical or psychosocial exposures and the supporting evidence from studies of shoulder symptoms are inconsistent.

<u>We conclude that there is insufficient evidence [0] to be able to draw conclusions with respect to the relationship between perceived occupational demands and the risk of the rotator cuff disease / biceps tendinitis.</u> The available studies are of insufficient number and consistency to permit a conclusion regarding the presence or absence of a causal association.

<u>We conclude that there is insufficient evidence [0] to be able to draw conclusions with respect to the relationship between perceived lack of control over work and the risk of the rotator cuff disease / biceps tendinitis outcome.</u> There are few studies examining the relationship but those that have been conducted have provided inconsistent results.

<u>We conclude that there is insufficient evidence [0] to be able to draw conclusions with respect to the relationship between rotator cuff disease / biceps tendinitis and other psychosocial factors, in particular job strain, lack of job satisfaction and perceived stress.</u>

10. Abstract

Aims

The aim of this document is to provide a high-quality scientific reference resource, summarising the existing epidemiological evidence with respect to the associations between occupational-related exposures and rotator cuff disease and / or biceps tendinitis.

Methods

An electronic bibliographic database search was conducted, simultaneously in Medline (1966 to February 7th, 2007) and Embase (1980 to February 7th, 2007). All identified titles were reviewed to identify potentially relevant abstracts; these abstracts were reviewed to identify potentially relevant papers; then the full-text of these papers were reviewed to identify those for inclusion in the review. At each stage, this was done by two reviewers, with a third reviewer arbitrating in the case of disagreement. Inclusion criteria required (a) that rotator cuff disease / biceps tendinitis were assessed using objective clinical criteria and / or imaging; (b) that exposures were occupationally related; and (c) that the paper presented exposure-outcome relationships in terms of risk (or odds), or presented data from which this was calculable.

Results

651 papers were initially identified, from which 327 abstracts were screened for relevance and 112 papers were selected for full-text review. From this, 13 papers were selected for inclusion in the review: ten cross-sectional studies, one case-control study, and two cohort studies. The focus on most studies has been on physical aspects of work (force, repetition and load) assessed using self-report – but many studies also incorporated more objective estimates of exposure, such as the use of video recordings. More recent studies also assessed psychosocial aspects of the workplace.

Six studies examined the relationship between working with the arm(s) in an elevated position and presented consistent evidence suggesting a positive risk-relationship with rotator cuff disease / biceps tendinitis. Eight studies examined the relationship between manual handing / force requirements and the outcome of interest and there was some evidence of a risk relationship, although this was somewhat inconsistent. Five studies investigated the role of task frequency, only three of which examined task frequency independently of force requirements. Results were inconsistent but suggested a positive association. Further, one study found an additional combined effect of task frequency and force, over and above the effect of these exposures alone. Although a number of studies examined other occupational physical exposures (occupational driving, vibration, manual work) data on any one exposure was scarce.

Five studies examined the relationship between occupational psychosocial exposures and rotator cuff disease / biceps tendinitis. A number of papers demonstrated a positive relationship between perceived

(lack of) support in the working environment and the outcome of interest. However, there was little consistent data on any other of the exposures examined (demands, control, job strain, job (dis)satisfaction).

Conclusion / discussion

We conclude that there is moderate to strong evidence to suggest a causal relationship between working with arms in an elevated position and rotator cuff disease / biceps tendinitis; moderate evidence to suggest a relationship with manual handling / occupational force requirements; but only limited evidence with respect to occupational task frequency (independent of force). There is insufficient evidence in terms of other occupational physical or mechanical exposures.

There is limited evidence to suggest a causal relationship between perceived lack of support in the working environment and the risk of the rotator cuff disease / biceps tendinitis, although insufficient evidence in terms of other occupational psychosocial exposures.

Currently, there is a paucity of high quality prospective cohort studies from which it is possible to fully understand the temporal relationship between exposure and outcome. Also, ideally, occupational epidemiology should be able to inform exposure standards. However, robust exposure-response data is scarce and it is not possible to use the current literature to identify ‘safe’ limits for exposure.

11. Popular summary

Background

This review was produced in response to a request from, and in collaboration with, the Scientific Committee of the Danish Society of Occupational and Environmental Medicine.

Shoulder pain is common. Typical of a number of other musculoskeletal pain conditions, it increases with age to around 50-60yrs, and decreases thereafter. It has been estimated that as many as 47% of persons may report shoulder pain in any month, and up to two-thirds in any year. There are many specific shoulder disorders which may lead to pain – including rotator cuff disease, impingement syndrome, biceps tendinitis, and subacromial bursitis – and these conditions have been observed in a number of different working populations. For example: some studies have shown that more than one-quarter of welders report supraspinatus tendinitis, compared to approximately 2% of office workers. Others have shown that 35% of women working in the fish processing industry have neck / shoulder symptoms, compared with only 7% in other women.

These differences between different occupations have led some to suggest specific working environments or job tasks may place individuals at an increased risk of symptoms and a number of studies have been conducted to examine whether this is the case.

Aim

The aim of this document is to review these studies, to summarise the results, and to draw conclusions as to whether there is any evidence that specific occupational exposures are causally associated with rotator cuff disease and / or biceps tendinitis.

Because of differences in the diagnosis of these conditions, it was decided only to include studies that defined rotator cuff disease as: a history of pain in the shoulder and pain on resisted movement of the shoulder joint; and / or defined biceps tendinitis as: a history of pain in the shoulder and pain on resisted movement of the elbow or forearm.

Methods

A search was conducted of all medical literature published in English and listed in two computerised databases: Medline and Embase. The search was conducted using search terms relating to the outcome of interest (e.g. shoulder / rotator cuff / biceps tendinitis), the exposures of interest (e.g. occupation / job / task). All studies that were identified then went through a three-level screening process. Firstly, all titles were reviewed to identify potentially relevant papers. Secondly, the abstracts of these papers were reviewed to exclude studies that did not meet our strict disease definition requirements. And thirdly, all remaining papers we reviewed in full, to identify those suitable for inclusion in the review. At each stage, this was done by two independent reviewers, with a third reviewer making a judgement in the case of disagreements.

Results

The initial literature search identified 651 papers from which 327 abstracts were screened for relevance and 112 papers were selected for full-text review. From this, 13 papers were selected for inclusion in the review, published between 1993 and 2006. Most studies focused on physical aspects of work (e.g. postural factors, force and task frequency), although a number of the later studies also examined psychosocial aspects (e.g. job demands, control and support).

Risk factors of rotator cuff disease / biceps tendinitis

Six studies examined the relationship between arm posture and rotator cuff disease / biceps tendinitis. Although the results from individual studies varied slightly, there was general agreement between studies that working with the arm(s) in an elevated position led to an increase in the risk of shoulder disorders.

Five studies examined the association between tasks that require forceful movements of the shoulder or arm and rotator cuff disease / biceps tendinitis. Here, the evidence was less consistent, although there was still reasonable agreement between studies that these occupational tasks lead to an increase in the risk of shoulder disorders.

Five studies examined the association between repetitive work and rotator cuff disease / biceps tendinitis, however, the results on repetitive work were complicated by the fact that many individuals who undertake repetitive work also undertake tasks that require forceful movements. There was some evidence to suggest that repetitive tasks, independent of forceful tasks, were associated with an increase in the risk of disorders. Also, the results from one study suggested that persons who undertook both repetitive and forceful tasks were at additional risk.

Some of the 13 studies also looked at other occupational activities – such as driving, or working with vibrating tools – although there were too few studies focusing on any one area to be able to provide robust conclusions.

Five studies examined the psychosocial working environment (the psychological and social conditions people experience in the workplace) and the relationship with rotator cuff disease / biceps tendinitis. Some results suggested that individuals who perceive themselves to be unsupported in the workplace experience an increase in the risk of shoulder disorders, although there was insufficient evidence in other areas – in terms of high workplace demands, or low levels of control.

Gender differences

Only two studies investigated whether the effect of adverse occupational exposures was different in men and women. There was little data in this area but, in general, the results suggest that the men and women are equally affected by working with the arm(s) above shoulder level, repetitive work, and a poor psychosocial working environment.

Summary

We conducted a comprehensive literature search to identify studies that investigated whether persons who are exposed to certain occupational tasks and adverse psychological and social factors in the workplace experience an increase in the risk of rotator cuff disease / biceps tendinitis. From 651 papers that were identified, 13 were eligible and relevant for this review.

We conclude, firstly, that a causal relationship is (very) likely between working with the arms above shoulder level and rotator cuff disease / biceps tendinitis. There is consistent evidence across a number of studies to support this conclusions. Secondly, we conclude that causal relationship is likely between forceful movements of the shoulder or arm and rotator cuff disease / biceps tendinitis. Thirdly, although a causal relationship is certainly possible between repetitive work and rotator cuff disease / biceps tendinitis, the evidence is less clear. In addition, a causal relationship is possible between perceived lack of support in the working environment and the risk of the rotator cuff disease / biceps tendinitis

The available studies examining other physical and psychosocial exposures are of insufficient quality, consistency, or statistical power to permit a conclusion regarding the presence or absence of a causal association.

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13. Tables

Table 1 – Quality rating pro forma

Quality rating	Criteria
Study design	
0	Cross-sectional study
1	Case-control study
2	Cohort with short follow-up period and with single assessment of exposure and outcome
3	Cohort study with long follow-up period and / or with multiple assessments of exposure or outcome
Sample size and statistical power	
0	<100
1	100-399
2	400-599
3	600-1000
4	>1000
Sampling methods	
0	Not clearly stated
1	Clearly stated (with clear inclusion and exclusion criteria)
2	As 1, PLUS acceptable methods used to sample from the target population
3	As 2, PLUS robust methods used to sample from the target population
Participation and / or follow-up	
0	<50%
1	50-74%
2	75-84%
3	85-100%
Bias (inflationary bias and bias towards the null)	
0	High potential for one or both types of bias
1	Medium potential for both types of bias
2	Medium potential for one types of bias
3	Low potential for both types of bias
Confounding	
0	Analysis not adjusted for any of the following: age, sex, general health, mental health or sports activities
1	Analysis adjusted for 1 or 2 of the above factors
2	Analysis adjusted for 3 of the above factors
3	Analysis adjusted for 4 or more of the above factors
Blinding	
0	Assessment of outcome not blinded for exposure status and / or *vice versa*
1-2	Assessment of outcome blinded for exposure status and / or *vice versa* – a higher score was awarded if the methods of blinding were of greater robustness
Objective measurements of exposure	
0-3	Subjective assessment of the objectivity of exposure measurement – a higher score was awarded if, for example, the exposures had been observed by >1 observer and / or if video recording of the exposures had taken place
Exposure-response data	
0	Exposures mainly defined dichotomously
1	Exposures mainly defined on an ordinal scale (3 groups)
2	Exposures mainly defined on an ordinal scale (>3 groups)
3	Exposures mainly defined on a quantitative scale
Outcome measurement	
0-3	Subjective assessment of the quality of the outcome measurement – a higher score was awarded if, for example, a full clinical examination had taken place and / or if the criteria for assessing the outcome were explicitly mentioned

Table 2 – Quality rating of individual studies

Study	Exposure categories	Exposure measurement	Study design	Sample size	Sampling method	Participation / follow-up	Bias	Confounding	Blinding	Objective exposure	Exposure-response data	Outcome measurement
Andersen and Gaardboe 1993	Duration of exposure to work as a sewing machine operator (yrs)	Self-completion questionnaire	0	2	1	0	0	1	1	0	0	0
Chiang *et al*. 1993	• Repetitive movement of the upper limb • Forceful movements of the upper limb • Interaction of the above	Job tasks, and job analysis for 3 subjects	0	1	1	0	0	1	0	1	1	1
Stenlund *et al*. 1993	• Lifted load • Vibration • Manual work	Structured interview	0	1	1	2	0	1	1	0	1	2
Frost and Andersen 1999	Cumulative exposure to slaughter house work	Work type and video-based observations	0	4	3	1	2	1	1	2	1	2
Kaergaard and Andersen 2000	Number of years working as sewing machine operator	Work type	0	1	2	3	0	2	0	0	2	2
Punnett *et al*. 2000	Exposure to severe shoulder flexion or abduction	Work type and video-based observations	1	0	0	0	0	1	0	2	1	2
Frost *et al*. 2002	• Repetitive manual handling • Frequency of shoulder movements • Force requirements	Work type and video-based observations	0	4	3	2	2	2	2	2	3	2
Svendsen *et al*. 2004a	• Lifetime upper arm elevation >90° (months) • Lifetime shoulder force requirements	Questionnaire and observation of physical demands to a subgroup of subjects	0	1	3	1	2	1	2	2	3	3
Svendsen *et al*. 2004b	• Current upper arm elevation above 90° (% of working hours) • Lifetime upper arm elevation above 90° (months) • Job demand • Job control • Social support	Questionnaire and technical measurements of physical demands to a subgroup of subjects	0	4	3	1	2	2	2	2	2	2
Miranda *et al*. 2005	• Driving • Carrying weights • Arm elevation • High hand force • Repetitive motion	Interviewer-administered questionnaire on physical and psychosocial factors	0	4	3	2	0	1	0	0	2	3

	• Using vibrating tool • Job satisfaction • Job strain • Social support • Uncertainty of prospects • Threat of being bullied • Social climate at work												
Werner *et al*. 2005	• Repetition • Peak force • Job change • Skill discretion • Decision authority • Support • Job insecurity • Job satisfaction • Perceived stress	• Aggregated assessment of exposures was included • Ergonomic rating for each job • Each job was rated for hand activity and force level	2	3	1	1	0	0	0	1	0	0
Melchior *et al*. 2006	• Arm elevation • Other arm postures (behind trunk / away from body) • Forceful movements • Repetitive motion	Self-administered questionnaire, based on the international SALTSA criteria document	0	4	3	0	1	1	0	0	0	3
Walker-Bone *et al*. 2006	• Arm elevation • Carrying weights • Demands • Support • Control • Vitality score	Self-administered questionnaire on physical and psychosocial factors	0	4	3	1	1	3	2	0	0	2

Table 3 – General description of studies

Study	Design[a]	Study population	Outcomes measured	Prevalence of outcome of interest
Andersen and Gaardboe 1993	CS	107 sewing machine operators and a comparison group from a industrial cohort	Rotator cuff syndrome	• Sewing machine operators: 22.0% • Controls: 4.0%
Chiang *et al*. 1993	CS	207 workers from 8 fish processing factories in Taiwan	Shoulder girdle pain	• Fish processing industry workers: 30.9% • Office staff, skilled craftsmen: 9.8% • Semi-skilled workers: 37.3% • Workers in cutting and sorting: 50%
Stenlund *et al*. 1993	CS	208 construction workers in Sweden	Shoulder tendinitis	Left / Right • Rock blasters 32.7% 40.0% • Brick layers 11.1% 14.8% • Foremen 8.2% 17.1%
Frost and Andersen 1999	CS	1591 workers employed at a slaughterhouse or a chemical factory	Shoulder impingement syndrome	• Current slaughterhouse workers: 6.9% • Ex-slaughterhouse workers: 10.4%
Kaergaard and Andersen 2000[b]	CO	178 female sewing machine operators and 357 controls engaged in non repetitive work	Specific neck / shoulder disorders • Rotator cuff tendinitis; and / or • Myofascial pain syndrome	• Sewing machine operators: 5.8% • Controls: 2.2%
Punnett *et al*. 2000	CC	79 workers with shoulder pain and 124 referents from automobile assembly plant	Shoulder pain with physical findings	–
Frost *et al*. 2002[b]	CS	1961 workers engaged in repetitive work and 782 referents	Shoulder tendinitis	• Shop workers: 0% • Slaughterhouse workers: 8.7% • Overall: 3.2%
Svendsen *et al*. 2004a	CS	393 right handed male machinists, car mechanics and house painters, 40-50yrs, employed in the same trade for not less than 10yrs (Denmark)	Rotator cuff disorder	• Prevalence of a number of difference outcomes is presented. • 38.2% of the sample had some supraspinatus tendon abnormality
Svendsen *et al*. 2004b	CS	1886 male machinists, car mechanics and house painters in Denmark	Supraspinatus tendinitis	• Machinists: 2.0% • Car mechanics: 1.4% • House painters: 4.4%
Miranda *et al*. 2005	CS	4071 persons aged 30-64yrs who held a job during the preceding 12 months from Finland health survey sample of 8028 persons	Chronic rotator cuff tendinitis	• 2.0%
Werner *et al*. 2005	CO	501workers from four industrial and 3 clerical cites in US (985 at the baseline survey)	Shoulder tendinitis	–
Melchior *et al*. 2006	CS	2656 men and women aged 20-57yrs in France	Rotator cuff syndrome	• Men: 6.7% • Women: 8.9%
Walker-Bone *et al*. 2006	CS	10,264 men and women of 25-64yyrs registered in two GP practices in Southampton	Specific shoulder disorders: • Rotator cuff tendinitis; • Adhesive capsulitis; • Biceps tendinitis; • Subacromial bursitis; or	• 2.5%

	• Acromioclavicular joint dysfunction

Notes / Abbreviations

a CS – Cross-sectional study.
CO – Cohort study.
CC – Case-control.

b Both papers originate from the same study – the PRIM Study (Project on Research and Intervention in Monotonous work).

Table 4 – Description of primary outcome of individual studies

Study	Outcome measurement	Definition of outcome
Andersen and Gaardboe 1993	Rotator cuff syndrome	• Self reported chronic shoulder pain; and • Tenderness (graded moderate or severe) at the tuberculum majus; and • Positive pain-arc or impingement sign (pain at passive abduction of the arm when the rotation of the scapulae is fixed)
Chiang *et al*. 1993	Shoulder girdle pain	• Pain in the neck / shoulder / upper arms; and • Signs of at least two tender points or palpable hardenings, or both which may be caused or aggravated by work conditions
Stenlund *et al*. 1993	Shoulder tendinitis	• Pronounced palpable pain of the muscle attachment; or • Pronounced pain reaction to isometric contraction in any of the four rotator cuff muscles or the biceps muscles
Frost and Andersen 1999	Shoulder impingement syndrome	• Self-reported symptoms in the shoulder region for at least 3 months within the past year; and • Positive sign for impingement at physical examination during the past year and signs of subacromial impingement in the corresponding shoulder
Kaergaard and Andersen 2000	Specific neck / shoulder disorders: • Rotator cuff tendinitis; and / or • Myofascial pain syndrome	One or both of: • Rotator cuff tendinitis: ○ Self-reported pain in the shoulder or neck region; ○ Palpation tenderness at the turberculam majus humeri or sign of subacromial impingement; ○ Shoulder pain in resisted abduction • Myofascial pain syndrome: ○ Pain in shoulder or neck region, or both; ○ Palpation tenderness (graded 2 or 3, out of 3) in a minimum of one of the upper neck muscles and upper trapezius muscle, and in a minimum of one of the supraspinatus and infraspinatus muscle in the relevant neck-shoulder regions
Punnett *et al*. 2000	Shoulder pain with physical findings	• Shoulder disorder reported to the plant medical; and • History of shoulder pain on more than three occasions, or for more than one week, during the past year; and • Positive findings during at least one manoeuvre in the physical examination of the shoulder
Frost *et al*. 2002	Shoulder tendinitis	• Shoulder pain and activity impairment scales summing to at least twelve points (out of 36); and • Pain at resisted abduction; and • Impingement pain and / or palpation tenderness of the greater humeral tubercle
Svendsen *et al*. 2004a	Rotator cuff disorder	MRI consensus diagnosis by two experienced musculoskeletal radiologists
Svendsen *et al*. 2004b	Supraspinatus tendinitis	• Self-report of pain / discomfort in the shoulder during last 12 months; and • Self-report of being at least ‘somewhat’ bothered by this pain / discomfort; and • At least one sign of indirect tenderness ○ Painful arc test positive; or ○ Pain provoked by isometric abduction; or ○ Jobe’s Test positive • And at least one sign of direct tenderness ○ Hawkin’s Test positive; or ○ Abduction internal rotation test positive
Miranda *et al*. 2005	Chronic rotator cuff tendinitis	• History of pain in the rotator cuff region lasting for at least 3 months; • Pain during the month preceding the examination; and • Pain in the rotator cuff region upon: ○ Abduction of the arm; ○ External rotation of the arm; or

		○ Internal rotation of the arm ○ Abduction of the shoulder
Werner *et al*. 2005	Shoulder tendinitis	• Self-report of pain stiffness, aching, burning or tenderness, present for a week or more or occurred on three or more episodes; and • Pain with palpation or with resistive movements at shoulder
Melchior *et al*. 2006	Rotator cuff syndrome	• Diagnosis derived from examination based on the international SALTSA criteria document: ○ ICD10 M75.1, 75.2
Walker-Bone *et al*. 2006	Specific shoulder disorders: • Rotator cuff tendinitis; • Adhesive capsulitis; • Biceps tendinitis; • Subacromial bursitis; or • Acromioclavicular joint dysfunction	Diagnosis derived from examination using Southampton Examination Schedule (Palmer *et al*. 2000)

Table 5 – Occupational physical exposures and shoulder disorders (position of upper limb)

Study	Outcome	Exposure	Assessment of exposure	Results[a]	Notes
Punnett *et al*. 2000	Shoulder pain with physical findings	Exposure to severe (>90°) shoulder flexion or abduction, analysed as percentage of job cycle	Videotape analysis of job cycle	Right shoulder • 0%: 1.0 • >0-10%: 2.0[b] • ≥10%: 3.9[b] Left shoulder • 0%: 1.0 • >0-10%: 2.5[b] • ≥10%: 6.1[b]	
Svendsen *et al*. 2004a	Supraspinatus tendinopathy	Life time upper arm elevation >90°	Questionnaire, plus objective measures of physical exposure in random sub-sample	• 0-10 months: 1.0 • 10-20 months: 0.95 (0.41-2.20) • ≥20 months: 2.33 (0.93-5.84)	Adjusted for age, as a continuous variable
	Acromioclavicular joint disorders	Life time upper arm elevation >90°	Questionnaire, plus objective measures of physical exposure in random sub-sample	• 0-10 months: 1.0 • 10-20 months: 0.79 (0.35-1.77) • ≥20 months: 0.49 (0.19-1.23)	Adjusted for age, as a continuous variable
Svendsen *et al*. 2004b	Supraspinatus tendinitis	Current arm elevation >90° (percentage of working hours)	Percentage of daily working hours spent with arm elevated more than 90° by time weighting averaging of exposure for jobs in the previous 10 months	• 0-3%: 1.0 • 3-6%: 0.94 (0.37-2.39) • 6-9%: 4.70 (2.07-10.68)	
		Lifetime arm elevation >90°	Exposure for each job * reduction factor * duration of employment; summed across all jobs	Dominant shoulder • 0-6 months: 1.0 • 6-12 months: 0.73 (0.27-1.94) • 12-24 months: 1.30 (0.57-2.99) • ≥24 months: 1.87 (0.79-4.44) Non-dominant shoulder • 0-6 months: 1.0 • 6-12 months: 0.97 (0.25-3.85) • 12-24 months: 0.54 (0.13-2.24)[c]	• Adjusted for age and smoking • Non-dominant model shows some evidence of instability: unadjusted odds ratios = 1.0, 1.69 and 1.46, respectively
Miranda *et al*. 2005	Chronic rotator cuff tendinitis	Duration of working with a hand above shoulder level for ≥1hr per day	Based on interview and questionnaire	• None: 1.0 • 1-3yrs: 2.3 (0.9-5.4) • 4-13yrs: 3.2 (1.6-6.5) • 14-23yrs: 4.5 (2.3-8.6) • >23yrs: 2.3 (1.1-4.9)	Adjusted for age and sex
Melchior *et al*. 2006	Rotator cuff syndrome	Working with arm above shoulder[d]	Self-administered questionnaire, based on the international SALTSA criteria document	Men • Never: 1.0 • <2hr per day: 1.06 (0.67-1.67) • ≥2hr per day: 2.57 (1.67-3.87) Women • Never: 1.0	Adjusted for age, obesity, diabetes, thyroid disease, arthritis, repetitive movements, force exertion, working with hand behind trunk

				• <2hr per day: 1.21 (0.75-1.93) • ≥2hr per day: 1.75 (1.09-2.83)	and / or arms away from body, and manual occupation
		Working with arms held away from body[d]	Self-administered questionnaire, based on the international SALTSA criteria document	Men • Never: 1.0 • <2hr per day: 1.49 (0.96-2.30) • ≥2hr per day: 1.42 (0.87-2.31) Women • Never: 1.0 • <2hr per day: 1.23 (0.69-2.09) • ≥2hr per day: 2.13 (1.36-3.33)	Adjusted for age, obesity, diabetes, thyroid disease, arthritis, repetitive movements, force exertion, working with arms above shoulder level and / or hands behind trunk, and manual occupation
		Working with hands behind trunk[d]	Self-administered questionnaire, based on the international SALTSA criteria document	Men • Never: 1.0 • <2hr per day: 1.07 (0.68-1.68) • ≥2hr per day: 1.02 (0.44-2.36) Women • Never: 1.0 • <2hr per day: 1.43 (0.88-2.32) • ≥2hr per day: 2.11 (1.13-3.93)	Adjusted for age, obesity, diabetes, thyroid disease, arthritis, repetitive movements, force exertion, working with arms above shoulder level and / or arms away from body, and manual occupation
Walker-Bone *et al*. 2006	Rotator cuff tendinitis and / or adhesive capsulitis, biceps tendinitis, subacromial bursitis, or acromioclavicular joint dysfunction	Working with arm elevated	Self administered questionnaire (postal)	• <1hr per day: 1.0 • >1hr per day: 1.6 (0.9-2.9)	Adjusted for age, sex, smoking, blue / white collar working status, SF36 vitality score, carrying weights on one side and level of demands / support / control

Notes

a Results expressed as odds ratios with 95% confidence intervals, unless otherwise stated.
b Confidence intervals not available.
c Includes 14 subjects with an exposure of ≥24 months.
d Results expressed as prevalence ratios with 95% confidence intervals.

Table 6 – Occupational physical exposures and shoulder disorders (manual handling / force requirements)

Study	Outcome	Exposure	Assessment of exposure	Results[a]	Notes
Chiang *et al*. 1993	Shoulder girdle pain	Forceful movements of the upper limb	Based on observation of worker for >30mins or >3 work cycles.	• No: 1.0 • Yes: 1.8 (1.2-2.5)	Adjusted for age, sex and repetitive movements of the upper limb
Stenlund *et al*. 1993	Shoulder tendinitis	Lifted load during work life (0-709t; 710-25999t; and >25999t)[b]	Interviewer administered questionnaire	Right shoulder • 0-709t: 1.0 • Per 1 category increase: 1.04 (0.50-2.18) Left shoulder • 0-709t: 1.0 • Per 1 category increase: 1.55 (0.58-4.12)	Adjusted for age, dexterity, smoking and sports activities
Frost *et al*. 2002	Shoulder tendinitis	Force requirements (percentage of maximum voluntary contraction (MVC))	Subjective estimate from repeated review of video recording in sub-group of workers	• Reference group of workers: 1.0 • Low (<10% MVC): 2.17 (0.84-5.59) • High (>10% MVC): 4.21 (1.71-10.40)	• Reference group assigned the value of zero. • Adjusted for centre, age, age^2, gender, shoulder injury, shoulder operation, physical activity during leisure, overhead sport, BMI, height and low pressure pain threshold
Svendsen *et al*. 2004a	Supraspinatus tendinopathy	Lifetime shoulder force requirements	Questionnaire, plus objective measures of physical exposure in random sub-sample	• Low: 1.0 • Medium: 1.24 (0.48-3.18) • High: 0.71 (0.30-1.65)	Adjusted for age, as a continuous variable
	Acromioclavicular joint degeneration	Lifetime shoulder force requirements	Questionnaire, plus objective measures of physical exposure in random sub-sample	• Low: 1.0 • Medium: 0.58 (0.22-1.53) • High: 1.29 (0.57-2.93)	Adjusted for age, as a continuous variable
Miranda *et al*. 2005	Chronic rotator cuff tendinitis	Frequent lifting (≥5kg, ≥2 times per minute, >2hrs per day)	Based on interview and questionnaire	• None: 1.0 • 1-3yrs: 1.4 (0.5-3.7) • 4-13yrs: 1.5 (0.7-3.3) • 14-23yrs: 1.9 (0.9-3.9) • >23yrs: 2.0 (0.9-4.3)	Adjusted for age and sex
		Heavy lifting (>20kg, >10 times per day)	Based on interview and questionnaire	• None: 1.0 • 1-3yrs: 1.5 (0.6-4.1) • 4-13yrs: 3.0 (1.6-5.8) • 14-23yrs: 2.8 (1.4-5.7) • >23yrs: 1.8 (0.8-4.2)	Adjusted for age and sex
		Work requiring high hand	Based on interview and	• None: 1.0	Adjusted for age and

		force (≥1hr per day)	questionnaire	• 1-3yrs: 2.3 (0.9-6.3) • 4-13yrs: 2.8 (1.4-6.0) • 14-23yrs: 3.7 (1.9-7.1) • >23yrs: 1.8 (0.8-4.1)	sex
Werner *et al*. 2005	Incident shoulder tendinitis	Peak force (dominant side)	Job rating according to the ACGIH[c] threshold limit values on hand repetition / peak force	No significant difference between cases / controls in peak force score (p=0.98)	
Melchior *et al*. 2006	Rotator cuff syndrome	Forceful movements[d]	Self-administered questionnaire, based on the international SALTSA criteria document	Men • Never: 1.0 • <2hr per day: 1.09 (0.66-1.80) • ≥2hr per day: 1.65 (1.03-2.61) Women • Never: 1.0 • <2hr per day: 1.11 (0.66-1.84) • ≥2hr per day: 1.03 (0.53-2.00)	Adjusted for age, obesity, diabetes, thyroid disease, arthritis, repetitive movements, working with arms above shoulder level, hands behind trunk and / or arms away from body, and manual occupation
Walker-Bone *et al*. 2006	Rotator cuff tendinitis and / or adhesive capsulitis, biceps tendinitis, subacromial bursitis, or acromioclavicular joint dysfunction	Lifting / carrying weights of >5kg in one hand / Carrying weights on one shoulder	Self administered questionnaire (postal)	Carrying weights on one side • No: 1.0 • Yes: 1.8 (1.2-2.8)	Adjusted for age, sex, smoking, blue / white collar working status, SF36 vitality score, working with arm elevated and level of demands / support / control

Notes / Abbreviations

a Results expressed as odds ratios with 95% confidence intervals, unless otherwise stated.
b t = tonnes. 710t corresponds to lifting 19.7kg per hour, 8hrs per day, 225 days per year for 20yrs.
c American Congress of Governmental Industrial Hygienists.
d Results expressed as prevalence ratios with 95% confidence intervals.

Table 7 – Occupational physical exposures and shoulder disorders (repetitive tasks)

Study	Outcome	Exposure	Assessment of exposure	Results[a]	Notes
Chiang *et al*. 1993	Shoulder girdle pain	Repetitive movements of the upper limb	Based on observation of worker for >30mins or >3 work cycles.	• No: 1.0 • Yes: 1.6 (1.1-2.5)	Adjusted for age, sex and forceful movements of the upper limb
		Interaction of frequency and force[b]	Based on observation of worker for >30mins or >3 work cycles.	• No: 1.0 • Yes: 1.4 (1.0-2.0)	Adjusted for age, sex and forceful movements of the upper limb
Frost *et al*. 2002	Shoulder tendinitis	Repetitive manual handling	Repeated review of video recording in sub-group of workers	• No: 1.0 • Yes: 3.12 (1.33-7.34)	Adjusted for centre, age, age^2, gender, shoulder injury, shoulder operation, physical activity during leisure, overhead sport, BMI, height and low pressure pain threshold
		Frequency of shoulder movements (movements per minute)	Repeated review of video recording in sub-group of workers	• None: 1.0 • 1-14 movements: 2.93 (1.17-7.36) • 15-36 movements: 3.29 (1.34-8.11)	• Reference group assigned the value of zero. • Adjusted for centre, age, age^2, gender, shoulder injury, shoulder operation, physical activity during leisure, overhead sport, BMI, height and low pressure pain threshold
		Combined exposures of task frequency (Fr) and force (Fo)[b]	Subjective estimate from repeated review of video recording in sub-group of workers	• Reference group of workers: 1.0 • Low Fr + Low Fo: 2.49 (0.94-6.64) • High Fr + Low Fo: 1.73 (0.56-5.53) • Low Fr + High Fo: 2.89 (0.77-10.77) • High Fr + High Fo: 4.82 (1.86-12.51)	• Reference group assigned the value of zero. • Adjusted for centre, age, age^2, gender, shoulder injury, shoulder operation, physical activity during leisure, overhead sport, BMI, height and low pressure pain threshold
Miranda *et al*. 2005	Chronic rotator cuff tendinitis	Work requiring repetitive motion of the hand or wrist ($\geq$2hrs per day)	Based on interview and questionnaire	• None: 1.0 • 1-3yrs: 1.6 (0.5-5.2) • 4-13yrs: 0.8 (0.3-2.1) • 14-23yrs: 2.4 (1.3-4.3)	Adjusted for age and sex

				• >23yrs: 2.6 (1.4-4.9)	
Werner *et al*. 2005	Incident shoulder tendinitis	Repetition	Job rating according to the ACGIH[c] threshold limit values on hand repetition / peak force	No significant difference between cases / controls in repetitive tasks (p=0.96)	
Melchior *et al*. 2006	Rotator cuff syndrome	Repetitive movements with breaks[d]	Self-administered questionnaire, based on the international SALTSA criteria document	Men • No: 1.0 • Yes: 2.12 (1.43-3.15) Women • No: 1.0 • Yes: 1.83 (1.21-2.74)	Adjusted for age, obesity, diabetes, thyroid disease, arthritis, force exertion, working with arms above shoulder level, hands behind trunk and / or arms away from body, and manual occupation
		Repetitive movements without breaks[d]	Self-administered questionnaire, based on the international SALTSA criteria document	Men • No: 1.0 • Yes: 1.97 (0.93-4.17) Women • No: 1.0 • Yes: 2.57 (1.50-4.41)	Adjusted for age, obesity, diabetes, thyroid disease, arthritis, force exertion, working with arms above shoulder level, hands behind trunk and / or arms away from body, and manual occupation

Notes / Abbreviations

a Results expressed as odds ratios with 95% confidence intervals, unless otherwise stated.
b For force alone, refer to Table 6.
c American Congress of Governmental Industrial Hygienists.
d Results expressed as prevalence ratios with 95% confidence intervals.

Table 8 – Occupational physical exposures and shoulder disorders (other exposures)

Study	Outcome		Assessment of exposure	Results	Notes
Andersen and Gaardboe 1993	Rotator cuff syndrome	Duration of exposure to work as a sewing machine operator (yrs)		• Control group[b]: 1.0 • 0-7yrs: 1.20 (0.07-20.43)[c] • 8-15yrs: 7.58 (0.84-68.46)[c] • >15yrs: 10.56 (1.26-88.19)[c]	
Stenlund *et al*. 1993	Shoulder tendinitis	Manual work (0-9yrs; 10-28yrs; and >28yrs)	Interviewer administered questionnaire	Right shoulder • 0-9yrs: 1.0 • Per 1 category increase: 0.96 (0.51-1.83) Left shoulder • 0-9yrs: 1.0 • Per 1 category increase: 2.31 (0.85-6.28)	Adjusted for age, dexterity, smoking and sports activities
		Work life exposure to vibration (0-8999hrs; 9000-255,199hrs; >255,199hrs)[d]	Interviewer administered questionnaire	Right shoulder • 0-8999hrs: 1.0 • Per 1 category increase: 1.86 (1.00-3.44) Left shoulder • 0-8999hrs: 1.0 • Per 1 category increase: 2.49 (1.06-5.87)	Adjusted for age, dexterity, smoking and sports activities
Frost and Andersen 1999	Shoulder impingement syndrome	Exposure to slaughter house work (SHW). Former SHW = out of work for previous 3 months	Postal questionnaire and company files	• Control group[e]: 1.0 • Current SHW: 5.27 (2.09-13.26) • Former SHW: 7.9 (2.94-21.18)	
Kaergaard and Andersen 2000	Rotator cuff tendinitis and / or myofascial pain syndrome	Duration of exposure (years as a sewing machine operator)[f]		Women only • <2yrs: 2.44 (0.72-8.23) • 2-10yrs: 1.0 • 10-20yrs: 1.80 (0.62-5.26) • >20yrs: 4.44 (1.54-12.78)	Adjusted for age, smoking, BMI, living alone with children and level of job strain / support / stress
Svendsen *et al*. 2004b	Supraspinatus tendinitis	Duration of exposure to being a machinist, car mechanic, or house painter		For dominant shoulder • Per 10yr increase in job duration: 0.74 (0.52-1.06)	Adjusted for age, smoking and total population
		Occupation	Self-completed postal questionnaire	• Machinist or car mechanic: 1.0 • House painter: 2.04 (0.59-7.13)	
Miranda *et al*. 2005	Chronic rotator cuff tendinitis	Driving a motor vehicle ($\geq$4hrs per day, >3 months per year)	Based on interview and questionnaire	• None: 1.0 • 1-3yrs: 2.6 (0.9-7.2) • 4-13yrs: 1.4 (0.6-3.5) • 14-23yrs: 2.7 (1.1-6.4) • >23yrs: 1.1 (0.4-3.0)	Adjusted for age and sex
		Working with a vibrating tool ($\geq$2hrs per day)	Based on interview and questionnaire	• None: 1.0 • 1-3yrs: 0.6 (0.1-4.6) • 4-13yrs: 2.5 (1.0-5.9) • 14-23yrs: 3.5 (1.5-7.8)	Adjusted for age and sex

				• >23yrs: 1.4 (0.5-4.4)	
Melchior *et al*. 2006	Rotator cuff syndrome	Manual occupation[f]	Self-report	Men • No: 1.0 • Yes: 1.35 (0.86-2.12) Women • No: 1.0 • Yes: 1.34 (0.88-2.03)	Adjusted for age, obesity, diabetes, thyroid disease, arthritis, repetitive movements, force exertion, arm(s) above shoulder position, hand behind trunk posture, arm(s) away from body

Notes

a Results expressed as odds ratios with 95% confidence intervals, unless otherwise stated.
b Control group: auxiliary nurses or home helpers.
c Odds ratios and confidence intervals not presented in the original article, but computed from data given in the paper.
d Weighted hours of exposure – i.e. hours of exposure * 1, 10 or 100 corresponding to recognised vibration energy emitted by the tool.
e Control group: repair men or in other service groups in the same working environments.
f Results expressed as prevalence ratios with 95% confidence intervals.

Table 9 – Occupational psychosocial exposures and shoulder disorders

Study	Outcome	Exposure	Assessment of exposure	Results[a]	Notes
Kaergaard and Andersen 2000	Rotator cuff tendinitis and / or myofascial pain syndrome	Job strain[b]	Questionnaire based on Job Content Questionnaire	Women only • Low: 1.0 • High: 0.88 (0.45-1.71)	Adjusted for years as a sewing machine operator, age, smoking, BMI, living alone with children and level of job support / stress
		Social support[b]	Questionnaire based on Job Content Questionnaire	• High: 1.0 • Low: 1.66 (0.86-3.23)	Adjusted for years as a sewing machine operator, age, smoking, BMI, living alone with children and level of job strain / stress
Svendsen *et al*. 2004b	Supraspinatus tendinitis	Job demands	Copenhagen Psychosocial Questionnaire	• Low: 1.0 • High: 3.19 (1.62-6.31)	
		Job control	Copenhagen Psychosocial Questionnaire	• High: 1.0 • Low: 1.83 (0.93-3.60)	
		Social support	Copenhagen Psychosocial Questionnaire	• High: 1.0 • Low: 0.91 (0.46-1.77)	
Miranda *et al*. 2005	Chronic rotator cuff tendinitis	Psychological demands of work	Based on interview and questionnaire	• Low: 1.0 • High: 1.7 (1.0-3.0)	Adjusted for age and sex
		Burnout	Based on interview and questionnaire	• None: 1.0 • Mild / severe: 1.0 (0.5-1.9)	Adjusted for age and sex
		Threat of being bullied / mentally abused	Based on interview and questionnaire	• None / little: 1.0 • Much / very much: 1.7 (0.9-3.5)	Adjusted for age and sex
Werner *et al*. 2005	Incident shoulder tendinitis	• Support from colleagues • Support from supervisors • Skill discretion • Decision authority • Job insecurity • Perceived stress • Job satisfaction	Questionnaire based on Karasek's Job Content Questionnaire	Controls scored higher on • Support from colleagues (p=0.02) • Support from supervisor (p<0.01) although no significant difference were observed between cases / controls in: • Skill discretion (p=0.18) • Decision authority (p=0.13) • Job insecurity (p=0.53) • Perceived stress (p=0.74) • Job satisfaction (p=0.09)	
Walker-Bone *et al*. 2006	Rotator cuff tendinitis and / or adhesive capsulitis, biceps tendinitis, subacromial bursitis, or acromioclavicular joint dysfunction	Work demands	Self administered postal questionnaire	• No: 1.0 • Yes: 1.0 (0.7-1.5)	Adjusted for age, sex, smoking, blue / white collar working status, SF36 vitality score, working with arm elevated, carrying weights on one side and

				level of support / control
	Control over work	Self administered postal questionnaire	• Yes: 1.0 • No: 1.2 (0.7-2.6)	Adjusted for age, sex, smoking, blue / white collar working status, SF36 vitality score, working with arm elevated, carrying weights on one side and level of demands / support
	Support at work	Self administered postal questionnaire	• Yes: 1.0 • No: 1.6 (1.0-2.6)	Adjusted for age, sex, smoking, blue / white collar working status, SF36 vitality score, working with arm elevated, carrying weights on one side and level of demands / control

Notes

a Results expressed as odds ratios with 95% confidence intervals, unless otherwise stated.

b Results expressed as prevalence ratios with 95% confidence intervals.

Table 10 – Contributory evidence (general description of studies)

Study	Study population	Outcome	Prevalence of outcome of interest
Miranda *et al*. 2001	3312 Forestry workers	New onset 'mild or severe' shoulder pain over 12 months	• 14% onset at 1yr
Feveile *et al*. 2002	1895 employees in Denmark	1yr prevalence of neck / shoulder symptoms, 5yrs after baseline	–
Andersen *et al*. 2003[a]	3123 workers in Denmark	Incident episode of neck / shoulder pain over 4yr follow-up	• 14.1%
Harkness *et al*. 2003	803 workers from 12 occupational groups	1 month prevalence of shoulder pain, 1yr and 2yrs after baseline	• 15% onset at 1yr among those free of pain at baseline • 15% onset at 2yrs, among those free of pain at baseline and 1yr
Östergren *et al*. 2005	4919persons of 45-65yrs in Sweden	Neck / shoulder pain 'often' or 'all the time' in 12 months after baseline	–
van den Heuvel *et al*. 2005[b]	787 workers from 34 companies	3yr cumulative incidence of neck and upper limb symptoms, 3yrs after baseline	• 24%
van den Heuvel *et al*. 2006[b]	398 workers from 34 companies	1yr prevalence of neck and upper limb symptoms, 3yrs after baseline	–

Notes

a Paper originates from the same study as two of main papers (Frost *et al*. 2002; Kaergaard and Andersen 2000) – the PRIM Study (Project on Research and Intervention in Monotonous work).

b Both papers originate from the same study – the SMASH Study (Study of musculoskeletal disorders Absenteeism Stress and Health).

Table 11 – Contributory evidence (physical exposures and pain involving the shoulder region)

Study	Outcome	Exposure	Assessment of exposure	Results[a]	Notes
Working with hands above shoulder level					
Miranda *et al*. 2001	New onset 'mild or severe' shoulder pain over 12 months	Working with hands above shoulder level (minutes per day)	Self-completion questionnaire	• <30mins: 1.0 • 30-60mins: 1.1 (0.8-1.6) • >60mins: 1.3 (0.8-1.9)	Adjusted for age, sex, BMI, mental stress, jogging, dancing, physical strenuousness of work and working with the trunk flexed forward
Harkness *et al*. 2003	1 month prevalence of shoulder pain, 1yr and 2yrs after baseline	Working with hands above shoulder level in past working day	Self-completion questionnaire	• Never: 1.0 • <15mins: 1.0 (0.6-1.6) • ≥15mins: 1.6 (0.98-2.5)	Adjusted for age, sex, occupation, lifting with one or two hands, pushing and pulling (at work), monotonous work and any other pain
		Lifting at or above shoulder level in past working day	Self-completion questionnaire	• Never: 1.0 • ≤20lbs: 2.0 (1.2-3.3) • >20lbs: 2.2 (1.2-3.9)	Adjusted for age, sex and occupation
van den Heuvel *et al*. 2006	1yr prevalence of neck and upper limb symptoms, 3yrs after baseline	Arm elevation at 30-60° (% of time)	Self-completion questionnaire and video observation	• Low (9-32%): 1.0 • Medium (32-35%): 0.76 (0.42-1.38) • High (36-65%): 0.81 (0.55-1.19)	Adjusted for baseline symptoms, age, sex and psychosocial work characteristics
Lifting or carrying weights					
Harkness *et al*. 2003	1 month prevalence of shoulder pain, 1yr and 2yrs after baseline	Lifting with one or two hands	Self-completion questionnaire	• Never: 1.0 • ≤22lbs: 1.6 (0.99-2.7) • >22lbs: 1.7 (0.9-3.0)	Adjusted for age, sex, occupation, working with hands above shoulder level, pushing and pulling (at work), monotonous work and any other pain
		Carrying on one shoulder	Self-completion questionnaire	• Never: 1.0 • ≤25lbs: 1.5 (0.9-2.6) • >25lbs: 1.8 (0.99-3.4)	Adjusted for age, sex and occupation
Physically demanding tasks					
Feveile *et al*. 2002	1yr prevalence of neck / shoulder symptoms, 5yrs after baseline	Heavy lifting (HL) and sedentary work (SW) (% of working hours)	Interview	HL: Seldom / never: • SW: Seldom / never: 1.0 • SW: 25-50%: 1.42 (0.99-2.03) • SW: ≥50%: 1.50 (1.05-2.15) HL: 25-50%: • SW: Seldom / never: 1.42 (0.89-2.67) • SW: 25-50%: 1.61 (0.80-3.24) • SW: ≥50%: 0.18 (0.02-1.41) HL: ≥50%: • SW: Seldom / never: 2.35 (1.10-	• Men only • Adjusted for twisting or bending and social support

				5.00) • SW: 25-50%: 1.38 (0.33-5.76) • SW: >50%: 2.36 (0.14-39.45)	
Miranda *et al*. 2001	New onset 'mild or severe' shoulder pain over 12 months	Physical strenuousness	Self-completion questionnaire	• Not at all / rather light: 1.0 • Somewhat strenuous: 1.6 (1.1-2.3) • Rather or very strenuous: 2.0 (1.3-3.1)	Adjusted for age, sex, BMI, mental stress, jogging, dancing, working with hands above shoulder level and working with the trunk flexed forward
Andersen *et al*. 2003	Incident episode of neck / shoulder pain over 4yr follow-up	Force requirements (percentage of maximum voluntary contraction (MVC))	Subjective estimate from repeated review of video recording of sub-group	• Reference group: 1.0 • Low (<10% MVC): 1.9 (1.0-3.6) • High (>10% MVC): 2.0 (1.0-4.2)	Adjusted for age, sex, BMI, pain pressure threshold, intrinsic effort, physical leisure time activity, psychosocial factors and level of distress
Harkness *et al*. 2003	1 month prevalence of shoulder pain, 1yr and 2yrs after baseline	Pushing / pulling weights in past working day	Self-completion questionnaire	• Never: 1.0 • <70lb: 1.3 (0.8-2.2) • >70lb: 2.6 (1.6-4.2)	Adjusted for age, sex and occupation
Repetitive tasks					
Andersen *et al*. 2003	Incident episode of neck / shoulder pain over 4yr follow-up	Repetition (shoulder movements per minute)	Repeated review of video recording in sub-group of workers	• None: • Low (1-15 movements): 1.3 (0.7-2.6) • High (16-40 movements): 3.0 (1.5-5.8)	Adjusted for age, sex, BMI, pain pressure threshold, intrinsic effort, physical leisure time activity, psychosocial factors and level of distress
		Repetition (shoulder movements per minute) (R) and force requirements (percentage of maximum voluntary contraction) (F)	Subjective estimate from repeated review of video recording of sub-group	• Low R + Low F: 1.0 • High R + Low F: 2.4 (1.3-4.5) • Low R + High F: 1.2 (0.5-3.0) • High R + High F: 2.6 (1.4-4.8)	Adjusted for age, sex, BMI, pain pressure threshold, intrinsic effort, physical leisure time activity, psychosocial factors and level of distress
Harkness *et al*. 2003	1 month prevalence of shoulder pain, 1yr and 2yrs after baseline	Repetitive arm / wrist movements in past working day	Self-completion questionnaire	• Never: 1.0 • <15mins: 1.0 (0.6-1.6) • >15mins: 1.0 (0.6-1.6)	Adjusted for age, sex and occupation
Work posture					
Miranda *et al*. 2001	New onset 'mild or severe' shoulder pain over 12 months	Working with trunk flexed forwards (minutes per day)	Self-completion questionnaire	• <30mins: 1.0 • 30-60mins: 1.7 (1.2-2.5) • 60-120mins: 1.2 (0.7-2.0) • >120mins: 1.6 (0.9-2.6)	Adjusted for age, sex, BMI, mental stress, jogging, dancing, physical strenuousness and working with hands above shoulder level
		Twisting movements of the trunk during a work day	Self-completion questionnaire	• Not at all: 1.0 • Little or moderately: 2.9 (1.3-6.7) • Much: 5.1 (2.1-12.3)	Adjusted for age and sex
		Working in a sitting position (hours per day)	Self-completion questionnaire	• <2hrs: 1.0 • 2-4hrs: 0.7 (0.5-1.0)	Adjusted for age and sex

				• >4hrs: 0.7 (0.5-0.9)	
		Working with a rotated neck (minutes per day)	Self-completion questionnaire	• <30mins: 1.0 • 30-60mins: 1.3 (1.0-1.9) • >60mins: 1.6 (1.2-2.2)	Adjusted for age and sex
Feveile *et al*. 2002	1yr prevalence of neck / shoulder symptoms, 5yrs after baseline	Twisting or bending (% of working hours)	Interview	• Seldom / never: 1.0 • 25-50%: 1.56 (1.10-2.22) • >75%: 1.51 (1.01-2.26)	• Men only • Adjusted for heavy lifting, sedentary work and social support
Andersen *et al*. 2003	Incident episode of neck / shoulder pain over 4yr follow-up	Neck flexion (proportion of task cycle time with neck flexed >20°)	Repeated review of video recording in sub-group of workers	• Reference group: 1.0 • Low (<66% of time): 1.4 (0.7-2.9) • High (>66% of time): 2.6 (1.3-5.1)	Adjusted for age, sex, BMI, pain pressure threshold, intrinsic effort, physical leisure time activity, psychosocial factors and level of distress
		Repetition (shoulder movements per minute) (R) and neck flexion (proportion of task cycle time with neck flexed >20°) (F)	Subjective estimate from repeated review of video recording of sub-group	• Low R + Low F: 1.0 • High R + Low F: 1.4 (0.2-13.2) • Low R + High F: 1.4 (0.5-4.1) • High R + High F: 3.0 (1.1-8.6)	Adjusted for age, sex, BMI, pain pressure threshold, intrinsic effort, physical leisure time activity, psychosocial factors and level of distress
Harkness *et al*. 2003	1 month prevalence of shoulder pain, 1yr and 2yrs after baseline	Drive as part of job	Self-completion questionnaire	• No: 1.0 • Yes: 1.5 (0.9-2.5)	Adjusted for age, sex and occupation
		Stretching below knee level	Self-completion questionnaire	• Never: 1.0 • <15mins: 1.1 (0.8-1.7) • >15mins: 1.6 (0.95-2.8)	Adjusted for age, sex and occupation
van den Heuvel *et al*. 2006	1yr prevalence of neck and upper limb symptoms, 3yrs after baseline	Neck flexion >20° (% of time)	Self-completion questionnaire and video observation	• Low (0-33%): 1.0 • Medium (33-38%): 0.92 (0.58-1.46) • High (38-73%): 1.06 (0.65-1.72)	Adjusted for baseline symptoms, age, sex and psychosocial work characteristics
		Neck flexion >45° (% of time)	Self-completion questionnaire and video observation	• Low (0-3%): 1.0 • Medium (3-4): 0.95 (0.59-1.52) • High (4-24%): 1.10 (0.67-1.80)	Adjusted for baseline symptoms, age, sex and psychosocial work characteristics
		Neck rotation >45° (% of time)	Self-completion questionnaire and video observation	• Low (2-13%): 1.0 • Medium (14): 1.06 (0.70-1.60) • High (14-45%): 1.57 (0.99-2.50)	Adjusted for baseline symptoms, age, sex and psychosocial work characteristics

Notes

a Results expressed as odds ratios with 95% confidence intervals, unless otherwise stated.

Table 12 – Contributory evidence (psychological factors and pain involving the shoulder region)

Study	Outcome	Exposure	Assessment of exposure	Results[a]	Notes
Miranda *et al*. 2001	New onset 'mild or severe' shoulder pain over 12 months	Mental stress	Self-completion questionnaire	• Not at all: 1.0 • Only a little: 1.3 (0.8-2.0) • To some extent: 1.5 (1.0-2.4) • Rather much, or much: 1.9 (1.1-3.3)	Adjusted for age, sex, BMI, jogging, dancing, physical strenuousness, working with hands above shoulder level and working with trunk flexed forward
Feveile *et al*. 2002	1yr prevalence of neck / shoulder symptoms, 5yrs after baseline	Social support	Interview	• Low: 1.76 (1.24-2.50) • Rather low: 1.17 (0.83-1.66) • Rather high: 1.0 • High: 1.45 (1.00-2.09)	• Men only • Adjusted for twisting or bending, heavy lifting, sedentary work and social support
Andersen *et al*. 2003	Incident episode of neck / shoulder pain over 4yr follow-up	Job demands	Self-completion questionnaire	• Low: 1.0 • High: 1.7 (1.1-2.9)	Adjusted for age, sex, BMI, intrinsic effort, physical leisure time activity, level of distress, job control and job support
		Job control	Self-completion questionnaire	• High: 1.0 • Low: 1.3 (0.8-2.1)	Adjusted for age, sex, BMI, intrinsic effort, physical leisure time activity, level of distress, job demands and job support
		Job support	Self-completion questionnaire	• High: 1.0 • Low: 1.3 (0.8-2.1)	Adjusted for age, sex, BMI, intrinsic effort, physical leisure time activity, level of distress, job demands and job control
Harkness *et al*. 2003	1 month prevalence of shoulder pain, 1yr and 2yrs after baseline	Job demand (stressful work)	Self-completion questionnaire	• Never / occasionally: 1.0 • At least half the time: 0.9 (0.6-1.4)	Adjusted for age, sex and occupation
		Job demand (monotonous work)	Self-completion questionnaire	• Never / occasionally: 1.0 • At least half the time: 1.9 (1.2-3.1)	Adjusted for age, sex and occupation
		Job demand (hectic work)	Self-completion questionnaire	• Never / occasionally: 1.0 • At least half the time: 0.9 (0.6-1.4)	Adjusted for age, sex and occupation
		Job satisfaction	Self-completion questionnaire	• Not dissatisfied: 1.0 • (Very) dissatisfied: 0.7 (0.2-2.1)	Adjusted for age, sex and occupation
		Support from colleagues	Self-completion questionnaire	• Not dissatisfied: 1.0 • (Very) dissatisfied: 1.0 (0.3-3.1)	Adjusted for age, sex and occupation
		Control over work (control over own work)	Self-completion questionnaire	• At least sometimes: 1.0 • (Very) seldom: 1.0 (0.5-2.0)	Adjusted for age, sex and occupation

		Control over work (learn new things)	Self-completion questionnaire	• At least sometimes: 1.0 • (Very) seldom: 1.0 (0.5-2.3)	Adjusted for age, sex and occupation
Östergren *et al*. 2005	Neck / shoulder pain 'often' or 'all the time' in 12 months after baseline	Psychological demands	Self-completion questionnaire	Men • Low: 1.0 • High: 1.04 (0.78-1.38) Women • Low: 1.0 • High: 1.10 (0.84-1.44)	Adjusted for age, mechanical exposure, marital status, country of origin, education and pain from other regions
		Decision latitude	Self-completion questionnaire	Men • Low: 1.0 • High: 0.93 (0.69-1.27) Women • Low: 1.0 • High: 1.14 (0.87-1.51)	Adjusted for age, mechanical exposure, marital status, country of origin, education and pain from other regions
		Job support	Self-completion questionnaire	Men • High: 1.0 • Low: 1.14 (0.86-1.51) Women • High: 1.0 • Low: 1.13 (0.87-1.47)	Adjusted for age, mechanical exposure, marital status, country of origin, education and pain from other regions
		Job strain	Self-completion questionnaire	Men • No: 1.0 • Yes: 0.94 (0.63-1.40) Women • No: 1.0 • Yes: 1.49 (1.10-2.03)	Adjusted for age, mechanical exposure, marital status, country of origin, education and pain from other regions
van den Heuvel *et al*. 2005	Onset of upper limb symptoms	Job demands[b]	Self-completion questionnaire	• Low: 1.00 • Medium: 1.16 (0.82-1.64) • High: 2.06 (1.19-3.55)	Adjusted for age, sex, and physical and personal risk factors
		Skill discretion[b]	Self-completion questionnaire	• High: 1.00 • Medium: 1.17 (0.76-1.79) • Low: 0.99 (0.48-2.05)	Adjusted for age, sex, and physical and personal risk factors
		Decision authority[b]	Self-completion questionnaire	• High: 1.00 • Medium: 1.13 (0.74-1.73) • Low: 1.25 (0.70-2.22)	Adjusted for age, sex, and physical and personal risk factors
		Support from colleagues[b]	Self-completion questionnaire	• High: 1.00 • Medium: 1.04 (0.65-1.64) • Low: 0.98 (0.51-1.92)	Adjusted for age, sex, and physical and personal risk factors
		Support from supervisor[b]	Self-completion questionnaire	• High: 1.00 • Medium: 1.01 (0.59-1.70) • Low: 0.93 (0.53-1.64)	Adjusted for age, sex, and physical and personal risk factors
		Job strain[b]	Self-completion questionnaire	• Low: 1.00 • Active: 1.10 (0.67-1.80) • Passive: 1.12 (0.67-1.86) • High: 1.54 (0.97-2.44)	Adjusted for age, sex, and physical and personal risk factors

Notes

a Results expressed as odds ratios with 95% confidence intervals, unless otherwise stated.

b Results expressed as risk ratios with 95% confidence intervals.

Table 13 – Studies of prognosis (occupational factors)

Study	Outcome	Exposure	Assessment of exposure	Results[a]	Notes
Physical exposures					
Brox and Brevik 1996	Neer shoulder score of >80	Working with hand above level of head	Self-completion questionnaire	• (Very) often: 1.0 • Seldom / sometimes / never: 1.0 (0.3-2.8)	
Bonde *et al*. 2003[b]	Recovery from shoulder tendinitis	Repetitive work	Observation of sub-groups of workers	• No: 1.0 • Yes: 1.0 (0.4-8.5)	Adjusted for age, sex, right / left side tendinitis, intrinsic effort personality and algometric threshold
		Task cycle duration	Observation of sub-groups of workers	• >20 seconds: 1.0 • <20 seconds 1.0 (0.5-2.1)	Adjusted for age, sex, right / left side tendinitis, intrinsic effort personality and algometric threshold
		Shoulder movements per minute	Observation of sub-groups of workers	• <15: 1.0 • >15: 0.6 (0.2-2.0)	Adjusted for age, sex, right / left side tendinitis, intrinsic effort personality and algometric threshold
		Use of shoulder force	Observation of sub-groups of workers	• <10% maximum voluntary contraction: 1.0 • >10% maximum voluntary contraction: 0.5 (0.1-2.3)	Adjusted for age, sex, right / left side tendinitis, intrinsic effort personality and algometric threshold
Psychosocial exposures					
Bonde *et al*. 2003[b]	Recovery from shoulder tendinitis	Perceived job demands	Self-completion questionnaire	• Low: 1.0 • Moderate: 4.1 (1.1-19.2) • High: 1.8 (0.5-6.1)	Adjusted for age, sex, right / left side tendinitis, intrinsic effort personality and algometric threshold
		Perceived job control	Self-completion questionnaire	• Low: 1.0 • Moderate: 2.5 (0.6-10.4) • High: 1.8 (0.5-6.3)	Adjusted for age, sex, right / left side tendinitis, intrinsic effort personality and algometric threshold
		Perceived social support	Self-completion questionnaire	• Low: 1.0 • Moderate: 6.8 (2.0-23.0) • High: 3.1 (0.9-10.1)	Adjusted for age, sex, right / left side tendinitis, intrinsic effort personality and algometric threshold

Notes

a Results expressed as odds ratios with 95% confidence intervals, unless otherwise stated.

b Paper originates from the same study as two of main papers (Frost *et al*. 2002; Kaergaard and Andersen 2000) – the PRIM Study (Project on Research and Intervention in Monotonous work).

Table 14 – Studies of prognosis (non-occupational factors)

Study	Outcome	Exposure	Assessment of exposure	Results[a]	Notes
Brox and Brevik 1996	Neer shoulder score of >80	Professional education	Self-completion questionnaire	• <3yrs: 1.0 • >3yrs: 1.6 (0.6-4.3)	
		On sick leave	Self-completion questionnaire	• No: 1.0 • Yes: 4.3 (1.4-12.9)	
		Other diseases	Self-completion questionnaire	• No: 1.0 • Yes: 1.5 (0.5-4.7)	
		Emotional distress	Self-completion questionnaire	• No: 1.0 • Yes: 1.0 (0.4-4.5)	
		Health locus of control	Self-completion questionnaire	• Internal: 1.0 • Non-internal: 1.4 (0.4-4.6)	
		Medication	Self-completion questionnaire	• Not regular: 1.0 • Regular: 5.3 (1.5-19.1)	
		Isometric endurance	Self-completion questionnaire	• 0-119 seconds: 1.0 • ≥120 seconds: 1.0 (0.4-2.7)	
		Treatment	Self-completion questionnaire	• Non-active: 1.0 • Active: 5.4 (1.7-14.2)	
Bonde *et al*. 2003[b]	Recovery from shoulder tendinitis	Sex	Self-report	• Male: 1.0 • Female: 0.8 (0.4-1.8)	Adjusted for age, right / left side tendinitis, intrinsic effort personality and algometric threshold
		Age	Self-report	• <45yrs: 1.0 • 45-55yrs: 3.8 (1.4-10.7) • >55yrs: 2.0 (0.8-5.0)	Adjusted for sex, right / left side tendinitis, intrinsic effort personality and algometric threshold
		Side of shoulder disorder	Clinical examination	• Dominant: 1.0 • Non-dominant: 0.8 (0.4-1.6)	Adjusted for age, sex, right / left side tendinitis, intrinsic effort personality and algometric threshold
		Diagnosis	Clinical examination	• At baseline: 1.0 • At follow-up: 1.1 (0.5-2.3)	Adjusted for age, sex, right / left side tendinitis, intrinsic effort personality and algometric threshold

Notes

a Results expressed as odds ratios with 95% confidence intervals, unless otherwise stated.

b Paper originates from the same study as two of main papers (Frost *et al*. 2002; Kaergaard and Andersen 2000) – the PRIM Study (Project on Research and Intervention in Monotonous work).

14. Appendices

Appendix I – Literature search strategy

Literature search 1 – outcome(s) of interest

1. shoulder.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
2. rotator cuff.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
3. rotator-cuff.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
4. supraspinatus.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
5. supra-spinatus.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
6. infraspinatus.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
7. infra-spinatus.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
8. teres minor.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
9. subscapularis.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
10. sub-scapularis.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
11. biceps tend$.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
12. glenohumeral.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
13. gleno-humeral.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
14. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13

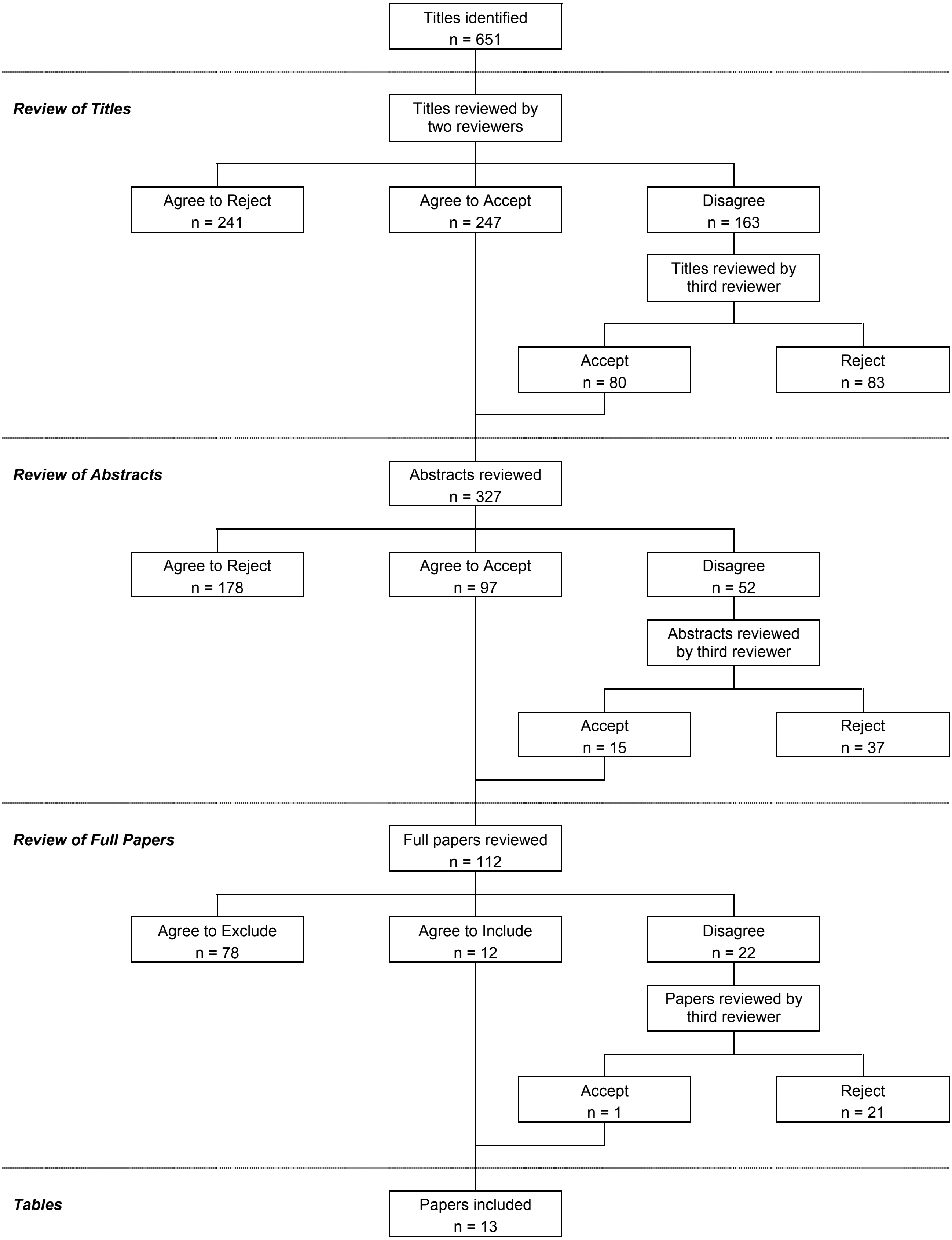
Literature search 2 – exposure(s) of interest

15. epidemiolo$.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
16. aetiolo$.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
17. etiolo$.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
18. risk factor$.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
19. predictive factor$.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
20. risk marker$.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
21. odds ratio$.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
22. hazard ratio$.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
23. risk ratio$.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
24. rate ratio$.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
25. prevalence ratio$.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
26. relative risk$.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
27. 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25 OR 26
28. occupation$.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
29. employment$.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
30. job$.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
31. work$.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
32. task.mp. [mp=ti, hw, ab, it, sh, tn, ot, dm, mf, nm]
33. 28 OR 29 OR 30 OR 31 OR 32

Literature search 3 – combination and restriction of searches

34. 14 AND 27 AND 33
35. remove duplicates from 34
36. limit 35 to english language
37. limit 36 to humans

Appendix II – Literature search flowchart



Appendix III – Articles included in final review

1. Andersen JH, Gaardboe O. Musculoskeletal disorders of the neck and upper limb among sewing machine operators: a clinical investigation. American Journal of Industrial Medicine. 1993;24(6):689-700.
2. Chiang HC, Ko YC, Chen SS, Yu HS, Wu TN, Chang PY. Prevalence of shoulder and upper-limb disorders among workers in the fish-processing industry. Scandinavian Journal of Work, Environment and Health. 1993;19:126-31.
3. Stenlund B, Goldie I, Hagberg M, Hogstedt C. Shoulder tendinitis and its relation to heavy manual work and exposure to vibration. Scandinavian Journal of Work, Environment and Health. 1993;19:43-9.
4. Frost P, Andersen JH. Shoulder impingement syndrome in relation to shoulder intensive work. Occupational and Environmental Medicine 1999;56:494-8.
5. Kaergaard A,.Andersen JH. Musculoskeletal disorders of the neck and shoulders in female sewing machine operators: prevalence, incidence, and prognosis. Occupational and Environmental Medicine 2000;57:528-34.
6. Punnett L, Fine LJ, Keyserling WM, Herrin GD, Chaffin DB. Shoulder disorders and postural stress in automobile assembly work. Scandinavian Journal of Work, Environment and Health 2000;26:283-91.
7. Frost P, Bonde JP, Mikkelsen S, Andersen JH, Fallentin N, Kaergaard A *et al*. Risk of shoulder tendinitis in relation to shoulder loads in monotonous repetitive work. American Journal of Industrial Medicine 2002;41:11-8.
8. Svendsen SW, Gelineck J, Mathiassen SE, Bonde JP, Frich LH, Stengaard-Pedersen K *et al*. Work above shoulder level and degenerative alterations of the rotator cuff tendons: a magnetic resonance imaging study. Arthritis and Rheumatism 2004;50:3314-22.
9. Svendsen SW, Bonde JP, Mathiassen SE, Stengaard-Pedersen K, Frich LH. Work related shoulder disorders: quantitative exposure-response relations with reference to arm posture. Occupational and Environmental Medicine 2004;61:844-53.
10. Miranda H, Viikari-Juntura E, Heistaro S, Heliovaara M, Riihimaki H. A population study on differences in the determinants of a specific shoulder disorder versus nonspecific shoulder pain without clinical findings. American Journal of Epidemiology 2005;161:847-55.
11. Werner RA, Franzblau A, Gell N, Ulin SS, Armstrong TJ. A longitudinal study of industrial and clerical workers: predictors of upper extremity tendinitis. Journal of Occupational Rehabilitation 2005;15:37-46.
12. Melchior M, Roquelaure Y, Evanoff B, Chastang JF, Ha C, Imbernon E *et al*. 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). Occupational and Environmental Medicine 2006;63:754-61.
13. Walker-Bone K, Reading I, Coggon D, Cooper C, Palmer KT. Risk factors for specific upper limb disorders as compared with non-specific upper limb pain: Assessing the utility of a structured examination schedule. Occupational Medicine 2006;56:243-50.

Appendix IV – Table A1 – Articles excluded following full-paper review

	Excluded paper	Reason for exclusion
1.	Back to work: neck-and-shoulder problems; etiology, prevention, consequences and rehabilitation. Proceedings of an international conference. Stockholm, April 21-23, 1992. Scandinavian Journal of Rehabilitation Medicine - Supplementum 1995;32:1-127.	c
2.	Alamanos *et al*.: Working at the loom and musculoskeletal disorders in a female population of Crete, Greece. Scandinavian Journal of Social Medicine 1993;21:171-5.	e
3.	Alvarez-Nemegyei *et al*.: Evidence-Based Soft Tissue Rheumatology. Part I: Subacromial Impingement Syndrome. Journal of Clinical Rheumatology 2003;9:193-9.	a
4.	Andersen *et al*.: Physical, psychosocial, and individual risk factors for neck / shoulder pain with pressure tenderness in the muscles among workers performing monotonous, repetitive work. Spine 2002;27:660-7.	e
5.	Andersen *et al*.: Risk factors in the onset of neck / shoulder pain in a prospective study of workers in industrial and service companies. Occupational and Environmental Medicine 2003;60:649-54.	e
6.	Anderson: Shoulder pain and tension neck and their relation to work. Scandinavian Journal of Work, Environment and Health 1984;10:435-42.	g
7.	Aptel *et al*.: Work-related musculoskeletal disorders of the upper limb. Joint, Bone, Spine: Revue du Rhumatisme 2002;69:546-55.	a
8.	Arboleya and.Garcia: Suprascapular nerve entrapment of occupational etiology: clinical and electrophysiological characteristics. Clinical and Experimental Rheumatology 1993;11:665-8.	i
9.	Bjelle: Epidemiology of shoulder problems. Baillieres Clinical Rheumatology 1989;3:437-51.	a
10.	Bjelle *et al*.: Occupational and individual factors in acute shoulder-neck disorders among industrial workers. British Journal of Industrial Medicine 1981;38:356-63.	e
11.	Bjelle : Scapulohumeral syndromes. Baillieres Clinical Rheumatology 1987;1:547-59.	a
12.	Bjelle *et al*.: Work-related shoulder-neck complaints in industry: A pilot study. British Journal of Rheumatology 1987;26:365-9.	e
13.	Bongers *et al*.: Are psychosocial factors, risk factors for symptoms and signs of the shoulder, elbow, or hand / wrist?: A review of the epidemiological literature. American Journal of Industrial Medicine 2002;41:315-42.	a
14.	Bovenzi *et al*.: Bone and joint disorders in the upper extremities of chipping and grinding operators. International Archives of Occupational and Environmental Health 1987;59:189-98.	e
15.	Bovenzi: Health risks from occupational exposures to mechanical vibration. Medicina del Lavoro 2006;97:535-41.	a
16.	Brown and Baker: Work-Related Musculoskeletal Disorders in Sonographers. Journal of Diagnostic Medical Sonography 2004;20:85-93.	a
17.	Brox and Brevik: Prognostic factors in patients with rotator tendinosis (stage II impingement syndrome) of the shoulder. Scandinavian Journal of Primary Health Care 1996;14:100-5.	f
18.	Buckle: Upper limb disorders and work: the importance of physical and psychosocial factors. Journal of Psychosomatic Research 1997;43:17-25.	a
19.	Buckle and Devereux: The nature of work-related neck and upper limb musculoskeletal disorders. Applied Ergonomics 2002;33:207-17.	a
20.	Burdorf and Monster: Exposure to vibration and self-reported health complaints of riveters in the aircraft industry. Annals of Occupational Hygiene 1991;35:287-98.	d
21.	Carnide *et al*.: Interaction of biomechanical and morphological factors on shoulder workload in industrial paint work. Clinical Biomechanics 2006;21:S33-S38.	e
22.	Chard *et al*.: The long-term outcome of rotator cuff tendinitis - A review study. British Journal of Rheumatology 1988;27:385-9.	f
23.	Cohen and Williams Jr: Impingement syndrome and rotator cuff disease as repetitive motion disorders. Clinical Orthopaedics and Related Research 1998;95-101.	a
24.	Ekberg *et al*.: Case-control study of risk factors for disease in the neck and shoulder area. Occupational and Environmental Medicine 1994;51:252-66.	d
25.	Fagarasanu and Kumar: Shoulder musculoskeletal disorders in industrial and office work. Journal of Musculoskeletal Research 2003;7:1-14.	a
26.	Feveile *et al*.: Risk factors for neck-shoulder and wrist-hand symptoms in a 5-year follow-up study of 3,990 employees in Denmark. International Archives of Occupational and Environmental Health 2002;75:243-51.	e
27.	Forde *et al*.: Prevalence of musculoskeletal disorders in union ironworkers. Journal of Occupational and Environmental Hygiene 2005;2:203-12.	e
28.	Fredriksson *et al*.: Work environment and neck and shoulder pain: the influence of exposure time. Results from a population based case-control study. Occupational and Environmental Medicine 2002;59:182-8.	d
29.	Frost *et al*.: Is supraspinatus pathology as defined by magnetic resonance imaging associated with clinical sign of shoulder impingement? Journal of Shoulder and Elbow Surgery 1999;8:565-8.	h
30.	Fu *et al*.: Shoulder impingement syndrome. A critical review. Clinical Orthopaedics and Related Research 1991;162-73.	a
31.	Grieco *et al*.: Epidemiology of musculoskeletal disorders due to biomechanical overload. Ergonomics 1998;41:1253-60.	a
32.	Hagberg: Occupational musculoskeletal stress and disorders of the neck and shoulder: A review of possible pathophysiology. International Archives of Occupational and Environmental Health 1984;53:269-78.	a
33.	Hagberg and Wegman: Prevalence rates and odds ratios of shoulder-neck diseases in different occupational groups. British Journal of Industrial Medicine 1987;44:602-10.	g
34.	Hansson *et al*.: Impact of physical exposure on neck and upper limb disorders in female workers. Applied Ergonomics 2000;31:301-10.	e
35.	Harkness *et al*.: Mechanical and psychosocial factors predict new onset shoulder pain: a prospective cohort study of newly employed workers. Occupational and Environmental Medicine 2003;60:850-7.	d
36.	Herberts and Kadefors: A study of painful shoulder in welders. Acta Orthopaedica Scandinavica 1976;47:381-7.	h
37.	Herberts *et al*.: Shoulder pain and heavy manual labor. Clinical Orthopaedics and Related Research 1984;166-78.	h
38.	Herberts *et al*.: Shoulder pain in industry: an epidemiological study on welders. Acta Orthopaedica Scandinavica	g

	1981;52:299-306	
39.	Holness *et al*.: Prevalence of upper extremity symptoms and possible risk factors in workers handling paper currency. Occupational Medicine (Oxford) 1998;48 :231-6.	e
40.	Holte and Westgaard: Daytime trapezius muscle activity and shoulder-neck pain of service workers with work stress and low biomechanical exposure. American Journal of Industrial Medicine 2002;41:393-405.	e
41.	Hooftman *et al*.: Gender differences in the relations between work-related physical and psychosocial risk factors and musculoskeletal complaints. Scandinavian Journal of Work, Environment and Health 2004;30:261-78.	a
42.	Hughes *et al*.: Risk factors for work-related musculoskeletal disorders in an aluminum smelter. American Journal of Industrial Medicine 1997;32:66-75.	e
43.	Jacobson *et al*.: Shoulder pain and repetition strain injury to the supraspinatus muscle: etiology and manipulative treatment. Journal of the American Osteopathic Association 1989;89:1037-40.	a
44.	Kamwendo *et al*.: Neck and shoulder disorders in medical secretaries. Part II. Ergonomical work environment and symptom profile. Scandinavian Journal of Rehabilitation Medicine 1991;23:135-42.	e
45.	Keyserling: Workplace risk factors and occupational musculoskeletal disorders, Part 2: A review of biomechanical and psychophysical research on risk factors associated with upper extremity disorders. American Industrial Hygiene Association Journal 2000;61:231-43.	a
46.	Kivi: Rheumatic disorders of the upper limbs associated with repetitive occupational tasks in Finland in 1975-1979. Scandinavian Journal of Rheumatology 1984;13:101-7.	g
47.	Leino-Arjas: Smoking and musculoskeletal disorders in the metal industry: a prospective study. Occupational and Environmental Medicine 1998;55:828-33.	e
48.	Leroux *et al*.: Job strain and neck-shoulder symptoms: a prevalence study of women and men white-collar workers. Occupational Medicine (Oxford) 2006;56:102-9.	e
49.	Lewis *et al*.: The aetiology of subacromial impingement syndrome. Physiotherapy 2001;87:458-69.	a
50.	Lundberg: Stress responses in low-status jobs and their relationship to health risks: musculoskeletal disorders. Annals of the New York Academy of Sciences 1999;896:162-72.	a
51.	Madeleine *et al*.: The effects of neck-shoulder pain development on sensory-motor interactions among female workers in the poultry and fish industries. A prospective study. International Archives of Occupational and Environmental Health 2003;76:39-79.	e
52.	Mäkelä *et al*.: Shoulder joint impairment among Finns aged 30 years or over: prevalence, risk factors and co-morbidity. Rheumatology 1999;38:656-62.	i
53.	Malchaire *et al*.: Review of the factors associated with musculoskeletal problems in epidemiological studies. International Archives of Occupational and Environmental Health 2001;74:79-90.	a
54.	Mani and Gerr: Work-related upper extremity musculoskeletal disorders. Primary Care; Clinics in Office Practice 2000;27:845-64.	a
55.	Mee: Shoulder injuries in veterinary surgeons [1]. Veterinary Record 2005;157:635-6.	c
56.	Mehta *et al*.: Etiologic and pathogenetic factors for rotator cuff tendinopathy. Clinics in Sports Medicine 2003;22:791-812.	a
57.	Meservy *et al*.: Ergonomic risk exposure and upper-extremity cumulative trauma disorders in a maquiladora medical devices manufacturing plant. Journal of Occupational and Environmental Medicine 1997;39:767-73.	e
58.	Miranda *et al*.: A prospective study of work related factors and physical exercise as predictors of shoulder pain. Occupational and Environmental Medicine 2001;58:528-34.	d
59.	Muggleton *et al*.: Hand and arm injuries associated with repetitive manual work in industry: A review of disorders, risk factors and preventive measures. Ergonomics 1999;42:714-39.	a
60.	Natvig and Picavet: The epidemiology of soft tissue rheumatism. Best Practice and Research in Clinical Rheumatology 2002;16:777-93.	a
61.	Nelson: Are pushing and pulling strong risk factors for occupational shoulder disorder? Scandinavian Journal of Work, Environment and Health 2002;28:289-92.	b
62.	Niedhammer *et al*.: Shoulder disorders related to work organization and other occupational factors among supermarket cashiers. International Journal of Occupational and Environmental Health 1998;4:168-78.	d
63.	Nordander *et al*.: Fish processing work: the impact of two sex dependent exposure profiles on musculoskeletal health. Occupational and Environmental Medicine 1999;56:256-64.	e
64.	O'Neil *et al*.: Chronic occupational repetitive strain injury. Canadian Family Physician 2001;47:311-6.	a
65.	Ohlsson *et al*.: Disorders of the neck and upper limbs in women in the fish processing industry. Occupational and Environmental Medicine 1994;51:826-32.	e
66.	Ohlsson *et al*.: Repetitive industrial work and neck and upper limb disorders in females. American Journal of Industrial Medicine 1995;27:731-47.	e
67.	Östergren *et al*.: Incidence of shoulder and neck pain in a working population: effect modification between mechanical and psychosocial exposures at work? Results from a one year follow up of the Malmo shoulder and neck study cohort. Journal of Epidemiology and Community Health 2005;59:721-8.	d
68.	Piedrahita *et al*.: Musculoskeletal symptoms in cold exposed and non-cold exposed workers. International Journal of Industrial Ergonomics 2004;34:271-8.	e
69.	Pienimaki: Cold exposure and musculoskeletal disorders and diseases. A review. International Journal of Circumpolar Health 2002;61:173-82.	a
70.	Punnett: Ergonomic stressors and upper extremity disorders in vehicle manufacturing: cross sectional exposure-response trends. Occupational and Environmental Medicine 1998;55 :414-20.	e
71.	Punnett *et al*.: Soft tissue disorders in the upper limbs of female garment workers. Scandinavian Journal of Work, Environment and Health 1985;11 :417-25.	e
72.	Punnett: Upper extremity musculoskeletal disorders in hospital workers. Journal of Hand Surgery - American Volume 1987;12:858-62.	e
73.	Ranney *et al*.: Upper limb musculoskeletal disorders in highly repetitive industries: precise anatomical physical findings. Ergonomics 1995;38:1408-23.	e
74.	Rauoof *et al*.: Etiological factors and clinical profile of adhesive capsulitis in patients seen at the Rheumatology clinic of a tertiary care hospital in India. Saudi Medical Journal 2004;25:359-62.	i
75.	Roquelaure *et al*.: Active epidemiological surveillance of musculoskeletal disorders in a shoe factory. Occupational and Environmental Medicine 2002;59:452-8.	g
76.	Roquelaure *et al*.: Epidemiologic surveillance of upper-extremity musculoskeletal disorders in the working population. Arthritis and Rheumatism 2006;55:765-78.	g

77.	Silverstein *et al*.: Claims incidence of work-related disorders of the upper extremities: Washington state, 1987 through 1995. American Journal of Public Health 1998;88:1827-33.	g
78.	Silverstein and Hughes: Upper extremity musculoskeletal disorders at a pulp and paper mill. Applied Ergonomics 1996;27:189-94.	e
79.	Solem *et al*.: Pain in head-neck-shoulder-arm in an occupational health department. Acta Neurologica Scandinavica 1984;69:128-9.	b
80.	Solomon *et al*.: Arthroscopic rotator cuff repair in active duty military personnel: A young cohort of patients with rotator cuff tears. Operative Techniques in Sports Medicine 2005;13:136-42.	a
81.	Sommerich *et al*.: Occupational risk factors associated with soft tissue disorders of the shoulder: a review of recent investigations in the literature. Ergonomics 1993;36:367-717.	a
82.	Soto-Quijano *et al*.: Work-related musculoskeletal disorders of the upper extremity. Critical Reviews in Physical and Rehabilitation Medicine 2005;17:65-82.	a
83.	Stenlund: Shoulder tendinitis and osteoarthritis of the acromioclavicular joint and their relation to sports. Br J Sp Med 1993; 27(2): 125-30.	i
84.	Tornqvist *et al*.: The influence on seeking care because of neck and shoulder disorders from work-related exposures. Epidemiology 2001;12:537-45.	i
85.	van den Heuvel *et al*.: Do work-related physical factors predict neck and upper limb symptoms in office workers? International Archives of Occupational and Environmental Health 2006;79:585-92.	e
86.	van den Heuvel *et al*.: Psychosocial work characteristics in relation to neck and upper limb symptoms. Pain 2005;114:47-53.	e
87.	van Der Beek: Work and non-work-related stress increase the risk of arm symptoms. Australian Journal of Physiotherapy 2003;49:71.	b
88.	van der Windt *et al*.: Occupational risk factors for shoulder pain: a systematic review. Occupational and Environmental Medicine 2000;57:433-42.	a
89.	Vasseljen Jr and Westgaard: Arm and trunk posture during work in relation to shoulder and neck pain and trapezius activity. Clinical Biomechanics 1997;12:22-31.	e
90.	Viikari-Juntura: Neck and upper limb disorders among slaughterhouse workers. An epidemiologic and clinical study. Scandinavian Journal of Work, Environment and Health 1983;9:283-90.	e
91.	Waersted and Westgaard: Working hours as a risk factor in the development of musculoskeletal complaints. Ergonomics 1991;34:265-76.	e
92.	Walker-Bone and Cooper: Hard work never hurt anyone: or did it? A review of occupational associations with soft tissue musculoskeletal disorders of the neck and upper limb. Annals of the Rheumatic Diseases 2005;61:1391-6.	a
93.	Walker-Bone *et al*.: Soft-tissue rheumatic disorders of the neck and upper limb: prevalence and risk factors. Seminars in Arthritis and Rheumatism 2003;33:185-203.	a
94.	Waris : Occupational cervicobrachial syndromes. A review. Scandinavian Journal of Work, Environment and Health 1979;5:3-14.	a
95.	Werner *et al*.: Prevalence of upper extremity symptoms and disorders among dental and dental hygiene students. Journal of the California Dental Association 2005;33:123-31.	g
96.	Westerling and Jonsson: Pain from the neck-shoulder region and sick leave. Scandinavian Journal of Social Medicine 1980;8:131-6.	e
97.	Westgaard: Effects of physical and mental stressors on muscle pain. Scandinavian Journal of Work, Environment and Health 1999;25:19-24.	a
98.	Williams and Westmorland: Occupational cumulative trauma disorders of the upper extremity. American Journal of Occupational Therapy 1994;48:411-20.	a
99.	Zakaria: Rates of carpal tunnel syndrome, epicondylitis, and rotator cuff claims in Ontario workers during 1997. Chronic Diseases in Canada 2004;25:32-9.	g

Notes

a Review article / discussion paper.
b Journal commentary / editorial.
c Letter / conference proceedings.
d Outcome measured subjectively / definition unclear.
e Outcome not restricted to shoulder symptoms.
f Paper on prognosis.
g Descriptive evidence / surveillance data.
h Biomechanical / experimental studies.
i Other reason.

Appendix V – Literature search strategy (time relationship)

1. shoulder AND case-control AND time AND work
2. shoulder AND case-control AND time AND occupation
3. shoulder AND case-control AND time AND occupational
4. shoulder AND case-control AND latency AND work
5. shoulder AND case-control AND latency AND occupation
6. shoulder AND case-control AND latency AND occupational
7. shoulder AND case-control AND induction AND work
8. shoulder AND case-control AND induction AND occupation
9. shoulder AND case-control AND induction AND occupational
10. shoulder AND cohort AND time AND work
11. shoulder AND cohort AND time AND occupation
12. shoulder AND cohort AND time AND occupational
13. shoulder AND cohort AND latency AND work
14. shoulder AND cohort AND latency AND occupation
15. shoulder AND cohort AND latency AND occupational
16. shoulder AND cohort AND induction AND work
17. shoulder AND cohort AND induction AND occupation
18. shoulder AND cohort AND induction AND occupational
19. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18

Appendix VI – Criteria for grading 'causal' associations

Criteria for assessing the degree of evidence of a causal association between an exposure to a specific risk factor and a specific outcome, as specified by the Scientific Committee of the Danish Society of Occupational and Environmental Medicine.

Strong evidence of a causal association [+++]

A causal relationship is very likely. A positive relationship between exposure to the risk factor and the outcome has been observed in several epidemiological studies. It can be ruled out with reasonable confidence that this relationship is explained by chance, bias or confounding.

Moderate evidence of a causal association [++]

A causal relationship is likely. A positive relationship between exposure to the risk factor and the outcome has been observed in several epidemiological studies. It cannot be ruled out with reasonable confidence that this relationship can be explained by chance, bias or confounding, although this is not a very likely explanation.

Limited evidence of a causal association [+]

A causal relationship is possible. A positive relationship between exposure to the risk factor and the outcome has been observed in several epidemiological studies. It is not unlikely that this relationship can be explained by chance, bias or confounding.

Insufficient evidence of a causal association [0]

The available studies are of insufficient quality, consistency, or statistical power to permit a conclusion regarding the presence or absence of a causal association.

Evidence suggesting lack of a causal association [–]

Several studies of sufficient quality, consistency and statistical power indicate that the specific risk factor is not causally related to the specific outcome.