Brief Report

Work-related risk factors for rotator cuff syndrome

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Important Note:

- *The purpose of this brief report is to summarise the best evidence for the relationship between rotator cuff syndrome and workplace physical factors. It has not been systematically developed according to a predefined methodology.*
- *It is not intended to replace clinical judgement, or be used as a clinical protocol.*
- *A reasonable attempt has been made to find and review papers relevant to the focus of this report, however it does not claim to be exhaustive*
- *The document has been prepared by the staff of the Research Unit, ACC. The content does not necessarily represent the official view of ACC or represent ACC policy*
- *This report is based upon information supplied up to August 2014.*

Executive Summary

The purpose of this report is to provide a narrative for the findings of the AUT review dated 2010 and update these finding with any relevant recent published after 2011. The evidence described in this report is aimed to facilitate decision making by the ACC Work-Related Gradual Process Diseases and Infections team (WRGPDI) for work-related physical factors and Rotator Cuff Syndrome (RCS).

A total of 23 studies from the AUT review and four additional studies are discussed in this report. Studies were first graded by two ACC reviewers using the Scottish Intercollegiate Guidelines Network criteria (SIGN, Appendix 3) in an attempt to ensure the best evidence available was presented. Risk factors were described in the literature as either single (repetition, posture, force, heavy physical work, duration, vibration) or combined (force and repetition; force and posture; repetition and posture; force, posture and duration; heavy physical work and repetition; and force and vibration). The scope of what was considered as RCS between studies ranged from vaguely described shoulder pain to specific supraspinatus tears that were identified with imaging techniques. The methodology of how risk factors were measured also differed. The variability in definitions, methodologies and participant occupations across studies produced variable results that were described as "inconsistent evidence" by the AUT review.

The main findings show that there is more evidence to support relationships between single risk factors and RCS than combined risk factors. Variability across studies contributed to inconsistency across the evidence when their results were grouped together as individual risk factors. Positive relationships were found within each risk factor but due to the variability it is hard to detect trends or patterns in the relationships of risk factors to RCS. The variability across studies is a caveat within the evidence that should be taken into consideration when using this report to facilitate decision making processes on claims within ACC.

This report provides both quick reference material and more in-depth summaries for the reader. Quick reference material is provided in the form of Summary Tables (Table 3 - 14) that outline the main results for each physical risk factor. In the subsequent sections (Single Risk Factors and Combined Risk Factors) a more comprehensive outline of the evidence is provided, including specific study results in the form of odds ratios and related statistics (95% confidence intervals and statistical significance). This is followed by a short conclusion and discussion into the limitations within the evidence base. Descriptions of the individual papers used in this report are found in Appendix 2 and evidence tables in Appendix 5.

Recommendations for the WRGDPI unit:

When using the evidence from this report to assist decision-making it is important to understand that the majority of evidence included in this report is of low to moderate quality and does not provide evidence of causation for RCS. For individual claims other guidance such as the Bradford-Hill Criteria and the specifics of the case should be used in conjunction with this evidence to ensure the best decision is made.

Table of Contents

List of Tables

List of Abbreviations

AUT	Auckland University of Technology
CC	Case-control study
CI	Confidence Interval
CS	Cross-sectional study
GP	General Practitioner
MSD	Musculoskeletal Disorders
OR	Odds Ratio
PC	Prospective-cohort study
RCS	Rotator Cuff Syndrome
SIGN	Scottish Intercollegiate Guidelines Network
WRGPDI	Work-Related Gradual Process Diseases and Infections team

Definition of RCS

Rotator cuff disorders are complex and can involve multiple mechanisms and structures around the glenohumeral joint. The following disorders can be included under the umbrella term of Rotator cuff syndrome (RCS) as is defined by New Zealand Guideline Group [(1)]:

Impingement, sub-acromial bursitis, tendinosis, painful arc syndrome, partial or full thickness and massive tear of the rotator cuff, long head of biceps tendinosis or rupture and calcific tendinitis.

When making a clinical diagnosis common RCS related symptoms are:

- Most pain occurs when performing overhead activities.
- Active range of movement is limited with a 'painful arc' through active shoulder abduction, but there is a full passive range of movement.
- Weakness on resisting arm movement away from the side of the body (abduction and external rotation) indicates a tear.
- Pain is most commonly felt in the upper arm, in the deltoid muscle, and at night.
- If there is a history of trauma or dislocation, severe pain, and profound weakness, a massive rotator cuff tear is indicated.

For further information regarding the diagnosis, management and prognosis of RCS, please refer to 'The diagnosis and management of soft tissue shoulder injuries and related disorders - best practice evidence-based guideline (2004)'[(1)].

Methodology

The purpose of this report is to provide a narrative to the findings of the AUT review and update the findings with any relevant recent studies that have since been produced.

Outline of studies included in this report

The AUT report included a total of 39 primary studies[(2)]. Only studies from the AUT report that adequately described work-related physical risk factors were included in this report (n = 23). An additional literature search was conducted by ACC Research repeating the same search strategy used by AUT to identify any recent studies published since, or not included in the AUT review. The evidence tables for the secondary and primary studies are presented in Appendix 5 at the end of this report.

A total of 23 studies from the AUT review and four additional studies published between 2011 and 2014 are included in this report. As physical risk factors were being analysed in this report only observational studies could be investigated: six Prospective Cohort, 17 Cross-Sectional and four Case-Control studies. A short description of the methodologies and populations investigated for each study can be found in Appendix 2 at the end of this report.

Assessment of quality of studies included in report

The studies were assessed for quality and assigned a level of evidence using the Scottish Intercollegiate Guidelines Network (SIGN) criteria (Appendix 3). It should be noted that cross-sectional studies are usually not assigned a SIGN level of evidence however they are given one in this report to enable the reader to understand their level of evidence in context with the prospective cohort and case-control studies.

The relationship between physical risk factors and RCS are most commonly reported as an odds ratio (OR) in the primary studies, the AUT review and this report. This provides the reader with quantification that the likelihood that the outcome (in this case RCS) will occur if a particular risk factor (e.g. high forces) is present. The descriptors shown in Table 1 below provide a context of how strong and in which direction the OR (association) is - the higher the OR the higher the odds of RCS occurring if that particular risk factor is present [(3)]. A more in-depth description of ORs can be found in Appendix 1.

Table 1. Odds Ratios and relevant descriptor outlining the strength of evidence

Odds Ratio	Descriptor
<1.0	Protective
1.0 – 2.4	Weak
2.5 – 3.9	Moderate
>4.0	Strong

Summary of Findings: Work-related risk factors for RCS

The physical work related risk factors for RCS were presented as either single or combined physical risk factors in the AUT review and this report. The single risk factors included repetition, posture, force, heavy physical work, duration and vibration use. The combined risk factors summarised were force and repetition, force and posture, repetition and posture, force with posture and duration, heavy physical work and repetition, force and vibration. The main findings are summarised in Table 2 below.

Positive associations were found within each of the risk factors, however the amount and quality of the evidence is variable between factors. Across the studies included by the AUT report there were differences in what was actually diagnosed, some papers investigated shoulder pain in general, others RCS in general whereas some studies looked specifically at individual muscle (predominantly supraspinatus and infraspinatus) tears. This is reflective of the complexity of the shoulder joint which is capable of performing movements in multiple planes and anatomically is composed of multiple joints and muscles. This makes RCS complex and difficult to diagnose and treat, and likely contributed to the heterogeneity between the studies.

More detailed descriptions of the information seen in the summary tables are provided in the sections for single and combined risk factors. This is followed by a discussion of the limitations of the literature included in this report and conclusions. Evidence tables providing details of individual studies are included in Table 2 and 3 at the end of this document. It is important to note when reading this report that the evidence comes mainly from cross-sectional and case-control studies which can determine if a relationship exists between RCS and the risk factor, but cannot assess causation.

Table 2. Summary of main findings for physical risk factors related to RCS

Risk Factor	Main Findings	Main issues with current evidence	Main occupations* or sectors assessed
Single Risk Factors			
Repetition	**Increased odds with:** -Repetitive hand-arm movements at Low (1-14 movements/min) and high (1-36 movements/min) rates [4] -Repetitive work for more than 4 hours a day in women aged between 45 – 59 years [5] - Repetitive movements of the wrist and hand (>2hr/day) for more than 14 years in the occupation examined [6] **Null or no association:** - Repetitive motions of hand and wrist (>2hr/day) for less than 14 years on the job [6] -Frequent shoulder movement of more than 10 times/min [7] -Working very fast for short periods [8]	Variable in results, wide confidence intervals with some associations indicating variability within the study. Heterogeneity between studies in methodology and how they defined RCS Differences in how repetition was measured	Slaughterhouse workers, nurses, home helpers, sewing machine operators, supermarket checkers, manual workers, food processing, textile plant and electronic plant workers, postal sorting centres, bank workers, construction, public administration, manufacturing, trade, real estate, hotel workers, restaurant workers, agriculture workers, education and community services, musicians (violin players), brick-layers, rock-blasters, foremen and other "working populations"
Posture	**Increased odds with:** -Shoulders in sustained postures of more than $45^0/60^0/90^0$ depending on study and duration (higher odds with longer time working with shoulders in sustained postures, please refer to outline of main results table) [5, 9] -Work with arms raised at ≥ 45° for more than 18% of working time [7]	Variable in results, wide confidence intervals with some associations indicating variability within the study. Heterogeneity between studies in methodology and how they defined RCS Results inconsistent between studies (e.g. studies show one gender has higher odds	Slaughterhouse workers, nurses, home helpers, sewing machine operators, supermarket checkers, manual workers, food processing, textile plant and electronic plant workers, postal sorting centres, bank workers, construction, public administration, manufacturing, trade, real estate,

	-Working with hand above shoulder level for more than 1 hour a day for over 1 year [6] -Working in same position for long periods (sitting, bent over, kneeling) [8] **Null or no association:** - Cumulative work above shoulder level of less than 3,200 hours [10] -Upper arm extension of less than 50 of flexion of more than 45^0 in males and females for less than 20% of their working time [11] - Reaching over head or away from body [8] -Working with arm elevation above 90^0 for 3 – 6% of work-time [12]	of RCS with variable but another investigating a similar variable did not find same result) Only cross-sectional studies included so causation cannot be insinuated with these results Null associations could be due to selection bias within the study or small datasets	hotel workers, restaurant workers, agriculture workers, education and community services, musicians (violin players), brick-layers, rock-blasters, foremen and other "working populations"
Force	**Increased odds with:** -High forces: • More than 10% maximal voluntary contraction [4] • With no pauses for more than 80% of cycle time [4]More than two hours a day in males [13] • Hand-grips in females [14] • More than five times a minute compared to 1 time a minute [7] **Null or no association:** - Working with high hand forces for more than 1 hour a day for less than 4 years performing the job [6] -High hand forces in males [14] -High pinch-grips [7]	Heterogeneity between studies in methodology and how they defined RCS Only cross-sectional studies included so causation cannot be insinuated with these results Differences in what muscles were measured with reference to shoulder disorders	Slaughterhouse workers, nurses, home helpers, sewing machine operators, supermarket checkers, manual workers, food processing, textile plant and electronic plant workers, postal sorting centres, bank workers, construction, public administration, manufacturing, trade, real estate, hotel workers, restaurant workers, agriculture workers, education and community services, musicians (violin players), brick-layers, rock-blasters, foremen and other "working populations"
Heavy physical	**Increased odds with:**	Heterogeneity between studies in	Slaughterhouse workers, nurses, home helpers, sewing machine

work	-Heavy lifting of more than 20kg more than 10 times a day for 4 – 13 years or 14 – 23 years [6] -Manual handling of loads more than 5kg or in another study more than 44.1N in women [11, 14] **Null or no association:** - Manual handling of loads in men [14] -Heavy lifting of more than 20kg more than 10 times a day for less than 4 years in the same/similar job [6] - Carrying, lifting or moving heavy materials and equipment [8]	methodology and how they defined RCS Only cross-sectional studies included so causation cannot be insinuated with these results Differences in what muscles were measured with reference to shoulder disorders	operators, supermarket checkers, manual workers, food processing, textile plant and electronic plant workers, postal sorting centres, bank workers, construction, public administration, manufacturing, trade, real estate, hotel workers, restaurant workers, agriculture workers, education and community services, musicians (violin players), brick-layers, rock-blasters, foremen and other “working populations”
Duration	**Increased odds with:** -longer durations worked (more than 5 to 20 years) [15] -Using hand tools for four or more hours a day [5] **Null or no association:** - Less than 15 years exposure [16] -Working with hand tools for less than 4 hours a day in women [5]	Only cross-sectional studies included so causation cannot be insinuated with these results Less heterogeneity between these studies	Manufacturing, healthcare, trade, restaurant workers, agriculture workers, education and community services, brick-layers, rock-blasters, foremen and other “working populations”
Vibration	**Increased odds with:** -Using hand-tools for more than 2 hours a day [5] -Handheld vibration (for more than 4.4 cumulative years on the job) [10] -Long durations (14-23 years) working with vibrating tools for more than two hours a day [6] **Null or no association:**	Only cross-sectional studies included so causation cannot be insinuated with these results Lower number of studies included	Manufacturing, trade, healthcare, restaurant workers, agriculture workers, education and community services, brick-layers, rock-blasters, foremen and other “working populations”

	- Long durations of working with vibrating tools (>2 hours a day) for less than 14 years [6]		
Combined Risk Factors			
Repetition and posture	**Increased odds with:** -Supraspinatus and infraspinatus tendonitis [17] -Performing work at 10 times a minute with arms raised to more than 30^0 for 48% of working time in current and former slaughterhouse workers [15] -Upper arm flexion of more than 45^0 for a high percentage of the time [7]	Mostly significant associations reported for this combination amongst lower grade cross-sectional studies Low number of studies	Manufacturing, trade, healthcare, working populations, industrial and non-industrial workers, farming, meat cutting, dentistry, hairdressing, Tradespeople, journeymen, machinists, mechanics, house painters
Duration and posture	**Increased odds with:** -Women working with their upper arms in more than 45^0 more than 18% of the time [11] **Null or no association:** -Working with upper arms elevated for more than 90^0 measured as a cumulative lifetime exposure [18]	Low number of studies that do not provide high quality levels of evidence Studies do not investigate whether at longer duration people with RCS just cannot work so the potential association cannot be measured with their criteria	Tradespeople, journeymen, machinists, mechanics, house painters, play shoulder intensive sports, manufacturing and healthcare
Repetition and force	**Increased odds with:** -High frequency and high force [4] -Frequent use high hand forces of more than 5-6 times a minute, especially in females [11] **Null or no associations:**	Low number of studies that do not provide high quality levels of evidence Available amount of evidence is insufficient	Tradespeople, journeymen, machinists, mechanics, house painters, play shoulder intensive sports, manufacturing and healthcare

	-With Low repetition or low force [4] -Frequency of forceful exertions are less than 5 times/min [11]		
Force and posture	**Increased odds with:** -Upper arm flexion of more than 45^0 for more than 15% of the time with forceful pinch grip in females [11]	Available associations derived from same data cohort used across two cross-sectional studies. This means the evidence is low level of quality and insufficient to draw a cohesive conclusion	Manufacturing or healthcare sectors
Force and vibration	No association found with vibration and forceful pinch grip for some of the time [11]	Available associations derived one cross-sectional study. This means the evidence is low level of quality and insufficient to draw a cohesive conclusion	Manufacturing or healthcare sectors
Posture, force and duration	**Increased odds with:** -Upper arm flexion of more than 45^0 for more than 15% at a duty cycle of more than 9% [7] - Upper arm flexion of more than 45^0 for me than 15% of the time with positive pinch-grip forces [7]	Available associations derived one cross-sectional study. This means the evidence is low level of quality and insufficient to draw a cohesive conclusion	Manufacturing or healthcare sectors

Single risk factors

Evidence for single risk factors in association with RCS is discussed in further detail in this section. The single risk factors outlined are repetition, posture, force, heavy physical work, duration and vibration use. Each section provides a brief description of findings from the AUT review followed by further primary and secondary evidence.

Repetition

The evidence provided by the AUT review concluded there is a weak to strong strength of association between RCS and repetitive shoulder movement. However this evidence was conflicting due to differences in how repetition was defined and measured between studies. The methods and findings of these studies are discussed further below and outlined in Table 3.

Nine cross-sectional studies and two prospective cohort studies investigated repetition within some capacity of their investigation. Six of these studies report a positive association between repetitive movements and RCS and heterogeneity between studies arose from differences in the outcome assessments; how repetitiveness was defined, if rotator cuff muscles were measured specifically (e.g. supraspinatus, infraspinatus) or generalised as one entity (e.g. Rotator Cuff tendinitis, RCS, shoulder tendinitis); how it was assessed and the occupation of participants (mostly manual working populations). These differences are the likely reasons for the conflicting results reported by the AUT review.

Positive associations are reported by five cross-sectional studies and one case-control study (Table 3). Some of the more notable findings included a positive dose response in a group of workers where the increase in the number of repetitions per minute increased with the association of RCS [(4)]. The association increased with duration in years[(6)] and increased with the duration per day the participants performed the task for [(5)]. Repetition and RCS also were reported to have a higher association in men [(5-6, 14)]. One study that measured rotator cuff disorders in specific muscles showed a positive association with supraspinatus tendonitis and a statistically insignificant association with infraspinatus tendonitis [(19)]. Other positive associations are reported in Table 3 but were reported to be statistically insignificant.

The evidence outlined in this report shows that repetitious upper-limb activities can increase the odds of RCS but is dependent on the context of the study, and how variables are measured and defined. There is evidence odds may increase with increases in activity and duration but differences across the study methodologies mean that the evidence can be conflicting as described by the AUT review. A brief overview of the evidence is outlined in Table 3 below and a more detailed description can be found in Appendix 5.

Table 3. Outline of main results for association between repetition and RCS

Authors	Study design	Outcome assessment	Risk factor	Risk estimate OR/PR(95%CI)
Frost 2002 [(4)]	CS	Shoulder tendinitis-Questionnaire, Work place assessments, Physical	▪ Repetitive hand-arm movements at work ▪ Low repetitive (1-14 shoulder movement/min) ▪ High repetitive (1- 36 shoulder movements/min)	OR[a]=3.12(1.33-7.34)* OR[a]=2.93(1.17-7.36)* OR[a]=3.29(1.34-8.11)*

		examination		
Frost 1999 [15]	CS	Shoulder impingement syndrome- questionnaire and physical examination	Repetitive work 10 times/minute (arms raised to ≥ 30° for 48% of working time) ▪ Current former slaughterhouse workers ▪ Former slaughterhouse workers	OR=5.27 (2.09-13.26) * OR=7.9 (2.94-21.18) *
Melchior 2006 [13]	CS	RCS- Questionnaire, physical examination for those participants with reported symptoms	Repetitive movements (>2 times /min; ≥ 4hr/day) ▪ With 10 min break hourly– male ▪ With 10 min break hourly – female ▪ Without break – male ▪ Without break – female	PR[b]= 2.12 (1.43–3.15) * PR[b]=1.83 (1.21–2.74) * PR[b]=1.83 (1.21–2.74) * PR[b]=2.57 (1.50–4.41)
Miranda 2005 [6]	CS	RCS- Questionnaire and health examination	Repetitive motion of the hand or the wrist (>2 h/day) 1-3 year vs. none ▪ total ▪ men ▪ women 4-13 year vs. none ▪ total ▪ men ▪ women 14-23 year vs. none ▪ total ▪ men ▪ women >23 year vs. none ▪ total ▪ men ▪ women	 OR[c]=1.6 (0.5-5.2) OR[c]=2.2 (0.5-10.5) OR[c]=0.8 (0.1-6.2) OR[c]=0.8 (0.3-2.1) OR[c]=0.6 (0.1-3.3) OR[c]=0.8 (0.2-2.9) OR[c]=2.4 (1.3-4.3) * OR[c]=2.5 (1.0-6.6) * OR[c]=2.0 (0.8-4.2) OR[c]=2.6 (1.4-4.9) * OR[c]=3.4 (1.3-9.1) * OR[c]=1.8 (0.8-4.2)
Ohlsson 1995 [19]	CS	Questionnaire and physical examination	• Supraspinatus tendonitis • Infraspinatus tendonitis	OR=8.75 (1.09-70.27) * OR=1.58 (0.13-17.77)
Rechardt 2010 [14]	CS	Rotator cuff tendinitis: Structured interview and clinical examination	Repetitive movements of the hands or wrists • Men: • Women	 OR=1.6 (0.9-2.5) OR=1.2 (0.7-1.9)
Silverstein 2006 [20]	CS	RCS -Interview, physical examination	Hand exertion frequency >20 times/min	OR=1.63 (0.69-3.82)
Silverstein 2008	CS	RCS -Interview, physical examination	Frequency of shoulder movement (times/min) • ≥10 to <20 times/min vs. <10 times/min • ≥20 times/min vs. <10 times/min	 OR[d]=1.76 (0.83-3.71) OR[d]=1.01 (0.43-2.38)
Silverstein 2009 [7]	CS	Same cohort as used in 2008 paper reported above	Frequency of shoulder movement (times/min) *Women* From 1 to 4 times /min More than 5 times/min *Men* From 1 to 4 times /min More than 5 times/min	 OR=1.5(0.63-4.84) OR=3.35(1.19-9.42) 1.05(0.41-2.71) 1.38(0.54-3.52)
Borstad 2009 [8]	PC	Subacromial impingement- Self-reported and confirmed by clinical examination	• Performing the same task over and over • Working very fast for short periods	OR=1.04 OR=0.97
Roquelaure 2011 [5]	CS	RCS- Extracted from surveillance data collected by Occupational Physicians	High Repetitiveness (≥4 hours/day) Men Women High Repetitiveness (≥4 hours/day) stratified by age: *Men* 20-44 years 45-59 years High Repetitiveness (≥4 hours/day) stratified by	 OR=2.3(1.6-3.3)* OR=2.2(1.5-3.1)* OR=2.4(1.3-4.4)* OR=1.0(0.5-1.9)

		age: *Women* 20-44 years 45-59 years	 OR=1.4(0.7-2.6) OR=2.0(1.1-3.5)*

[a] OR adjusted for: age, age squared, gender, shoulder injury, shoulder operation, physical activity during leisure time, overhead support, BMI, height and pressure algometry.
[b] OR adjusted for: age, obesity, diabetes, thyroid disease, arthritis and manual occupation
[c] OR adjusted for: age, gender
[d] OR adjusted for age and BMI
* Significant positive association
CS, cross-sectional study; PC. Prospective cohort

Posture

Evidence in the AUT review concluded there was conflicting evidence for an association between shoulder postures and RCS. This is likely due to differences in methodology and how posture was defined with individual studies. The methods and findings of these studies are discussed further below and findings are outlined in Table 4.

Ten cross-sectional studies reported a statistically significant positive association between shoulder posture and RCS. Participants within these studies were mainly from occupations that worked with their arms elevated so their shoulders were in flexed positions. Different shoulder angles and durations investigated between studies lead to general results being mixed (5-6, 13-14). Most studies showed that longer durations working with shoulders in an elevated position of more than 60^0 - 90^0 flexion, or above acromion height, increased the odds of RCS (5, 9, 12, 18). The evidence found indicates elevated postures are related to increased odds of RCS. However due to differences in methodologies and definitions between studies this evidence appears conflicting as described by the AUT review. Further descriptions of postures are provided in Table 4 and the evidence tables in Appendix 5.

Table 4. Outline of main results for association between posture and RCS

Authors	Study design	Outcome assessment	Risk factor	Risk estimate OR/PR(95%CI)
Bodin 2012 (9)	CS	RCS-Questionnaire, physical examination	Shoulder pain with RCS with sustained/repeated arm posture in abduction (for 2 or more hours a day): Men ▪ More than 60^0 ▪ More than 90^0 *Women* ▪ More than 60^0 ▪ More than 90^0	 OR=1.1(0.6-2.1) OR=2.4(1.4-4.1)* OR=1.8(1.0-3.4) OR=1.2(0.6-2.4)
Frost 1999 (15)	CS	Shoulder impingement syndrome-questionnaire and physical examination	Arms raised to ≥ 30° for 48% of working time for about 10 times/minute ▪ current slaughterhouse workers ▪ former slaughterhouse workers	 PR=5.27 (2.09-13.26) * PR=7.9 (2.94-21.18) *
Melchior 2006 (13)	CS	RCS-Questionnaire, physical examination for those participants with reported symptoms	Arm(s) above shoulder: <2 hours/day ▪ male ▪ female Arm(s) above shoulder: ≥ 2 hours/day ▪ male ▪ female Hand behind trunk posture: <2 hours/day	 PR[a]= 1.06 (0.67–1.67) PR[a]=1.21 (0.75–1.93) PR[a]=2.57 (1.67–3.97)* PR[a]=1.75 (1.09–2.83)* PR[a]=1.07 (0.68–1.68)

			▪ male ▪ female Hand behind trunk posture: ≥2 hours/day ▪ male ▪ female Arm(s) away from the body: <2 hours/day ▪ male ▪ female Arm(s) away from the body: ≥2 hours/day ▪ male ▪ female	PR^a=1.43 (0.88–2.32) PR^a=1.02 (0.44–2.36) PR^a=2.11 (1.13–3.93)* PR^a=1.49 (0.96–2.30) PR^a=1.23 (0.69–2.09) PR^a=1.42 (0.87–2.31) PR^a=2.13 (1.36–3.33)*
Miranda 2005 [(6)]	CS	RCS-Questionnaire and health examination	Working with hand above the shoulder level (≥ 1 hr/day) 1-3 year vs. none ▪ total ▪ men ▪ women 4-13 year vs. none ▪ total ▪ men ▪ women 14-23 year vs. none ▪ total ▪ men ▪ women More than23 year vs. none ▪ total ▪ men ▪ women	OR^b=2.4 (1.0-5.9) * OR^b=3.1 (1.1-8.4) * OR^b=1.0 (0.2-4.6) OR^b=3.2 (1.6-6.5) * OR^b=3.0 (1.2-7.7) * OR^b=2.2 (0.6-7.4) OR^b=4.7 (2.4-9.1) * OR^b=4.8 (1.9-12.1) * OR^b=4.4 (1.5-12.4) * OR^b=2.3 (1.1-4.9) * OR^b=2.3 (0.7-7.0) OR^b=2.5 (0.8-7.9)
Rechardt 2010 [(14)]	CS	Rotator cuff tendinits-Structured interview and clinical examination	Working with hands above the shoulder level • Male: • Female	OR=1.5 (0.9-2.3) OR=2.0 (1.3-3.1)*
Roquelaure 2011 [(5)]	CS	RCS-Extracted from surveillance data collected by Occupational Physicians	Shoulder pain with RCS with sustained/repeated arm posture in abduction (for 2 or more hours a day): Men (22-44 years) ▪ More than 60^0 ▪ More than 90^0 *Women (22-44 years)* ▪ More than 60^0 ▪ More than 90^0 Men (45-59 years) ▪ More than 60^0 ▪ More than 90^0 Women(45-59 years) ▪ More than 60^0 ▪ More than 90^0	OR=1.0(0.4-2.3) OR=2.5(1.1-5.7)* OR=2.2(1.0-5.1)* OR=2.2(0.8-5.7) OR=0.9(0.2-2.4) OR=2.2(1.1-4.4)* OR=1.5(0.6-3.3) OR=1.1(0.4-2.8)
Siedler 2011 [(10)]	CC	Supraspinatus tears-Radiologist records, interview	Cumulative work above shoulder level (total hours): • 0 to less than 610 hours • Between 610 to 3,195 hours • Between 2,195 hours to 64,057 hours	OR^d=1.0(0.6-1.8) OR^d=1.4(0.8-2.4) OR^d=2.0(1.1-3.5)*
Svendsen 2004a [(12)]	CS	Supraspinatus tendinits-Physical examination	Current upper arm elevation above 90^0 • 3-6% working hours • 6 – 9% working hours	OR=0.94(0.37 – 2.39) OR=4.7 (2.07 – 10.68)*
Svendsen 2004b [(18)]	CS	Supraspinatus tendinopathy-Questionnaire and MRI	Lifetime exposure to working with dominant arm elevated to greater than 90^0 (months) • Between 10 and 20 months • More than 20 months	OR^e=0.95(0.41-2.20) OR^e=2.38(0.93-5.84)

		exam	• Continuously in 5 month increments	OR[e] =1.27(1.20-1.60)*
Silverstein 2006 [20]	CS	RCS-Interview, physical examination	Upper arm abduction >60° for > 7% of time Upper arm flexion >45° for >4% of time	OR=0.62 (0.23-1.66) OR=1.21 (0.56-2.61)
Silverstein 2008 [7]	CS	RCS-Interview, physical examination	Upper arm flexion ≥45° • ≥18% of working time Upper arm extension >5° or flexion ≥45° • Between 20% and 35% of working time • ≥35% of working time	 OR[c]=2.16(1.22 – 3.83) * OR[c]=1.90(0.95-3.79) OR[c]=1.42(0.64-3.12)
Silverstein 2009 [11]	CS	RCS-Interview, physical examination	Upper arm flexion ≥ 45°(% time) • ≥ 18 vs. <18% time-female • ≥ 18 vs. <18% time-male Upper arm extension ≥5° or flexion ≥45° (% time) • 20 – 34 vs <20% time-female • 20 – 34 vs <20% time-male • ≥35 vs <20% time-female • ≥35 vs <20% time-male	 OR[c]=3.12(1.12-7.68)* OR[c]=1.63(0.76-3.51) OR[c]=6.16(1.76 – 21.57) * OR[c]=0.77(0.31-1.92) OR[c]=2.97(0.69 – 12.82) OR[c]=0.89(0.34-2.32)
Borstad 2009 [8]	PC	Subacromial impingement Self-reported and confirmed by clinical examination	•Working in awkward or cramped positions: •Working in same position for long periods (standing, sitting, bent over, kneeling): •Reaching over head or away from body:	OR= 1.01 OR =1.06 OR =0.84

* Significant positive association

[a] OR 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 posture

[b] OR adjusted for: age, gender

[c]OR adjusted for age and BMI

[d]OR adjusted for age, region, force and vibration

[e]OR adjusted for age

Force

The evidence interpreted by the AUT review concluded that the association between RCS and force ranged from weak to strong but that across studies the association of force with RCS trended towards a null, or non-association. These findings are discussed further below and are briefly outlined in Table 5.

Eight cross-sectional studies were included in this analysis. Six of these studies reported statistically significant associations ranging from weak (1.11)[13] to strong (4.48)[4] and used a range of definitions and methodologies for force. Force was measured at the shoulder [4, 13], in different hand and finger grips [6-7, 11, 14, 20] and lifetime shoulder force requirements [18]. Stronger associations were found with higher force requirements [4] however the majority of the reported associations were not statistically significant (see Table 5). Two studies reported a positive association between pinch and handgrips for women and non-associations for men [6, 11, 14]. In contrast two other studies reported positive associations between forceful shoulder movements [13] and high hand forces over a larger number of years [6] with men but not women. These studies show there are associations between force and RCS but that between studies these associations are not consistent.

Overall the majority of measures showed statistically non-significant associations as reported by the AUT review, trending towards a null/non-association. A summary of the odds ratios and variables measured for force are exhibited in Table 5 below.

Table 5. Outline of main results for association between force and RCS

Authors	Study design	Outcome assessment	Risk factor	Risk estimate OR/PR(95%CI)
Frost 2002 [(4)]	CS	Shoulder tendinitis- Physical examination	Force requirements ▪ Low force (<10% of maximal voluntary contraction) ▪ High force (≥10% of maximal voluntary contraction) High force and no pauses ▪ ≤80% of cycle time ▪ >80% of cycle time	 OR[a]=2.17 (0.84-5.59) OR[a]=4.21 (1.17-10.40)* OR[a]=4.48 (1.73-11.61)* OR[a]=3.45 (0.9-13.23)
Melchior 2006 [(13)]	CS	RCS Questionnaire, physical examination for those participants with reported symptoms	Forceful movements: <2 hours/day • Male: • Female Forceful movements: ≥2 hours/day • Male: • Female	 PR[b]= 1.09 (0.66–1.80) PR[b]=1.11 (0.66–1.84) PR[b]=1.65 (1.03–2.61)* PR[b]=1.03 (0.53–2.00)
Miranda 2005 [(6)]	CS	RCS- Questionnaire and health examination	Work requiring high hand force (>1 h/day) 1-3 year vs. none ▪ total ▪ men ▪ women 4-13 year vs. none ▪ total ▪ men ▪ women 14-23 year vs. none ▪ total ▪ men ▪ women >23 year vs. none ▪ total ▪ men ▪ women	 OR[c]=2.3 (0.9-6.3) OR[c]=2.3(0.6-8.2) OR[c]=2.5 (0.6-11.0) OR[c]=2.8 (1.4-6.0) * OR[c]=2.5 (0.8-7.1) OR[c]=3.6 (1.4-9.5)* OR[c]=3.7 (1.9-7.1) * OR[c]=4.7 (1.9-11.9) * OR[c]=2.2 (0.7-7.4) OR[c]=1.8 (0.8-4.1) OR[c]=2.3 (0.8-6.6) OR[c]=1.3 (0.4-4.7)
Rechardt 2010 [(14)]	CS	Rotator cuff tendinitis Structured interview and clinical examination	High handgrip forces • Male: • Female	 OR=1.6 (0.9-2.6) OR=1.9 (1.2-3.0)*
Silverstein 2006 [(20)]	CS	RCS- Interview, physical examination	Frequency high hand forces >6/min	OR=2.4 (1.14-5.03)*
Silverstein 2008 [(7)]	CS	RCS- Interview, physical examination	Forceful pinch-grip (time-weighted average) • >0% vs. 0% of time Frequency of forceful exertions • ≥1 to <5 times/min vs. <1 times/min • ≥5 times/min vs. <1 times/min	 OR[d]=1.72 (0.98-3.00) OR[d]=1.35 (0.68-2.71) OR[d]= 2.02 (1.01-4.07)*
Silverstein 2009 [(11)]	CS	RCS- Interview, physical examination	Forceful pinch-grip >0% vs. 0% of working time • Male: • Female	 OR[d]=1.09 (0.49-2.39) OR[d]=3.04 (1.32-7.01)*
Svendsen 2004b [(18)]	CS	Supraspinatus tendinitis -MRI and questionnaire	Lifetime shoulder force requirements • Medium vs. low • High vs. low	 OR[e] =1.24(0.48 – 3.18) OR[e] 0.71(0.30-1.65)

[a] OR adjusted for: age, age squared, gender, shoulder injury, shoulder operation, physical activity during leisure time, overhead support, BMI, height and pressure algometry.

[b] OR adjusted for: age, obesity, diabetes, thyroid disease, arthritis and manual occupation

[c] OR adjusted for: age, gender

[d] OR adjusted for age and BMI

[e] OR adjusted for age
* Significant positive association
CS, cross-sectional study

Heavy physical work

Evidence presented by the AUT review concluded no evidence for heavy physical work and RCS based on high quality studies that reported non-associations. However there is conflicting evidence from lower graded cross-sectional studies that show moderate evidence that physical work can be associated with RCS. The main findings of these studies are discussed further below and are briefly outlined in Table 6.

A total of eight cross-sectional and one prospective cohort studies report evidence for an association between heavy physical work load and RCS. There are differences in the methodologies and definitions that together provide conflicting evidence; however there is some conformity between studies. Two different studies report a weak to moderate positive association between high perceived workload and RCS (5, 9). Moderate to high associations were found for women performing heavy lifting tasks (6, 11). Men performing heavy lifting also had a positive association; however within this study there were no obvious trends as these associations did not increase with the duration tasks were performed for (6). As seen in Table 6 most associations were statistically insignificant, supporting the evidence presented by the AUT review that although positive associations exist for heavy physical workload and RCS the larger body of evidence suggests no association.

Table 6.Outline of main results for association between heavy physical work and RCS

Authors	Study design	Outcome assessment	Risk factor	Risk estimate OR/PR(95%CI)
Bodin 2012 (9)	CS	RCS-Questionnaire, physical examination	High perceived physical demand (Borg Scale rating greater or equal to 13)	OR=2.2(1.4-3.4)*
Borstad 2009 (8)	PC	Subacromial impingement-Self-reported and confirmed by clinical examination	• Carrying, lifting, or moving heavy materials/equipment	OR=1.14
Miranda 2005 (6)	CS	RCS-Questionnaire and health examination	Heavy lifting (>20 kg,>10 times/day)	
			1-3 year vs. none	
			▪ total	OR[a]=1.5(0.6-4.1)
			▪ men	OR[a]=1.4(0.5-4.5)
			▪ women	OR[a]=1.2 (0.2-9.2)
			4-13 year vs. none	
			▪ total	OR[a]=3.0 (1.6-5.8) *
			▪ men	OR[a]=1.6 (0.6-4.1)
			▪ women	OR[a]=6.0 (2.8-12.6)*
			14-23 year vs. none	
			▪ total	OR[a]=2.8 (1.4-5.7) *
			▪ men	OR[a]=3.2 (1.4-7.5) *
			▪ women	OR[a]=1.8 (0.4-6.9)
			>23 year vs. none	
			▪ total	OR[a]=1.8 (0.8-4.2)
			▪ men	OR[a]=1.6 (0.6-4.6)
			▪ women	OR[a]=2.3 (0.6-8.8)
Rechardt 2010 (14)	CS	Rotator cuff tendinitis Structured	Manual handling of loads (RCS tendinitis) Men ▪ 5 kg or more	OR=1.2(0.7-2.0)

		interview and clinical examination	▪ 20 kg or more Women ▪ 5 kg or more ▪ 20 kg or more	OR=1.4(0.8-2.2) OR=1.8(1.1-2.9)* OR=2.6(1.6-4.0)*
Roquelaure 2011 [5]	CS	RCS-Extracted from surveillance data collected by Occupational Physicians	High perceived workload (RPE scale) ▪ Men ▪ Women	 OR=2.6(1.8-3.9)* OR=1.6(1.1-2.4)*
Silverstein 2006 [20]	CS	RCS-Interview, physical examination	Heavy lifting (time-weighted average > 44.1N)	OR=0.92 (0.31-2.75)
Silverstein 2008 [7]	CS	RCS-Interview, physical examination	Heavy lifting (time-weighted average > 44.1N) • >0% vs. 0% of time	 OR[b]=1.79 (0.95-3.38)
Silverstein 2009 [11]	CS	RCS-Interview, physical examination	Heavy lifting (time-weighted average > 44.1N)- >0% vs. 0% of time • Male: • Female	 OR[b]=0.85 (0.37-1.93) OR[b]=3.76 (1.46-9.68)*
Stenlund 1993 [21]	CS	Shoulder tendinitis - Questionnaire, physical examination	Lifted load 0-709,710-25999>25999 • Left • Right • Left • Right	 OR[c]=1.55 (0.58-4.12) OR[c]=1.04 (0.50-2.18) OR[d]=1.81 (0.95-3.44) OR[d]=1.02 (0.59-1.75)

[a] OR adjusted for: age, gender

[b] OR adjusted for age and BMI

[c] OR adjusted for age, dexterity, smoking and sports activities

[d] OR adjusted for sports activities

* Significant positive association

CS, cross-sectional study; PC, prospective cohort study; RPE, rate of perceived exertion scale (Borg scale)

Duration

The AUT review reported the evidence showed an increase in odds of RCS with an exposure of equal to, or greater than ten years. Again, differences were found between the studies in methodology and definitions, contributing to the conflicting consistency of association reported in this review. The main findings of these studies are discussed further below and are briefly outlined in Table 7.

The five cross-sectional studies outlined in Table 7 show significant moderate to strong associations between duration and the odds of RCS. These associations were reported over different durations: years of exposure [15-16, 22]; hours per day [5] or weeks [23]. Longer duration in some studies showed a stronger association [5, 16, 22-23], however some results were variable [16]. Overall (as seen in Table 7), all studies found significant positive associations with longer durations and RCS supporting the conclusions made by the AUT review.

Table 7. Outline of main results for association between duration and RCS

Authors	Study design	Outcome assessment	Risk factor	Risk estimate OR/PR(95%CI)
Andersen 1993 [16]	CS	RCS-Physical examination	• 0-7 years exposure • 8-15 years exposure • >15 years exposure	OR = 1.20 (0.07-20.43) OR = 7.58 (0.84-68.46) OR = 10.56 (1.26-88.19)*
Baron 1991 [23]	CS	Shoulder cumulative	Hours per week working as checkout operator • working 20-25 hrs/wk vs.<20 hrs/wk	 OR[b] =0.9

		trauma - questionnaire and physical examination	• working >25 hrs/wk vs.<20 hrs/wk	OR[b] =3.5*
Frost 1999 [15]	CS	Shoulder impingement syndrome- questionnaire and physical examination	• 5 years worked • 10 years worked • 15 years worked • 20 years worked	PR=6.7 (3.9-11.2)* PR=7.2 (4.3-12.2) * PR=6.7 (3.9-10.9) * PR=6.1 (3.7-9.9) *
Kaergaard 2000 [22]	CS	RCS-Clinical examination	• 2-10 years • 10-20 years • > 20 years	OR = 0.55 (0.07-4.48), OR = 2.77 (0.81-9.48) OR = 6.84 (2.46-19.04)*
Roquelaure 2011 [5]	CS	RCS- Extracted from surveillance data collected by Occupational Physicians	Use of handtools *Men* • Less than 2 hours a day • 2- 4 hours a day • Four or more hours a day *Women* • Less than 2 hours a day • 2- 4 hours a day • Four or more hours a day	 OR=1.7(1.3-3.0)* OR=1.7(1.1-2.8)* OR=1.8(1.2-2.9)* OR=0.9(0.5-1.8) OR=1.5(0.9-2.5) OR=2.0(1.3-3.2)*

[a] OR adjusted for: age, gender

[b] OR adjusted for working a second job

* Significant positive association

CS, cross-sectional study

Vibration

The AUT review concluded there is weak to moderate strength of association between RCS and vibration. As seen in Table 8, how vibration was measured and outcome assessments were defined differed, leading to the evidence appearing as conflicting across studies.

From the four cross-sectional studies and one case-control study included in this report positive associations were found between RCS and using vibrating tools (mostly handheld). Vibration through the hand was associated with supraspinatus tears from a comparatively short (0-4.4 years) to very long durations (51.6 years) however this study did not state at which point the tear occurred between participants [10]. A stronger association was found for the left shoulder than the right, however in this study only 1 – 3.7% of participants were left-handed which may have affected the results [10]. Working with a vibrating tool for more than two hours a day for more than 14 years in a job was associated with RCS [6]. However no association was found at more than 23 years in this cohort; as discussed in the study this could be due to people with RCS being unable to continue working for this length of time rather than RCS not being associated with this variable [6].

Table 8. Outline of main results for association between vibration and RCS

Authors	Study design	Outcome assessment	Risk factor	Risk estimate OR/PR(95%CI)
Miranda 2005 [6]	CS	RCS- Questionnaire and health examination	Working with a vibrating tool (>2 h/day) 1-3 year vs. none total men 4-13 year vs. none total men 14-23 year vs. none total men	 OR[a]=0.6(0.1-4.6) OR[a]=0.8(0.1-6.1) OR[a]=2.5 (1.0-5.9) OR[a]=2.7 (1.0-7.2) OR[a]=3.5 (1.5-7.8) * OR[a]=4.2 (1.8-9.8) *

			>23 year vs. none total men	OR[a]=1.4 (0.5-4.4) OR[a]=1.8 (0.6-5.9)
Rechardt 2010 (14)	CS	RCS- Structured interview and clinical examination	Using vibrating tools • Male • Female	OR=1.1 (0.6-1.9) OR=2.4 (1.1-5.5)*
Roquelaure 2011 (5)	CS	RCS- Extracted from surveillance data collected by Occupational Physicians	Use of vibrating hand-tools for 2 or more hours a day • Male • Female	OR=1.7(1.1-2.5)* OR=2.3(1.1-4.8)*
Seidler 2011 (10)	CC	Supraspinatus tear- Radiologist records, interview	Handheld vibration (for cumulative years on the job) • 0-4.4 years • 4.4 to 16 years • 16 to 51.6 years	OR[e]=2.7(1.3-5.6)* OR[e]=3.1(1.5-6.1)* OR[e]=3.2(1.7-5.9)*
Stenlund 1993 (21)	CS	Shoulder tendinitis - Questionnaire, physical examination	Vibration for between 0 to 8,999 hours, 9,000 to 255,199 hours, or more than 255,199 hrs • Left • Right *OR adjusted for sports activities out of work* • Left • Right	OR[b]=2.49(1.06-5.87)* OR[b]=1.04(0.5-2.18) OR[c]=2.49(1.06-5.87)* OR[c]=1.86(1.00-3.44)*
Sutinen 2006 (24)	CS	RCS- physical examination	Lifelong vibration energy	OR[d]=1.04 (1.00-1.07) *

[a] OR adjusted for: age, gender
[b] OR adjusted for age, dexterity, smoking and sports activities
[c] OR adjusted for sports activities
[d] OR adjusted for age, BMI, smoking
[e]OR adjusted for age, geographic region and other variables examined that are not vibration (i.e. force and posture)
* Significant positive association
CS, cross-sectional study; PC, prospective cohort study

Combined Risk Factors

Across the studies the risk factors were combined in different configurations to fit the work-tasks examined for evidence of their association with RCS. This section provides a brief description of the findings presented within the AUT review followed by further evidence. The combined risk factors included in this section are: force and repetition; force and posture; repetition and posture; force, posture and duration; heavy physical work and repetition; and force and vibration.

Repetition and Posture

The AUT review reported the findings of one cross-sectional review that showed a moderate to strong association between RCS and repetition with posture. These associations were considered "insufficient" because the findings were based on only one study (17). Further evidence is outlined in Table 9 below.

The results of three cross-sectional studies are included in Table 9. Each reports different risk factors that can be included within the repetition and posture spectrum. Prevalence ratios indicate that both supraspinatus and infraspinatus muscles can be affected by this combination (17) and postures where the upper arm is raised for a higher amount of time show increased odds of repetition and posture with RCS (7, 15). All of these studies show increased odds of repetition and posture with RCS; however the number of studies that can be included in this analysis is considered insufficient as reported by the AUT review.

Table 9. Outline of main results for association between vibration and posture with RCS

Authors	Study design	Outcome assessment	Risk factor	Risk estimate OR/PR(95%CI)
Nordander 2009 [17]	CS	Supraspinatus tendonitis and infraspinatus tendonitis-Physical examination and questionnaire	Supraspinatus tendonitis • Male • Female Infraspinatus tendonitis • Male • Female	 PR=2.7 (1.3-5.4) * PR=2.5 (1.4-4.2)* PR=4.0 (1.6-9.9)* PR=3.1 (1.6-6.4)*
Frost 1999 [15]	CS	Shoulder impingement syndrome- questionnaire and physical examination	Repetitive work 10 times/minute (arms raised to ≥ 30° for 48% of working time) ▪ Current former slaughterhouse workers ▪ Former slaughterhouse workers	 OR=5.27 (2.09-13.26) * OR=7.9 (2.94-21.18) *
Silverstein 2008 [7]	CS	RCS- Interview, physical examination	Upper arm flexion $\geq 45^0$ and duty cycle of forceful exertion (% time) • Intermediate† • High-High	 OR=2.14(0.94-4.89) OR=2.59(1.12-6.01)*

* Significant positive association

† Threshold limits for activity determined by ergonomists conducting workplace assessments

CS, cross-sectional study

Duration and posture

Duration and posture was not reported a combined risk factor in the AUT review however three cross-sectional studies were identified for this report. Across these studies different methodologies and measures were used. As seen in Table 10 most of the reported associations were non-significant, however it should be noted that there is limited evidence for this combination of risk factors.

Table 10. Outline of main results for association between duration and posture with RCS

Authors	Study design	Outcome assessment	Risk factor	Risk estimate OR/PR(95%CI)
Svendsen 2004a [12]	CS	Supraspinatus tendinitis -MRI and questionnaire	Upper arm elevation >90° as lifetime exposure (months) • 6-12 months vs. 0-6 months • 12-24 months vs. 0-6 months • >24 months vs. 0-6 months • Trend analysis (increment of 6 months)	 OR[a]=0.73 (0.27-1.94) OR[a]=1.30 (0.57-2.99) OR[a]=1.87 (0.79-4.44) OR[a]=1.14 (0.97-1.35)
Svendsen 2004b [18]	CS	Supraspinatus tendinitis -MRI and questionnaire	Upper arm elevation >90° as lifetime exposure (months) • 10 to <20 months vs. 0 to <10 months • ≥20 months vs. 0 to <10 months • Continuous (5 month increment)	 OR[b]=0.95 (0.41-2.20) OR[b]=2.33 (0.93-5.84) OR[b]=1.27 (1.02-1.60)*
Silverstein 2009 [11]	CS	RCS- Interview, physical examination	Upper arm flexion $\geq 45^0$ (% time) for less than 18% compared against more than 18% of the time • Women • Men	 OR=3.12(1.12-7.68)* OR=1.63(0.76-3.51)

[a]OR adjusted for age and smoking

[b] OR adjusted for age

* Significant positive association

CS, cross-sectional study

Repetition and force

The AUT review reported there was weak to strong positive association for repetition and force with RCS. The consistency of association was deemed limited because of the low number of studies. For this report the data from the same four cross-sectional studies are reported in Table 11. How the risk factors were defined, measured and reported differed between studies although statistically significant positive associations with RCS were found for high frequency and high force [15] or high hand forces used more than five or six times a minute [7, 11, 20]. As reported by the AUT review the evidence is limited and it should be noted that within this evidence three papers [7, 11, 20] all analysed the same data group, but categorised the data differently across the papers.

Table 11. Outline of main results for association between repetition and force with RCS

Authors	Study design	Outcome assessment	Risk factor	Risk estimate OR/PR(95%CI)
Frost 2002 [4]	CS	Shoulder tendinitis- Physical examination	▪ High frequency and high force ▪ High frequency and low force ▪ Low frequency and high force	OR[a]=4.82 (1.86-12.51)* OR[a]=1.73 (0.56-5.33) OR[a]=2.89 (0.77-10.77)
Silverstein 2006 [20]	CS	RCS- Interview, physical examination	Frequency high hand forces >6/min	OR=2.4 (1.14-5.03)*
Silverstein 2008 [7]	CS	RCS- Interview, physical examination	Frequency of forceful exertions ≥1 to <5 times/min vs. <1 times/min ≥5 times/min vs. <1 times/min	 OR[b]=1.35 (0.68-2.71) OR[b]= 2.02 (1.01-4.07)*
Silverstein 2009 [11]	CS	RCS- Interview, physical examination	Frequency of forceful exertions ≥1 to <5 times/min vs. <1 times/min • Male • Female Frequency of forceful exertions ≥5 times/min vs. <1 times/min • Male: • Female	 OR[b]=1.09 (0.49-2.39) OR[b]=3.04 (1.32-7.01) OR[b]=1.38 (0.54-3.52) OR[b]=1.38 (0.54-3.52)*

[a] OR adjusted for: age, age squared, gender, shoulder injury, shoulder operation, physical activity during leisure time, overhead support, BMI, height and pressure algometry.
[b] OR adjusted for age and BMI
* Significant positive association
CS, cross-sectional study

Force and posture

The AUT review reported a moderate to strong association between posture and force with RCS. However this association was reported by only one cross-sectional study so was regarded as insufficient. In this report the two cross-sectional studies reviewed (including the study reported by AUT) use the same cohort [7, 11]. For the initial study, statistically significant increased odds were found for force and posture in relation to RCS when high force and more extreme postures were used (upper arm flexion of 45^0 or more) [7]. In the second study the same data and variables were separated into male and female [11]. Separating the data based on gender showed mostly non-significant associations; the only significant associations found were in women performing tasks with the upper limb in at least 45^{0} flexion using pinch grips [11]. As only two studies that use the same dataset investigated effects of these variables, the data is limited which is in agreement with the AUT review.

Table 12. Outline of main results for association between posture and force with RCS

Authors	Study design	Outcome assessment	Risk factor	Risk estimate OR/PR(95%CI)
Silverstein 2009 [11]	CS	RCS- Interview, physical examination	Upper arm flexion ≥45°: ≥15% of time **or** forceful pinch grip vs. <15% of time and no forceful pinch grip • Male • Female	 OR[a]=0.71 (0.29-1.75) OR[a]=2.48 (0.66-9.41)
			Upper arm flexion ≥45°: ≥15% of time **and** forceful pinch grip vs. <15% of time and no forceful pinch grip • Male • Female	 OR[a]=2.48 (0.66-9.41) OR[a]=7.06 (1.94-25.66)*
			Upper arm flexion/abduction ≥45°: ≥20% of time **or** forceful pinch grip vs. <20% of time and no forceful pinch grip • Male • Female	 OR[a]=1.25 (0.43-3.63) OR[a]=0.62 (0.26-1.48)
			Upper arm flexion/abduction ≥45°: ≥20% of time **and** forceful pinch grip vs. <20% of time and no forceful pinch grip • Male • Female	 OR[a]=1.22 (0.45-3.31) OR[a]=3.72 (1.28-10.81)*
Silverstein 2008 [7]	CS	RCS- Interview, physical examination	Upper arm flexion ≥45° and duty cycle of forceful exertion (% time) • Intermediate vs. low-low • High-High vs. low-low	 OR=2.14(0.94-4.89) OR=2.59(1.12-6.01)*
			Upper arm flexion ≥45° and pinch grip force (% time) • Intermediate vs. low-low • High-High vs. low-low	 OR=1.09(0.53 – 2.25) OR=2.75(1.32-5.73)*
			Upper arm extension >5° or upper arm flexion ≥45° and pinch grip force(% time) • Intermediate vs. low-low • High-High vs. low-low	 OR=0.81(.40-1.64) OR=2.21(1.09-4.49)*
			Upper arm flexion or abduction ≥45° and duty cycle of forceful exertion (% time) • Intermediate vs. low-low • High-High vs. low-low	 OR=2.41(1.1-4.94)* OR=1.33 (0.57-3.11)
			Upper arm flexion or abduction ≥45° and pinch grip force (% time) • Intermediate vs. low-low • High-High vs. low-low	 OR=0.81(0.42-1.57) OR=2.02(1.00-4.1)*

[a] OR adjusted for age and BMI

* Significant positive association

CS, cross-sectional study

Force and vibration

Force and vibration was not reported on by the AUT review. Analyses for this report was found for one cross-sectional study that reported mostly non-significant associations between force and vibration with RCS (see Table 13 below). However this data is insufficient as only one study was found that examined these variables.

Table 13. Outline of main results for association between posture and vibration with RCS

Authors	Study design	Outcome assessment	Risk factor	Risk estimate OR/PR(95%CI)
Silverstein 2009 [(11)]	CS	RCS-Interview, physical examination	Vibration **or** forceful pinch grip >0% of time vs. no vibration and no forceful pinch grip • Male • Female Vibration **and** forceful pinch grip >0% of time vs. no vibration and no forceful pinch grip • Male • Female	 OR[a]=1.33 (0.61-2.90) OR[a]=2.83 (1.16-6.88)* OR[a]=1.98 (0.22-18.13) OR[a]=4.80 (0.90-25.77)

[a] OR adjusted for age and BMI

* Significant positive association

CS, cross-sectional study

Posture, force and duration

The AUT review reported results from one cross-sectional study for these variables as shown in Table 14 below. As only one study was found for the review and this report, data for these variables is insufficient. This study shows is there is significant and moderately strong evidence for an association between RCS with the combination of posture, force and duration within the participant group examined by this study [(7)].

Table 14. Outline of main results for association between posture, force and vibration with RCS

Authors	Study design	Outcome assessment	Risk factor	Risk estimate OR/PR(95%CI)
Silverstein 2008 [(7)]	CS	RCS-Interview, physical examination	Upper arm flexion ≥45° and duty cycle of forceful exertion (% time) • Flexion ≥ 15% **or** duty cycle <9% • Flexion ≥15% **and** duty cycle ≥9% Upper arm flexion ≥45[0] and pinch grip force (% time) • Flexion ≥15% OR pinch >0% • Flexion ≥15% AND pinch >0%	 OR[a]=2.14(0.94-4.89) OR[a]=2.59(1.12-6.01)* OR[a]=1.09(0.53 – 2.25) OR[a]=2.75(1.32-5.73)*

[a] OR adjusted for age and BMI

* Significant positive association

CS, cross-sectional study

Limitations to the evidence base

The evidence base is of low to moderate quality because most of the evidence came from cross-sectional studies. Two higher quality prospective cohort studies are included; however they only provided evidence for the single risk factors rather than combined risk factors. For the combined risk factors evidence was primarily drawn from three cross-sectional studies that used the same participant cohort [7, 11, 20] making this evidence limited. There was a lack of consistency in how the physical risk factors were defined and measured. However although there is heterogeneity across studies in methodologies, leading to the lack in consistent evidence for these risk factors, there is evidence that physical risk factors are linked to RCS.

Aside from quality of evidence the definitions of what was considered under the RCS umbrella by the AUT review were broad. Studies included within the review examined the shoulder in general which may inadvertently include non-rotator cuff muscles, some measured two rotator cuff muscles (supraspinatus and infraspinatus) and some only examined associations of the risk factors with one rotator cuff muscle (usually supraspinatus). As these muscles have different actions they will be affected differently by individual risk factors leading to variation within data.

Given the relative lack of prospective cohort studies, when considering the causation of RCS for individual claim wider considerations such as the Bradford-Hill Criteria, the specifics of the case, and expert opinion should be taken into account.

Conclusions

The extent of literature that investigates the role of physical risk factors in the development of rotator cuff related disorders is large. However there is wide variation in how these risk factors are defined and measured and variation in what components of the rotator cuff are measured in these analyses. This has led to considerable heterogeneity in the evidence for each physical risk factor, which was interpreted by the AUT review as “conflicting”. The evidence is more limited for the combined risk factors than the single risk factors, with between one to three papers found for each combined risk factor that was interpreted by the AUT review as “insufficient”. Most studies reported were cross-sectional in design and possessed limitations that make them open to potential sources of bias and only provide information about a link to RCS but not whether the risk factor causes RCS.

Insufficient and conflicting evidence from heterogeneity in the diagnostic criteria used across studies makes it difficult to draw strong conclusions for interpreting the association between physical risk factors and RCS. There are trends to be seen within studies for some of the risk factors but these are not consistent between studies. Notable trends were increased odds of RCS with elevated postures, longer durations and repetitive movements. However as the shoulder is a complex joint with multiple muscles and planes of movement there are many variables that can lead to injury making it hard to classify which specific risk factors will lead to RCS. Thus it is not surprising that this heterogeneity exists when interpreting inconsistency across the results reported in these studies.

Recommendations for the WRGDPI team when considering physical risk factors and RCS

When using the evidence in this report to assist decision-making, it is important to understand that the majority of evidence included in this report is variable, is of low to moderate quality and does not prove causation of RCS, only a link between that risk factor and RCS.

For individual claims other guidance such as the Bradford-Hill Criteria and the specifics of the case should be considered in conjunction with this evidence to ensure the best decision is made.

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Appendix 1. Project background

Background

ACC Research was commissioned by the Work-Related Gradual Process Diseases and Infections (WRGPDI) team to provide them with a brief report to support day-to-day decision-making as they carry out case assessments. The report uses an evidence-based approach to summarise the evidence regarding the relationship between specific occupational risk factors and rotator cuff syndrome (RCS). The purpose of this report is to provide decision-making support to the WRGPDI team and, in particular, to summarise and explain the current evidence regarding RCS and occupational risk factors across multiple studies. Additional information is included in other resources used by the team, including a quick reference decision-support spreadsheet.

AUT Investigation Analysis

In 2009, a group of researchers specialising in occupational health at Auckland University of Technology (AUT) were commissioned by ACC to complete a series of independent systematic reviews of the risk factors associated with 16 gradual process conditions, including rotator cuff syndrome(2). The authors searched an extensive set of databases up to October 2010 and all relevant cross-sectional, case-control and cohort studies meeting inclusion criteria were appraised for quality. Studies which did not meet a pre-determined quality assessment score were excluded from further analysis, the remaining studies were summarised in evidence tables and summary data was extracted. Due in part to the methodology utilised in these reviews and the presentation and length of the final reports, ACC Research was requested to complete a brief narrative report describing the findings of the primary studies included in the AUT report, and any additional studies which had been published subsequently.

Horizon Scanning for future upper limb disorder research

A large multi-centre prospective cohort study of distal upper-extremity musculoskeletal disorders also known as the WISTAH hand study started in 2012 (25). Two purposes of this study are to quantify the risks of upper limb disorders, including RCS, and to address weaknesses seen in prior research studies.

For this study over 1,000 workers from 17 different employment settings have been recruited. The settings include: (i) poultry processing, (ii) manufacturing and assembly of animal laboratory testing equipment, (iii) small engine manufacturing and assembly, (iv) small electric motor manufacturing and assembly, (v) commercial lighting assembly and warehousing, (vi) electrical generator manufacturing and assembly, (vii) metal automotive engine parts manufacturing (three facilities), (viii) plastic and rubber automotive engine parts manufacturing and assembly (ix) red meat processing, (x) apparel manufacturing, (xi) office work, (xii) cabinet manufacturing, (xiii) airbag manufacturing, (xiv) light valve assembly, and (xv) small metal parts fabrication. The aim of including this distribution was to include participants with low, medium and high physical demands at work.

One paper from this study has been published (26). However the focus of this study is carpal tunnel syndrome but not rotator cuff syndrome so does not add to this brief report(26). No further information was available regarding future publications from this study.

Measures

The relationship between RCS and occupational risk factors was most commonly reported as odds ratios. This is because of the nature of the research base (cross-sectional or case-control studies which are conducted at a point in time, rather than prospective studies conducted over a prolonged period). An odds ratio reports the likelihood of an outcome being present (e.g. tenosynovitis) when a particular exposure (e.g. forceful work) has been present, compared with the probability of the outcome being present when the exposure has not been present (27).

If the odds ratio is 1 then the outcome is equally as likely in the exposed group as the non-exposed group. If the odds ratio is greater than 1, then the outcome occurs more often in the exposed group. If it is less than 1, it occurs more often in the non-exposed group. The higher the odds ratio, the stronger is the association between the exposure and the outcome. The 95% confidence interval (95% CI) measures the precision of the odds ratio – wide confidence intervals indicate a low level of precision. It is important to note that odds ratios report probability based on association at a point in time. Using the odds ratio (OR) as a proxy for Relative Risk (RR) is based on an assumption that any such association arises because of a causal link, and this assumption cannot always be relied on.

The use and interpretation of odds ratios has been debated extensively in the literature, especially when compared with the use of relative risk (27). It is emphasised in the literature that the odds ratio is not a representation of risk, but of probability or odds, and that this can make it more difficult to interpret (28). The use of odds ratios has been criticised for exaggerating the strength of association between an exposure and an outcome when it is applied as a measure of risk. When an outcome is rare (initial risk <10% in both the exposed and non-exposed groups), for instance in the case of RCS where the prevalence in the normal population is estimated to be 1.3%, the odds ratio is said to be a valid approximation of the true relative risk and the strength of the association can be interpreted accordingly. However, as the prevalence of the outcome increases, the odds ratio moves further away from the true relative risk. Whereas the accepted relative risk cut-off for determining whether an outcome can be attributed to a particular exposure is >2.0 (29), the cut-off for odds ratios is not clear and depends on the prevalence of the outcome.

Appendix 2. Methodology of included studies

Outline of methodology of included studies

Andersen et al (1993) A cross-sectional study compared the prevalence of musculoskeletal disorders of the neck and upper limb in 82 sewing machine operators with 25 auxillary nurses or home helpers ('control group'). These participants were randomly selected from a cohort of 424 sewing machine operators and 55 auxillary nurses/home helpers who answered a questionnaire in 1987. Three groups of sewing machine operators were formed based on duration of employment and stratified by age: 0-7 yrs (n=21), 8-15 yrs (n=25), and >15 yrs (n=36). Rotator cuff syndrome was defined as: self-reported chronic shoulder pain (i.e. continuous pain lasting ≥1 month after work debut and pain episode of ≥30 days within the last year) and tenderness (graded 3/4 to 4/4) at the greater humeral tubercle and positive pain-arc or impingement sign (i.e. pain on passive abduction when rotation of scapula is fixed). Rotator cuff syndrome was found in 18 sewing machine operators and one auxillary nurse/home helper.

Level of evidence: 2-

Baron et al (1991) A cross-sectional study compared the prevalence of cumulative trauma disorders (CTD) of the neck and upper limb in 119 female checkers with 56 female non-checkers from 4 supermarkets in US. The medical and epidemiological data were collected using a detailed questionnaire (any pain, aching, stiffness, burning, numbness, or tingling during past year of neck, shoulder, elbow, hand, or back; work history, hobbies, second job, acute injuries, and other medical problems) and standardized physical examinations (blind to job title and questionnaire results). The participant was considered to have a work-related CTD if there were both complaints on questionnaire and a positive physical examination of particular part of the body. The physical examination case definition of shoulder CTD was pain on resisted abduction and/or deltoid palpation (rotator cuff), pain on Yergason's maneuver (bicipital tendinitis). A positive pain response was considered greater than 1 (0-5) on a grading of pain. The shoulder CTD was found in 17 female checkers and 2 female non-checkers.

Level of evidence: 2-

Bjelle et al (1979) A case-control study that included 20 consecutive male patients with chronic shoulder pain (>3 months) resistant to conventional medical treatment and/or physiotherapy from a total of 2500 employees at three machine ships, two pulpmills, and a sawmill. 40 manual workers (matched for age, sex, and workshop) and 9 industrial workers were included as a control groups. All patients were subjected to extensive medical examination, and both patients and their matched referents underwent an ergonomic evaluation regarding to working posture and workload. Three of the cases were found to have inflammatory rheumatoid disease, and12 of the final 17 (71%) had signs of bicipital tendinitis and/or supraspinatus tendinitis.

Level of evidence: 2-

Bodin et al (2012) A prospective cohort study that assessed the work-related factors for the incidence of RCS in a cohort of 1456 French workers (839 men & 617 women). Participants were part of an original cohort of 3710 workers selected randomly from workers undergoing mandatory annual health examination by an occupational physician between 2002 and 2005. All participants were followed up between 2007 and 2010. Incident cases of RCS were defined as workers free of RCS at baseline with diagnosed RCS at follow-up. A self-reported questionnaire was used to collect information on musculoskeletal symptoms and their working activities during a typical working day, which included repetitive work, working posture and use of vibrating tools. RCS was diagnosed in 51 men (6.1%) and 45 women (7.3%) via a physical examination conducted by an occupational physician.

Level of evidence: 2-

Borstad et al (2009) A prospective cohort examined work-related factors and shoulder pain onset over 2 years in a cohort of 240 construction apprentices from sheet metal, electrical, plumbing, and pipe-fitting trades from 16 classes. 13% (32/240) of the participants were loss to follow-up. Work-related risk factors were gathered using a self-reported survey and a questionnaire. Work-related risk factors included repetitive movement, working posture, heavy physical work and duration of work. New onset shoulder pain (a new "case") was defined as shoulder pain consistent with shoulder impingement reported and confirmed by clinical examination at year 1 and 2 by a subject who did not report shoulder pain at baseline. 30 subjects had new-onset shoulder pain that were confirmed by a clinical examination at either year 1 or year 2.

Level of evidence: 2-

Bovenzi et al (1991) A case-control study compared the prevalence of neck and upper limb musculoskeletal disorders in 65 vibration-exposed forestry operators using chainsaws with 31 maintenance workers (mechanics, electricians and painters) not exposed to vibration. Information about the participants and clinical evaluation of musculoskeletal disorders was gathered through a combination of medical interview, and physical examination. Physical work-related risk factors were collected through direct observation at the worksites and included posture, force and repetitiveness. Vibration measurement was made on the handles of 2 types of chainsaw. Supraspinatus tendinitis was diagnosed in 10 forestry workers (15.4%) and 0 control (0%).

Level of evidence: 2-

Frost et al (1999) A cross-sectional study compared the prevalence of shoulder impingement syndrome in currently working slaughterhouse workers with former slaughterhouse workers employed between 1986 and 1993. The study included 1591 subjects still alive and living in Denmark with ≥6 months of employment in the chosen period. The information on employment and musculoskeletal disorders was obtained via questionnaire and ergonomic observations of tasks. Subjects with self-reported shoulder symptoms were selected for standardised physical examinations. Criteria for shoulder impingement syndrome included self-reported symptoms in the shoulder region for at least 3 months within the past year, and positive impingement sign (pain anterolateral and superior to shoulder joint elicited or exacerbated by passive internal rotation of the arm at 90° abduction) at physical examination. Shoulder impingement syndrome was found in 38 current slaughterhouse workers, 16 former slaughterhouse workers and 5 referents.

Level of evidence: 2-

Frost et al (2002) A cross-sectional study compared the prevalence of dominant shoulder tendinitis among 1964 workers exposed to repetitive work tasks with 793 workers not exposed to repetitive work. Workers were selected from 19 workplaces in Denmark including food processing companies, textile plants, electronic plants, cardboard industries, postal sorting centres, a bank, and supermarkets. Physical workplace risk factors were assessed by self-reported questionnaire and video analysis. Shoulder tendinitis was defined as self-reported shoulder pain in combination with pain on resisted abduction and impingement pain (pain on internal rotation upper arm with 90° abduction) and/or tenderness at the greater humeral tubercle. Workplace factors included repetitive work, force requirements, micro-pauses, and combinations of these factors. Dominant shoulder tendinitis was found in 55 participants i.e. 2% (48 in the repetitive work group and 7 in the non-repetitive work group).

Level of evidence: 2+

Kaergarrd et al (2000) A prospective cohort study assessed the prevalence and persistence of rotator cuff tendinitis and myofascial pain syndrome among sewing machine operators. The study group initially included 243 female sewing machines without inflammatory rheumatic disease, disorders caused by trauma from three companies in Denmark. 110 participants dropped out during the 2 year follow up. The control group was 357 women with varied non-repetitive work from 15 different industrial plants. All participants completed a baseline questionnaire regarding work exposure, health, personal factors, social relations, lifestyle and physical activity in spare time. The current musculoskeletal complaints were collected by a self-reported questionnaire and a clinical examination regarding palpation tenderness, clinical tests and range of motion of the shoulder. Criteria for rotator cuff tendinitis was that self-reported shoulder pain (sum score max 12 points), pain at resisted abduction, and palpation tenderness of the greater humeral tubercle or sign of subacromial impingement pain.

Level of evidence: 2+

Melchior et al (2006) A cross-sectional study that compared the prevalence of upper limb disorders in 1160 French manual workers with 1496 non-manual workers employed in manufacturing, trade, real estate, public administration, health, transport, construction, community services, financial intermediation, hotels and restaurants, agriculture and education. A self-reported questionnaire was used to collect the information about participants' demographics, health characteristics, physical work exposure and musculoskeletal symptoms in the preceding 12 months. Additional physical examination was carried out for participant who reported symptoms of pain or paraesthesia in upper limbs. Participants who reported musculoskeletal symptoms at the time of the examination or during at least four days in the preceding week and physician observed physical abnormalities on the clinical examination were considered as cases. Rotator cuff syndrome was found in 116 manual workers and 88 non-manual workers. Work-related factors included repetitive work, force requirements and posture.

Level of evidence: 2-

Miranda et al (2005) A cross-sectional study that reported the prevalence of chronic rotator cuff tendinitis and self-reported nonspecific pain in 3909 participants who had held a job during the preceding 12 months in 2000-2001. Data was collected by questionnaires, interviews and health examinations. Work-related physical loading was assessed during the interview, including duration of employment, driving a motor vehicle, frequent lifting, heavy lifting, working with hand above the shoulder, work requiring high hand force, work requiring repetitive motion of the hand or wrist, work requiring intensive keying (e.g., typing, computer work), and working with a vibrating tool. Rotator cuff tendinitis was found in 78 Finnish general populations aged 30-64 years.

Level of evidence: 2-

Moore et al (2008) A cross-sectional study that compared the incidence of shoulder impingement syndrome in violin and viola players with age matched volunteer. Ten (violin played by 6, one the viola, and 3 played both) college-level string musicians who played the violin or viola were recruited by phone from college orchestras in Minneapolis/St Paul. 18 participants volunteered to be the controls. The primary exclusion criterion for both groups was that participants needed to be free of any recent shoulder injury unrelated to their playing. All subjects were interviewed by one person just prior to examination about their demographic background, overhead arm activities, and musical history. The musicians were also asked questions about their previous shoulder pain and medical diagnoses. The controls were asked about the medical history about their shoulders. The physical examination for shoulder included Neer impingement test, internal rotation, lower trapezius muscle strength test, forward shoulder posture assessment.

Level of evidence: 2-

Bodin et al, 2014: A prospective cohort study of 150 workers were recruited from the same group of participants included in the Bodin et al, 2012 study. The 150 workers included were from a subset of 274 participants who had RCS at baseline. Physical examinations were performed by an occupational physician, and biomechanical factors information was obtained through self-administered questionnaires initially and upon follow-up (2 – 8 years after baseline data). Participants were excluded if retired, were on leave, or unemployed. RCS was diagnosed as: there was at least intermittent pain in shoulder region (without paresthesias) that increased with elevation of upper arm as in scratching the upper back, pain present currently or for at least 4 days during preceding 7 days and if at least one of the following shoulder tests were positive: painful arc, resisted shoulder abduction, external / internal rotation and resisted elbow flexion. Participants were divided into two groups: RCS with recovery and RCS without recovery. There was a high loss to follow-up for this study (54.7%) due to participants retiring, deceased, loss of job, or not being employed for different reasons. Upon follow-up Occupational Physicians asked about changes to jobs (to determine changes in biomechanical risk factors), and for any history of treatments for RCS that included shoulder surgeries, corticosteroids, or physiotherapy. Physical/biomechanical risk factors investigated were repetition, posture, vibration and force.

Level of evidence: 2- (Low grade prospective cohort study due to low sample sizes and high loss to follow-up)

Rechardt et al, 2010: A cross-sectional study that investigated 6,237 participants recruited from 80 health centre districts in Finland. Participants were examined and interviewed using a previously piloted protocol that included interview with a trained nurse and standardised physical by trained physician. Shoulder pain was determined by: pain during preceding 30 days. Chronic rotator cuff tendinitis was defined as history of pain in region for at least 3 months; plus pain during past on the preceding examination; pain in >1 active resisted movements (abduction, internal/external rotation) and/or painful arc. Participants were excluded if there was missing information on their shoulder disorder and presence of rheumatoid arthritis and positive rheumatoid factor. Work related physical risk factors were not the primary focus of the study but variables are reported in supplementary data. Risk factors examined included posture, force, vibratory and repetitive measures.

Level of evidence: 2- since study is cross-sectional

Roquelaure et al, 2011: A cross-sectional study that investigated 3,710 workers from a working population from the Loire Valley in France. The study used data that as collected by Occupational Physicians (OP) in this area, where 18% (n = 83) participated. Cases of shoulder pain during the preceding 12 months and preceding days were detected using the Nordic questionnaire. Those testing positive underwent a physical examination by an OP. RCS was defined as: if there was at least intermittent pain in shoulder worsened by active elevation of upper arm as in scratching the upper back at time of testing or ≥4 days in last 7 before testing; and for ≥1 of following shoulder tests being positive – resisted shoulder abduction, external or internal rotation; resisted elbow flexion; painful arc. The associations were reported as ORs and adjusted for age in the report, a section was also included that separated men and women. The physical risk factors reported in association with RCS were: repetition, workload, postures, and use of vibratory had tool.

Level of evidence: 2- since study is cross-sectional

Seidler et al, 2011: A case-control study that investigated the physical risk factors of 483 male patients who had a supraspinatus tear confirmed with MRI against 300 age-matched male controls (25-65 years). Inclusion criteria for this study were confirmed supraspinatus partial/total tear that was then detected with MRI within specific dates so data could be collected again at 18 months. Study did not exclude control subjects who suffered from shoulder complaints and control subjects did not have any MRI imaging done. Computer assisted personal interviews were used to obtain information about work time and posture. The associations that were reported were cumulative ORs for force, vibration and posture work related physical risk factors. The ORs were adjusted either for age and region (OR_1), or for age, region and criteria not included in the measure (OR_2).

Level of evidence: 2+, different inclusion criteria for cases and controls noted

Silverstein et al, 2008 and 2009: Two cross-sectional studies that followed the same group of 733 workers from across 12 occupational sectors in either the manufacturing or healthcare sectors. The 2009 study examined almost the same workplace factors as the 2008 study but separated the data by gender. For both studies the examiners (that included: ergonomists for workplace exposure analyses and physicians/nurses for physical examinations) were blinded to the others results. Workplace exposures were video-taped through two cameras at different angles and analysed at a later date. RCS was defined through current symptoms and tests that included: painful arc, resisted shoulder abduction/external rotation; internal rotation and no history of acute injury or degenerative disease. Associations between physical risk factors and psychosocial factors measured. Physical risk factors included measures of force, vibration, repetition and posture with some combinations between force and types of grip/repetition and posture.

Level of evidence: 2- since studies are cross-sectional; however they are high quality CS studies

Stenlund et al, 1993: A cross-sectional study that determined whether the signs of tendinitis or muscle attachment inflammation was related to different workloads, years of manual or work, hours of exposure or job title. The study analysed randomly chosen representatives from union work files and the final group included 54 bricklayers, 55 rock-blasters and 98 foremen. All participants were male and aged between 26 – 70 years. Exclusion criteria included those who did not want to participate because they lived a long distance away and those with language difficulties. Participants were asked questions by a trained nurse that included question about their work-life, years of manual work and outside sports activities. Clinical examiners were blinded to the exposure status of participants. Associations left and right shoulders for high vs low exposures to total cumulative calculation over the number of years the job had been performed for, for load, vibration and manual work. All logistic regression multivariate analyses took smoking, age, dexterity and sports activity into account.

Level of evidence: 2- studies are cross-sectional.

Sutinen et al, 2006: A cohort study performed on 52 forestry workers in Finland. This study is a follow-up study that originally started in 1976 that was partially funded by the Finnish National Board of Forestry who employed these workers. There was a high loss to follow-up, from the 139 included in the original cohort those that had not worked over 19 years were excluded but no analysis or discussion about this was included in the study. Inclusion criteria included subjects had to have more than 1,500 hours of chain-sawing in three consecutive years before the follow-up. Vibration was the only physical risk factor investigated as the main focus of this study was an investigation of the association between hand-arm vibration syndrome (vibration white finger syndrome) and cumulative exposure. Diagnoses of RCS were by physicians and lifelong vibration energy was calculated by taking into account daily and yearly exposures using a formula derived from previous literature.

Level of evidence: 2- limited cohort, one risk physical risk factor that could hold high amount of bias

Svendsen et al, 2004a and 2004b: These studies are cross-sectional studies that investigated the quantitative exposure response relationships in a cohort of male machinists, car mechanics and house painters in Denmark. In the 2004a paper a total of 1,886 participants completed a survey on their exposure to working with their arms elevated above 900 for their trade. Whole day measurements of upper arm elevation were performed on a subset of workers from each occupation over four consecutive days with inclinometers attached to their upper arm. Torque was based on force measurements that were provided by experienced tradespeople that measured elevation angles. Diagnoses of shoulder disorder (supraspinatus tendinopathy) were made by physicians who were blinded to exposure. Inclusion criteria included use of only computer operated and controlled tools, companies with more than five journeymen. Exclusion criteria included working in other jobs that had exposure to awkward postures and repetitive work, and if they had worked less than one year as a journeyman. Associations (both crude and age adjusted) were reported between supraspinatus tendinitis for percentage of hours working with the arm elevated above 90^0 and for lifetime exposure of working with shoulder above 90^0 elevation.

The 2004b paper examined supraspinatus tendinopathy as well as other shoulder disorders using Magnetic Resonance Imaging (MRI) and determined if there was an association of this with exposure. A subgroup of participants from the same cohort as that in 2004a were investigated. Inclusion criteria included: aged between 40 – 50 years old, are right-handed and worked as a journeyman in one of the three trades for at least 10 years. Participants who played shoulder intensive sports for a specific period, had previous traumatic should injury, diabetes, thyroid disorders, weighed over 120kg or had a pacemaker / suspected metallic foreign objects were excluded. Only the dominant shoulder was investigated and diagnoses of respective shoulder disorders were made by radiographers who were blinded to exposure. The lifetime exposures and force requirements were calculated using similar methods to 2004a paper and associations (both crude and age adjusted) for these with supraspinatus tendinopathy identified with MRI were reported.

Level of evidence: 2- for both papers. Specific cohort, assumptions made with lifetime exposure calculations.

Appendix 3. SIGN criteria

The studies included in these results were graded using the SIGN criteria for the relevant type of observational study. Based on this grading they were assigned a Level of Evidence as described in Table 15 below:

Table 15. Scottish Intercollegiate Guidelines for Levels of Evidence

1++	High quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias
1+	Well-conducted meta-analyses, systematic reviews, or RCTs with a low risk of bias
1-	Meta-analyses, systematic reviews, or RCTs with a high risk of bias
2++	High quality systematic reviews of case control or cohort or studies High quality case control or cohort studies with a very low risk of confounding or bias and a high probability that the relationship is causal
2+	Well-conducted case control or cohort studies with a low risk of confounding or bias and a moderate probability that the relationship is causal
2-	Case control or cohort studies with a high risk of confounding or bias and a significant risk that the relationship is not causal
3	Non-analytic studies, e.g. case reports, case series
4	Expert opinion

Appendix 4: Evidence Tables

Systematic Reviews					
Study	**Methodology**	**Outcomes & results**	**Paper Grading**		**Reviewer comments & evidence level**
van Rijn et al. (2010) Scandinavian Journal of Work Environment and Health , 36:3, 189-201 **Study design:** Systematic Review **Research Question:** Quantitative assessment of the exposure-response relationships between work-related physical and psychosocial factors and	**Comprehensive Literature search:** Medline, Embase, Cochrane Central Register **Assessment of methodological quality:** Used an assessment list derived from previous literature and Dutch Cochrane Centre. Studies assessed independently by two reviewers Studies scored on quality score assessment whether to be included or not **Data extraction:** Core findings expressed by measures of association: odds ratios/relative risks with 95% confidence intervals – extracted directly from studies where possible, calculated if raw data avaliable **Statistical Analysis**	**Outcomes assessed:** Job titles and shoulder disorders Exposure and occurrence of SIS (Subacromial impingement syndrome) **Results:** Exposure and occurrence of SIS: _Force:_ 2 high quality studies with significant associations (OR 2.8 – 4.21). Frost et al: CS study. *+ve associations* with requirements >10%MVC , lifting >20kg >10x day(for 4-13years and 14 – 23 years), work with high hand force ≥1hr/day. *Null associations* lifetime requirements and frequent lfting ≥5kg, >2x minute, >2 hours a day (OR 0.71 – 2.0). _Repetitiveness_ Increased risk with movements (1 – 14x/min: OR 2.93; and 15 – 36x minute: OR 3.29)	Clearly defined research question Two people selected studies and extract data Comprehensive literature search carried out Authors clearly state how limited review by publication type Included and excluded studies listed Characteristics of included studies are provided Scientific quality of included studies assessed and documented	Y Y Y Y N Y Y	High quality systemic review that follows defined and previously used criteria for paper inclusion. Listed and described included studies, did not list studies not included possibly due to large number of discarded papers. Although did mention relevant specific findings of some excluded papers in discussion. No mention of potential conflicts of interest in

occurrence of specific shoulder disorders in occupational populations **Funding:** WorksafeBC, Richmond, Canada	Three types of statistical associations: +ve for occurrence of one of four disorders at shoulder; -ve for a higher risk factor associated with lower occurrence of one of disorders; null for studies that were inclusive. Results pooled if studies deemed sufficiently homogenous, Investigated first the four shoulder disorders associated with types of work, then looked at association of five types of exposure (force, repetitiveness, vibration, combined exposures, posture) **<u>Inclusion criteria</u>:** Fulfil all of: i)report tendinitis of biceps, rotator cuff tears, SIS and suprascapular nerve compression in occupational populations, ii)Exclude complaints from acute trauma or systemic disease, iii) present quantitative description of measures of exposure iv)published in peer-reviewed scientific journals in English, German, French or Dutch **<u>Exclusion criteria</u>:** Studies with no description of specific shoulder disorders in occupational population Studies with no quantitative description of the measures of	Miranda et sl: CS study, repetitive motion wrist and hand ≥2 hours/day (14 – 23 years, and >23 years *<u>Vibration</u>* OR 1.04 – 3.5 found between two studies. Increased risk with using vibrating tool ≥2hours/day (4 -13, and 14-23 years). Increase with vibration energy does of $84x10^6(m^2s^4)$ *<u>Posture</u>* Five articles found positive associations Upper-arm elevation of >90^o (6-9% working hours, >20 months) Working with hand above shoulder ≥1 hour/day (4 to > 23 years). OR range: 1.27 – 4.70 Lack of micropauses in shoulder flexion in ≤80% (OR 2.82) and >80% (OR 3.33) Long durations of exposure in sewing machine operators: >15 years (OR 8.80; 95% CI: 1.05 – 74.04) *<u>Combined Exposure</u>* Two articles: *Frost et al*: High freq-High force >80% work cycle (OR 4.82); Low freq-no pauses (OR 3.08); High freq-no pauses (OR 3.53), High force-no pauses	Scientific quality of included studies assessed appropriately Appropriate methods used to combine individual study findings Likelihood of publication bias assessed Conflicts of interest declared Are results of study directly applicable to patient group targeted by guideline?	**Y** **Y** **Y** **N** **Y**	studies included although this could be because there weren't any **SIGN evidence level** **2+**

	exposure presented Reviews, Editorials, Commentaries, Cadaver study, Double publications	(OR 4.48). *Silverstein et al:* Upper arm flexion ≥45º for ≥15% of time with forceful exertions for ≥9% time (OR 2.43), or forceful pinch >0% time (OR 2.66). Gender analysis showed Upper arm flexion ≥45º for≥ 5% time, and forceful pinch >0% time significantly associated with SIS in women (OR 6.68) and non-significant in men (OR 1.45). **Author Conclusions:** Highly repetitive work, forceful exertion in work, awkward postures and high psychosocial job demand are associated with the occurrence of SIS (shoulder impingement syndrome). Highest increased risk found in jobs in fish and meat processing industries where they are exposed to the physical risk factors mentioned above.			
Van der Windt et al (2013) **Study design:** Systematic Review **Research Question:** Summarise available evidence	**Comprehensive Literature search:** Medline, Embase, Psychlit and Cinahl **Assessment of methodological quality:** Quality assessed by two independent reviewers using a standardised checklist Details of associations between study population and exposures with shoulder pain extracted. **Inclusion criteria:**	**Outcomes assessed:** Physical load factors, psychosocial risk factors **Results:** Summary of strength of evidence of risk factors for shoulder pain. Only high quality (described as ≥60% method score) studies included, no 95%CI reported **Characteristics** | **Consistency (# studies)** | **OR range** Heavy physical workload | 3/7 | 1.7-5.4 Awkward postures | 3/6 | 1.4-3.1 Repetitiveness | 3/3 | 1.6-46	Clearly defined research question Two people selected studies and extract data Comprehensive literature search carried out Authors clearly state how limited review by publication type Included and excluded	Y Y Y Y	Moderate quality, well-performed review. Studies assessed looked primarily at shoulder pain, but not specifically at rotator cuff disorders, however this could be limited by studies

on occupational risk factors related to physical load and identify methodological shortcomings to set priorities for future shoulder pain research **Funded by:** The Netherlands Organisation for Scientific Research	a) Study cross sectional, case-control or prospective cohort, b) paper full report in English in a peer-reviewed journal, c) Information presented on physical load or psychosocial risk factors at work, d)exposures assessed with standardised observational methods/interviews/questionnaires, e) shoulder pain self-reported/confirmed by physical examinations, f) studies on neck and upper limb pain presented shoulder pain separately **Exclusion criteria:** Studies on acute injuries due to trauma, studies that estimated exposure from job titles only	Same activity for long periods — 1/3 — 1.6 Vibration — 2/2 — 1.04-2.6 **Author Conclusions:** Likely that shoulder pain is a result of many factors including physical load and psychosocial factors. Evidence not consistent across studies and associations not strong. Consistent positive associations found for repetitive movements, vibration, duration of employment.	studies listed Characteristics of included studies are provided Scientific quality of included studies assessed and documented Scientific quality of included studies assessed appropriately Appropriate methods used to combine individual study findings Likelihood of publication bias assessed Conflicts of interest declared Are results of study directly applicable to patient group targeted by guideline?	**Y** **Y** **Y** **Y** **Y** **Y** **N/A** **N**	available at time written, but it is not certain if shoulder pain is rotator cuff involved **SIGN evidence level** 2++

Prospective Cohort Studies						
Study	**Participants**	**Interventions & Measures**	**Outcomes & results**	**Paper Grading (SIGN method for PC)**		**Reviewer comments & evidence level**
Borstad et al. (2009) Ergonomics, 52:2, 232-244 **Study design:** Prospective Cohort **Research Question:** Determine: - Demographic work-related factors predictive of first-episode shoulder pain over 2-years - If a home exercise programme to optimise shoulder mechanics had a	240 construction apprentices, in first or second year of course. Apprentice sectors: plumbers, electricians, pipe fitters, sheet metal workers followed over 2 years Each class assigned to an exercise (n=117) or non-exercise(control, n=123) group **Exclusion criteria:** Subacromial impingement confirmed by physiotherapist. 32 participants lost to follow-up (13%)	**Interventions:** Home exercise programme that was reviewed at 1 year **Measures:** Two questionnaires filled out at entry to study, at 1 year then at 2 year follow-ups *1st questionnaire:* Participant demographics, Shoulder pain history, previous work exposures *2nd Questionnaire:* Work –related factors	**Outcomes assessed:** Regression analysis to determine demographic and work-related factors that were predictive of a case (shoulder pain) **Results:** *Repetition:* Working very fast for short periods (lifting, grasping, pulling etc.): OR 0.97 (p = 0.784) *Posture:* Working in awkward or cramped positions: OR 1.01 (p = 0.885) Working in same position for long periods (standing, sitting, bent over, kneeling): OR 1.06 (p = 0.519) Reaching over head or away from body: OR 0.84 (p = 0.089) *Heavy physical work:* Carrying, lifting, or moving heavy materials/equipment: OR 1.14 (p =	Focused Question? Two comparable groups Indicate number people people took part out of population? Likelihood some eligible subjects have outcome at time of enrolment assessed and taken into a/c at analysis % dropout Comparison made btwn full participants and those lost to followup by exposure status Outcome defined Assessment outcome blind to exposure status Method of assessment reliable Evidence from other sources used to	**N** **Y** **Y** **Y** **13%** **Y** **Y** **N/A** **Y** **Y**	Although study well designed results are based on two questionnaires based on the apprentices experience without any objective measures. Study does not specifically refer to rotator cuff issues and these are not assessed for. For these reasons the question has been graded as not focused, and method of assessment not reliable Study makes an effort to have a matched and consistent population and has a low dropout rate Study makes effort to reduce level of bias but research question unfocussed: + Results for link to rotator cuff injury inconclusive **SIGN evidence level:** *Because unfocussed question and subjective methodology study graded as: **2+***

protective effect **Funding:** Centre to protect Worker's Rights Public Health Service University of Iowa			0.25) **Author Conclusions:** Proportion of new-onset shoulder pain in control group was higher than in the exercise group. Regression analysis identified four factors related to new-onset shoulder pain: previous neck pain; working in hot, cold or humid conditions; subject height; and bending and twisting the back	demonstrate method of outcome assessment reliable Exposure level assessed more than once Potential confounders identified Confidence intervals?	**Y** **Y** **N (only p-values)**	
Bodin et al, 2014 American Journal of Industrial Medicine, 57, 683 – 694 **Study design:** Prospective cohort **Research Question:** To assess the persistence of roatator cuff	150 workers from a total of 274 workers with RCS in 2002-2005 from a population selected at random for a previous study. The distribution of the original population was close to that of the regional workforce. High loss to followup (`54.7%) due to death, retired, loss of job, refused to participate,	**Groups:** RCS recovery, RCS without recovery **Methodology:** Physical examination by occupational physician Self-administered questionnaire: personal, organisational, biomechanical and psychosocial factors	**Outcomes assessed:** Workers characteristics according to gender. Comparisons between followed up and non-followed up groups **Results:** No statistical significance found for working postures and biomechanical factors between followed-up and non-followed up groups in baseline factors within each gender. In the recovery vs no recovery from RCS analysis only two physical risk factors were found to be significant in men, none were significant within women.	Focused Question? Two comparable groups Indicate number people people took part out of population? Likelihood some eligible subjects have outcome at time of enrolment assessed and taken into a/c at analysis % dropout Comparison made btwn full participants and those lost to followup by exposure status	**Y** **Y** **Y** **Y** **54.7%** **Y**	Prospective cohort with a small sample size and limited population as followups of 2-5 years are based on population used in a previous study. Consequentially has a very high loss to follow-up although no difference found between loss to follow-up group and that included. RCS observed in study likely less severe than that seen in clinical setting. Also possible that workers who left their baseline jobs were more severe cases Interval btwn baseline and follow-up between 2 and 8

<table>
<tr>
<td>syndrome (RCS) in workers and to study associations with personal and work-related factors, job change, exposure change and treatment.

Study design:

Prospective cohort

Funding:

French institute for public health surveillance and the French National Research Agency</td>
<td>maternity leave etc.

Inclusion criteria:

Only workers who suffered RCS at baseline for original study

Exclusion criteria:

Retired people, people on parental leave, long-term sick leave, unemployed</td>
<td>Follow-up examination: Occupational physicians asked about: change of job (physical /postural/psychological loads, change of company. Also asked about Hx shoulder surgery, corticosteroids, physio or other Rx for RCS. Only Rx for original diagnosed side included.</td>
<td><u>Men</u>
<table>
<tr><th>Factor</th><th>Recover RCS (n,%)</th><th>No recovery RCS</th><th>p-value</th></tr>
<tr><td>High repetitive(≥4h /day)</td><td>11(22.9)</td><td>11(47.8)</td><td>.034*</td></tr>
<tr><td>High perceived exertion</td><td>13(27.7)</td><td>13(56.5)</td><td>.019*</td></tr>
</table>
No significant difference was found for: Posture with arms above shoulder level (≥2hrs/day), posture with arms abducted (60-90^0, ≥2hrs/day), holding hand behind trunk (≥2hr/day), combinations of mechanical exposures, use of hand tools (≥2hrs/day), use of vibrating hand tools (≥2hrs/day), pushing or pulling load (≥2hrs/day), working seated (≥4hrs/day)

Authors Conclusion:

A high percentage of workers recovered and several personal and work-related factors were associated with persistent RCS. Larger prospective studies are needed to confirm results</td>
<td>Outcome defined

Assessment outcome blind to exposure status

Method of assessment reliable

Evidence from other sources used to demonstrate method of outcome assessment reliable

Exposure level assessed more than once

Potential confounders identified

Confidence intervals?</td>
<td>Y

N

Y

Y

N</td>
<td>years

SIGN evidence level:

Low sample sizes and very high loss to follow-up make this a low grade prospective cohort: 2-</td>
</tr>
<tr>
<td>Kaergaard et al, 2005

Journal of Occupational</td>
<td>Study group: n=243 women from a population of 259 sewing machine operators</td>
<td>Methodology:

<u>Baseline questionnaire</u> regarding work</td>
<td>Results:

Odds ratios: Univariate model

Referent: control group</td>
<td>Focused Question?

Two comparable groups

Indicate number people people took part out of</td>
<td>Y

Y

Y</td>
<td>• High drop-out rate

• self-reported questionnaire used to collect physical work factors – potential for</td>
</tr>
</table>

<table>
<tr>
<td>Rehabilitation. 15, 37 – 46

Study design:

Prospective cohort

Research Question:

To examine the occurrence and persistence of two neck-shoulder disorders among sewing machine operators

Funding:

Danish Working Environment Fund and Danish Research Academy</td>
<td>from six departments in three companies

94% participation rate

Mean age = 38.3 yrs (SD 10.4)

Employment duration = 13.0 yrs (9.6)

Drop-outs: 45% (110/243)

Control group: n=357 women with varied non-repetitive work from 15 different industrial plants

Mean age = 38.2 (9.4)

Exclusion criteria:

inflammatory rheumatic disease, disorders caused by trauma</td>
<td>exposure, health, personal factors, social relations, lifestyle and physical activity in spare time.

<u>Self-reported questionnaire</u> about the current musculoskeletal complaints

<u>Clinical examination for neck and shoulder</u> regarding palpation tenderness, clinical tests and range of motion of the shoulder.

<u>Criteria for rotator cuff tendinitis:</u> self-reported shoulder pain (sum score max 12 points), pain at resisted abduction, and palpation tenderness of the</td>
<td><table>
<tr><th>Duration</th><th>OR</th><th>95% CI</th></tr>
<tr><td>2-10 years</td><td>0.55</td><td>0.07-4.48</td></tr>
<tr><td>10-20 years</td><td>2.77</td><td>0.81-9.48</td></tr>
<tr><td>> 20 years</td><td>6.84</td><td>2.46-19.04</td></tr>
</table>
Authors Conclusion:

Rotator cuff tendinitis showed a higher degree of persistence than myofascial pain syndrome. Both disorders highly influenced the perception of general health. Women who lived alone with children, were smokers, or experienced low support from colleagues and supervisors had a higher risk of contracting a neck-shoulder disorder</td>
<td>population?

Likelihood some eligible subjects have outcome at time of enrolment assessed and taken into a/c at analysis

% dropout

Comparison made btwn full participants and those lost to followup by exposure status

Outcome defined

Assessment outcome blind to exposure status

Method of assessment reliable

Evidence from other sources used to demonstrate method of outcome assessment reliable

Exposure level assessed more than once

Potential confounders identified

Confidence intervals?</td>
<td>

Y

45%

N

Y

N

CS

N

Y

Y

Y</td>
<td>reporting bias.

SIGN evidence level:

2-</td>
</tr>
</table>

		greater humeral tubercle or sign of subacromial impingement pain.				

Case-Control Studies						
Study	**Participants**	**Interventions**	**Outcomes & results**	**Paper Grading***		**Reviewer comments & evidence level**
Andersen & Gaardboe (1993) American Journal of Industrial Medicine, 24, 689-700 **Research Question:** To assess the occurrence of neck and upper limb disorders and to evaluate the exposure-response relationship between years of sewing work and clinically confirmed syndromes. **Funding:**	Study population: n=107 (n=82 sewing machine operators; n=25 auxillary & home helpers) Source population: n=424 sewing machine operators and n=55 auxilliary nurses and home helpers who answered a questionnaire in 1987 The sewing machine operators were divided into 3 groups based upon years in work: group I, 0-7 years of sewing machine work (n=252); group II, 8-15 years (n=95); and group III, >15 years (n=77) A random	**Work-related exposure:** duration of employment as a sewing operator **Measures:** A physical examination was conducted, consisting of (1) a general health examination, (2) a comprehensive examination of the neck, shoulder, and arm, (3) an interview about health and work history, (4) a second examination of neck and upper limb, (5) a laboratory examination (including	**Outcomes:** RCS **Case definition of RCS:** Self-reported chronic shoulder pain; on clinical examination, tenderness (3 or 4/4) at greater tubercle, and positive pain-arc or impingement sign (pain with passive abduction when scapular rotation is fixed) **Results:** **Odds ratios**: Univariate model **Referent**: auxillary nurses/home helpers (see table below)	Focused Question? Two comparable groups Same exclusion criteria used for both cases and controls? % each group participated in study? Comparison made between participants and non-participants to establish conformity Cases clearly defined and differentiated from controls Clearly established controls are non-cases Measures taken to	**Y** **Y** **N** **Cases 76.6%** **Controls 45.5%** **N** **Y** **Y**	Controlling for potential confounding factors but only univariate analysis possible for RCS. Wide confidence intervals i.e. imprecise estimate of association Assumption that the 'control' group has a smaller exposure status i.e. control group selected from a different source population Small numbers **SIGN evidence level:** **2-** *Control group from a different population than sewing machine operators; limited external validity i.e. applicable to women sewing machine operators*

Duration	OR	95% CI
0-7 years exposure	**1.20**	**0.07-20.43**
8-15 years exposure	**7.58**	**0.84-68.46**
>15 years exposure	**10.56**	**1.26-88.19**

Danish Working Environment Foundation	selection of 30 women were selected from the highest exposed (group III, >15 years employment); frequency matching according to age was used to create the other groups, including controls n= 19 cases of RCS identified Thirty women in each group (including the 'control' group) were asked to participate in a clinical examination Six subjects were moved from group I to group II and 8 were moved from group II into group III (because of time between the administering the original questionnaire and	routine serology and serological screening for thyroid and rheumatic disease), (6) standard x-rays of cervical spine and shoulders, and (7) a psychological examination (including a structured interview, cognitive tests and personality test [MMPI])	**Author Conclusions:** The odds of having a clinical diagnosis of RCS was significantly greater in the high exposure group (>15 years working as a sewing machine operator) than in the 'control' group (auxiliary nurses/home helpers). There is no significant difference in the odds of a clinical diagnosis of RCS between the low and medium exposure groups (0-7 years and 8-15 years as sewing machine operator respectively) and the 'control' group (auxiliary nurses/home helpers).	prevent knowledge of primary exposure influencing case ascertainment Exposure measured in a reliable/valid way Main potential confounders identified and taken into account Confidence intervals?	**CS** **Y** **Y** **Y**	

	the clinical examination [~2 years] and a better estimation of exposure time at interview					
Seidler et al. (2011) International Archives of Occupational and Environmental Health, 84, 425-433 **Research Question:** To examine dose-response between cumulative duration of work with highly elevated arms as well as manual material handling and supraspinatus tendon rupture	**Participants:** n = 483 male patients with radiographically confirmed supraspinatus tears (through MRI): n = 385 partial, n = 98 total n = 300 male controls All subjects aged between 25 - 65 **Inclusion criteria:** Stated pain by patient that was then detected to be Supraspinatus partial/total tear via MRI within specific dates so data could be collected at 18	**Interventions:** Home exercise programme **Measures:** Computer-assisted personal interview to obtain information about work time, working posture, asked participant specific questions	**Outcomes assessed:** Occupational groups and supraspinatus tendon rupture Physical workload and suprapinatus tendon tears **Results:** *<u>OR_1</u>: OR adjusted for age and region* *<u>OR_2</u>: OR adjusted for age region, and criteria not included in measure* *Force:* **Cumulative** lifting and carrying loads ≥20kg (hours) **Variable** — **Adj OR_1** — **Adj OR_2** No load — **1.0** — **1.0** 0-9.6 — **1.4(0.8-2.4)** — **0.9(0.5-1.7)** 9.6-<77 — **2.0(1.2-3.3)** — **1.2(0.6-2.1)** 77-9,038 — **3.3(2.1-5.2)** — **1.8(1.0-3.2)** *Posture:* Cumulative work above shoulder	Focused Question? Two comparable groups Same exclusion criteria used for both cases and controls? % each group participated in study? Comparison made between participants and non-participants to establish conformity Cases clearly defined and differentiated from controls Clearly established controls are non-cases	**Y** **Y** **N** **Cases 48%** **Controls 54%** **Y** **Y** **Y**	Outcomes assessed are subjective, reliant on participant self-reporting, thus open to recall bias no objective measures apart from diagnosis of supraspinatus tears No indepth clinical analysis Supraspinatus tears can be asymptomatic thus some of controls could have had tears leading to underestimation of risk factors. No mention whether controls had supraspinatus examined via MRI **SIGN evidence level:** **2+** *Subjective measures and differing inclusion criteria between controls and cases are confounding issues for this study*

<table>
<tr>
<td>Funding:</td>
<td>months

Did not exclude control subjects that suffered from shoulder complaints.

Exclusion criteria:

Persons with: severed illness or deceased, unknown address, and lacking knowledge of German/Turkish languages.</td>
<td></td>
<td>level (hours)

<table>
<tr><th>Variable</th><th>Adj OR₁</th><th>Adj OR₂</th></tr>
<tr><td>No work</td><td>1.0</td><td>1.0</td></tr>
<tr><td>0-<610h</td><td>1.7(1.0-2.8)</td><td>1.0(0.6-1.8)</td></tr>
<tr><td>610-<3,195h</td><td>2.6(1.6-4.2)</td><td>1.4(0.8-2.4)</td></tr>
<tr><td>3,195-64,057h</td><td>4.1(2.6-6.4)</td><td>2.0(1.1-3.5)</td></tr>
</table>

Vibration: Handheld vibration (cumulative years on the job)

<table>
<tr><th>Variable</th><th>Adj OR₁</th><th>Adj OR₂</th></tr>
<tr><td>No vibration</td><td>1.0</td><td>1.0</td></tr>
<tr><td>0-4.4y</td><td>2.5(0.9-8.8)</td><td>2.7(1.3-5.6)</td></tr>
<tr><td>4.4-<16y</td><td>3.9(2.2-7.2)</td><td>3.1(1.5-6.1)</td></tr>
<tr><td>16-51.6y</td><td>4.6(2.7-7.8)</td><td>3.2(1.7-5.9)</td></tr>
</table>

Author Conclusions: Long-term cumulative effects of work with elevated arms and heavy lifting/carrying has a potential etiologic role on shoulder tendon disorders</td>
<td>Measures taken to prevent knowledge of primary exposure influencing case ascertainment

Exposure measured in a reliable/valid way

Main potential confounders identified and taken into account

Confidence intervals?</td>
<td>Y

Y

Y

Y</td>
<td></td>
</tr>
</table>

Cross-sectional studies

Study	Participants and methodology	Outcomes & results	Paper Grading*		Reviewer comments & evidence level
Baron et al. (1991) Niosh report No. No. HETA-88-344-2092 **Research Question:** To investigate the relationship between 'cumulative trauma disorders' [CTD] and working as a supermarket checkout operator **Funding:** National Institute for Occupational Safety and	**Participants:** n=119 female supermarket check-out staff from four Shoprite chain stores, New Jersey, New York N= 17 (14.2%) diagnosed with shoulder 'cumulative trauma disorder' (CTD) i.e. rotator cuff syndrome or bicipital tendinitis 85 % participation rate **Exclusion criteria:** meat, deli, and fish workers; those under 18 yrs old; pregnant women; history of trauma; discomfort began before employment at supermarket **Methodology:** Questionnaire about any pain, aching, stiffness, burning, numbness, or tingling during past year of neck, shoulder, elbow, hand, or back, in addition to	**Outcome Measures:** *Odds ratios for shoulder cumulative trauma disorder (CTD)* *Length of employment (adjusted for age):* No significant difference in odds for shoulder CTD for length of employment *Hours per week working as checkout operator (adjusted for working a second job):* **Duration / OR / *p-value*** working 20-25 hrs/week vs.<20 hrs/week / **0.9** / **-** working >25 hrs/week vs.<20 hrs/week / **3.5** / **P<0.05** **Author Conclusions:** Odds of having a shoulder CTD significantly greater for those checkout operators working >25 hrs per week compared to those working	Specific, clear objective	+	•Cross-sectional study so can only indicate association not causation – on its own this study presents only limited evidence of a causal relationship at best •Rotator cuff syndrome not distinguished from bicipital tendinitis •Limited external validity i.e. applicable to female checkout operators **SIGN evidence level** *(NB, although not usually used for CS studies has been used here so level of evidences is comparable with other study designs)*: **2-**
			Main features of study population described	+	
			Cases and controls derived from same population with clear definitions of each stated	N/A	
			Participation rate ≥80%/ if 60 – 80% is not selective	+	
			Response at any follow-up is ≥80% or if non-response is not selective	N/A	
			Data for physical load at work	+	
			Methods described	+	
			More than one dimension of load assessed (duration,	+	

Health (NOISH), USA	information about work history, hobbies, second job, acute injuries, and other medical problems *Standardised physical examination* (blind to job title and questionnaire results) *Case definition of work-related CTD* = complaints on questionnaire and a positive physical examination of particular part of the body *Physical examination case definition of shoulder CTD:* •Rotator cuff: pain on one of the following: resisted abduction, and/or deltoid palpation •Bicipital tendinitis: pain on Yergason's manoeuver *Ergonomic data* collected by videotape e.g. cycle time, number of items, scans, and key-ins etc	<20 hrs per week No significant difference of odds of having a shoulder CTD between those working 20-25 hrs per week and <20 hrs per week No significant difference of odds of having a shoulder CTD between length of employment as checkout operator of 0-5 years, 5-10 years, or >10 years	frequency, amplitude) Data presented about psychosocial factors More than one psychosocial factors assessed Data collected about factors during leisure time Data collected about past occupational exposure Data collected on Hx shoulder disorders Exposure measured in same way in controls Exposure assessment blinded to disease status Method for assessing shoulder Appropriate stats model (univariate/multivariate) Measures of	 - - - - + + – + +	

			associations presented (ORs/RRs) and 95% Cis Analysis is controlled for confounding or effect modification Number of cases in multivariate is at least 10x number of independent variables in analysis	- - +	
Frost & Andersen (1999) Occupational & Environmental Medicine 56(7): 494-498. **Study design:** Cross-sectional **Research Question:** To examine the risk of shoulder impingement syndrome relative to shoulder	**Participants:** Present and former workers employed between Jan 1986-Sept 1993 at a slaughterhouse or chemical factory n=1591 **Inclusion criteria:** Subjects still alive and living in Denmark with ≥6 months of employment in the chosen period **Methodology:** *Postal questionnaire, ergonomic observations of tasks, and standardised physical examination* *Criteria for shoulder impingement syndrome*: self-reported symptoms in the shoulder region	**Results:** Prevalence ratios (PR) for shoulder impingement syndrome adjusted for age *Duration* **Duration / PR / 95%CI** 5 years worked / **6.7** / **3.9-11.2** 10 years worked / **7.2** / **4.3-12.2** 15 years worked / **6.7** / **3.9-10.9** 20 years worked / **6.1** / **3.7-9.9** *Posture and repetition*	Specific, clear objective Main features of study population described Cases and controls derived from same population with clear definitions of each stated Participation rate ≥80%/ if 60 – 80% is not selective Response at any follow-up is ≥80% or if non-response is not selective Data for physical load at work	+ + + + N/R -	•Cross-sectional study so can only indicate association not causation – on its own this study presents only limited evidence of a causal relationship at best •Selection bias - "healthy worker effect" •Definition of impingement probably includes heterogeneous conditions •Physical examinations were unblinded for the employing company

intensive work **Funding:** Danish Working Environment Fund	for at least 3 months within the past year with a positive impingement sign (pain anterolateral and superior to shoulder joint elicited or exacerbated by passive internal rotation of the arm at 90° abduction) at physical examination	**Posture and repetition** / **PR** / **95%CI** Current slaughterhouse workers / **5.27** / **2.09-13.26** Former slaughterhouse workers / **7.9** / **2.94-21.18** **Author Conclusions:** Sustained intensive work that stresses the shoulders as much as in a Danish slaughterhouse is a risk factor for developing impingement syndrome characterised by functional impairment of the affected shoulder. The risk substantially increases after a few years of experience and tends to increase further with cumulative exposure.	Methods described More than one dimension of load assessed (duration, frequency, amplitude) Data presented about psychosocial factors More than one psychosocial factors assessed Data collected about factors during leisure time Data collected about past occupational exposure Data collected on Hx shoulder disorders Exposure measured in same way in controls Exposure assessment blinded to disease status Method for assessing shoulder Appropriate stats	+ + - - - - + + + +	**SIGN evidence level** *(NB, although not usually used for CS studies has been used here so level of evidences is comparable with other study designs)*: **2-**

<table>
<tr><td></td><td></td><td></td><td>model (univariate/multivariate)

Measures of associations presented (ORs/RRs) and 95% Cis

Analysis is controlled for confounding or effect modification

Number of cases in multivariate is at least 10x number of independent variables in analysis</td><td>+

+

+

N/A</td><td></td></tr>
<tr><td>Frost et al. (2002)

American Journal of Industrial Medicine 41(1): 11-18

Study design:

Cross-sectional

Research Question:

To examine the</td><td>Participants:

Study population: n=2757 (n=1964 repetitive work tasks, and n=793 not with repetitive work tasks i.e. referent group)

Source population: n=4162 workers at 19 workplaces in Denmark were asked to participate

Response rate: 75% (3123/4162)

Participation rate: 66% (2757/4162)

Workplaces included: food processing companies, textile</td><td>Outcome Measures:

<u>Odds ratios</u> for shoulder tendinitis (adjusted for centre, age, age2, gender, shoulder injury, shoulder operation, physical activity during leisure time, overhead sport, bodymass index, height, and pressure algometry)

Results:

<table><tr><th>Factors</th><th>OR</th><th>95%CI</th></tr><tr><td>Repetition (yes vs. no)</td><td>3.12</td><td>1.33-7.34</td></tr><tr><td>Frequency

--low (1-14</td><td></td><td></td></tr></table></td><td>Specific, clear objective

Main features of study population described

Cases and controls derived from same population with clear definitions of each stated

Participation rate ≥80%/ if 60 – 80% is not selective

Response at any follow-up is ≥80% or if non-</td><td>+

+

+

-

N/R</td><td>•Response rate reflective of a postal questionnaire but may have been a source of bias

•Lower confidence interval range was close to 1 for shoulder tendinitis

•Cross-sectional study so can only indicate association not causation – on its own this study presents only limited evidence of a causal relationship at best</td></tr>
</table>

risk of shoulder tendinitis in relation to shoulder loads identified by frequency of movements, force requirements, and lack of micro-pauses **Funding:** Danish Working Environment Fund and Danish Research Academy	plants, electronic plants, cardboard industries, postal sorting centres, a bank, and supermarkets **Methodology:** *<u>Baseline questionnaire</u>* sent to 4162 workers regarding physical leisure time activity, over head sports, dexterity, injuries, rheumatic or connective tissue disorders, previous shoulder surgery, intensity of current shoulder symptoms, and functional impairment due to shoulder problems *<u>Visit</u>* to all 19 workplaces *<u>by ergonomist</u>* to classify work tasks as either repetitive (involved continuous repetitive hand or arm movements) or control tasks (characterised by varied job tasks) *<u>Physical examination of neck and upper extremities</u>* was performed on site (examiners blind to exposure and health status) *<u>Criteria for shoulder tendinitis:</u>* shoulder pain and activity impairment scales summing to at least 12 points (max. 36) in combination with pain at resisted	movements/min)	**2.93**	**1.17-7.36**	response is not selective		•selection bias •healthy worker effect •self-reported questionnaire – recall bias •video analysis of a sample of the participants –exposure analysis – possible misclassification bias •assumption that workers not exposed to repetitive work have no forceful exertions, pauses, number exertions, cycle time of task (not measured) **SIGN evidence level** *(NB, although not usually used for CS studies has been used here so level of evidences is comparable with other study designs)*: **2-**
		--high (15-36 movements/min)	**3.29**	**1.34-8.11**	Data for physical load at work	+	
		Force requirements (% maximal voluntary contraction)			Methods described	+	
		--low force (<10% of MVC)	**2.17**	**0.84-5.59**	More than one dimension of load assessed (duration, frequency, amplitude)	+	
		–high force (≥10% of MVC)	**4.21**	**1.17-10.40**			
		Micro-pauses in shoulder flexion			Data presented about psychosocial factors	+	
		--≤80% of cycle time without pauses	**2.82**	**1.10-7.28**	More than one psychosocial factors assessed	+	
		-->80% of cycle time without pauses	**3.33**	**1.37-8.13**	Data collected about factors during leisure time	+	
		Combined exposures					
		-- High frequency and high force	**4.82**	**1.86-12.51**	Data collected about past occupational exposure	–	
		-- Low frequency and no pauses ≤80% of cycle time	**3.08**	**1.20-7.93**	Data collected on Hx shoulder disorders	–	
		-- High frequency and no pauses >80% of cycle time	**3.53**	**1.43-8.70**	Exposure measured in same way in controls	+	
		-- High force and no pauses >80% of cycle time	**4.48**	**1.73-11.61**	Exposure assessment blinded to disease		

	abduction and impingement pain (i.e. internal rotation of upper arm with 90° abduction elicits pain) and/or palpation tenderness of the greater humeral tubercle	**Author Conclusions:** The authors concluded that workers with repetitive tasks have increased risk of shoulder tendinitis, which can be partially attributed to force requirements	status Method for assessing shoulder Appropriate stats model (univariate/multivariate) Measures of associations presented (ORs/RRs) and 95% Cis Analysis is controlled for confounding or effect modification Number of cases in multivariate is at least 10x number of independent variables in analysis	+ + + + + N/A	
Melchior et al. (2010) Occupational & Environmental Medicine 63(11): 754-61. **Study design:** Cross-sectional	**Participants:** 2656 French workers (1594 men and 1107 women) employed in manufacturing, trade, real estate, public administration, health, transport, construction, community services, financial intermediation, hotels and restaurants, agriculture and education	**Outcome Measures:** *Odds ratios* for shoulder tendinitis (adjusted for centre, age, age2, gender, shoulder injury, shoulder operation, physical activity during leisure time, overhead sport, bodymass index, height, and pressure algometry) **Results:** Prevalence ratios (PR) for rotator cuff	Specific, clear objective Main features of study population described Cases and controls derived from same population with clear definitions of each stated Participation rate	+ + +	• Cross-sectional study so can only indicate association not causation – on its own this study presents only limited evidence of a causal relationship at best • Occupational physicians' low participation rate (17%)

Research Question: To examine the risk of shoulder tendinitis in relation to shoulder loads identified by frequency of movements, force requirements, and lack of micro-pauses **How funded:** French National Institute of Health Surveillance and National Institute of Health Research	Total pool n =2685 99% participation rate **Methodology:** *Self-reported questionnaire* regarding demographics, health characteristics, physical work exposure and musculoskeletal symptoms in the preceding 12 months. *Physical examination* for those participants who reported symptoms of pain or paraesthesia in upper limbs. *Case definition*: self-reported musculoskeletal symptoms at the time of the examination or during at least four days in the preceding week and physician observed physical abnormalities on the clinical examination.	syndrome *Repetition (adjusted for age obesity, diabetes, thyroid disease, arthritis)* •Repetitive (same action >2 times/min ≥4 hrs/day) movements with breaks (hourly 10 min break) men PR= 2.12 (1.43–3.15) women PR=1.83 (1.21–2.74) •Repetitive movements w/o breaks (as above) men PR=1.97 (0.93–4.17) women PR=2.57 (1.50–4.41) *Force requirements (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 posture)* •Forceful movements: <2 hours/day men PR=1.09 (0.66–1.80) women PR=1.11 (0.66–1.84) •Forceful movements: ≥2 hours/day men PR=1.65 (1.03–2.61) women PR=1.03 (0.53–2.00) *Posture (adjusted for same factors as force)*	≥80%/ if 60 – 80% is not selective Response at any follow-up is ≥80% or if non-response is not selective Data for physical load at work Methods described More than one dimension of load assessed (duration, frequency, amplitude) Data presented about psychosocial factors More than one psychosocial factors assessed Data collected about factors during leisure time Data collected about past occupational exposure Data collected on Hx shoulder disorders	+ N/R + + + N/A N/A – – +	• Potential overrated work exposures • The critical role of work is a source of risk **SIGN evidence level** *(NB, although not usually used for CS studies has been used here so level of evidences is comparable with other study designs)*: **2-**

		•Arm(s) above shoulder: <2 hours/day men PR=1.06 (0.67–1.67) women PR=1.21 (0.75–1.93) •Arm(s) above shoulder: ≥2 hours/day men PR=2.57 (1.67–3.97) women PR=1.75 (1.09–2.83) •Hand behind trunk posture: <2 hours/day men PR=1.07 (0.68–1.68) women PR=1.43 (0.88–2.32) •Hand behind trunk posture: ≥2 hours/day men PR=1.02 (0.44–2.36) women PR=2.11 (1.13–3.93) •Arm(s) away from the body: <2 hours/day men PR=1.49 (0.96–2.30) women PR=1.23 (0.69–2.09) •Arm(s) away from the body: ≥2 hours/day men PR=1.42 (0.87–2.31) women PR=2.13 (1.36–3.33) **Author Conclusions:** In working men and women, upper limb musculoskeletal disorders are frequent. Physical work exposures, such as repetitive and forceful movements, are an important source of risk and in particular account for a large proportion of excess morbidity among	Exposure measured in same way in controls Exposure assessment blinded to disease status Method for assessing shoulder Appropriate stats model (univariate/multivariate) Measures of associations presented (ORs/RRs) and 95% Cis Analysis is controlled for confounding or effect modification Number of cases in multivariate is at least 10x number of independent variables in analysis	+ – + + + + N/A	

		manual workers.			
Milanda et al. (2005) American Journal of Epidemiology 161(9): 847-855. **Study design:** Cross-sectional **Research Question:** To assess the prevalence of rotator cuff tendinitis and non-specific shoulder complaints in a general population and compare roles of several determinants, including biomechanical factors, in these conditions	**Participants:** Nationally representative sample of n=8028 This study restricted to those 30-60 years old who had held a job in the last 12 months (n=4071) Prevalence chronic rotator cuff tendinitis 2.0% (78/3909); non-specific shoulder pain 12% (410/3525) 88% (n=5152) participated in the interview 83% (n=4886) attended the health examination **Methodology:** _Baseline questionnaire, health examination._ _Work-related physical loading_ was assessed during the interview, including duration of employment, driving a motor vehicle, frequent lifting, heavy lifting, working with hand above the shoulder, work requiring high	**Outcome Measures:** _Odds ratios_ **Results:** Repetitive motion of the hand or the wrist (>2 h/day) 1-3 year vs. none ▪ total OR=1.6 (0.5-5.2) ▪ men OR=2.2 (0.5-10.5) ▪ women OR=0.8 (0.1-6.2) 4-13 year vs. none ▪ total OR=0.8 (0.3-2.1) ▪ men OR=0.6 (0.1-3.3) ▪ women OR=0.8 (0.2-2.9) 14-23 year vs. none ▪ total OR=2.4 (1.3-4.3) ▪ men OR=2.5 (1.0-6.6) ▪ women OR=2.0 (0.8-4.2) >23 year vs. none ▪ total OR=2.6 (1.4-4.9) ▪ men OR=3.4 (1.3-9.1) ▪ women OR=1.8 (0.8-4.2) Working with hand above the shoulder level (≥ 1 hr/day) 1-3 year vs. none ▪ total OR=2.4 (1.0-5.9) ▪ men OR=3.1 (1.1-8.4) ▪ women OR=1.0 (0.2-4.6) 4-13 year vs. none ▪ total OR=3.2 (1.6-6.5) ▪ men OR=3.0 (1.2-7.7) ▪ women OR=2.2 (0.6-7.4)	Specific, clear objective Main features of study population described Cases and controls derived from same population with clear definitions of each stated Participation rate ≥80%/ if 60 – 80% is not selective Response at any follow-up is ≥80% or if non-response is not selective Data for physical load at work Methods described More than one dimension of load assessed (duration, frequency, amplitude) Data presented about psychosocial factors More than one	+ + + + N/R + + + N/A	• Study design limitation - The healthy worker effect may have caused underestimation in the risk estimates. • Gender differences • Recall error **SIGN evidence level** *(NB, although not usually used for CS studies has been used here so level of evidences is comparable with other study designs)*: **2-**

How funded: Finnish Work Environment Fund	hand force, work requiring repetitive motion of the hand or wrist, work requiring intensive keying (e.g., typing, computer work), and working with a vibrating tool. *<u>Criteria for chronic rotator cuff tendinitis:</u>* pain in rotator cuff region lasting for ≥3 months; pain in the month before the examination; pain in rotator cuff region on one or more resisted active movements (study population for this outcome was 3740; mean age 44.4 years; 52% men) *<u>Non-specific shoulder pain:</u>* shoulder pain during last week; no pain on palpation or provocation tests; no clinical shoulder diagnosis by field physician (study population for this outcome was 3378; mean age 44.1 years; 51% men)	14-23 year vs. none ▪ total OR=4.7 (2.4-9.1) ▪ men OR=4.8 (1.9-12.1) ▪ women OR=4.4 (1.5-12.4) >23 year vs. none ▪ total OR=2.3 (1.1-4.9) ▪ men OR=2.3 (0.7-7.0) ▪ women OR=2.5 (0.8-7.9) Work requiring high hand force (>1 h/day) 1-3 year vs. none ▪ total OR=2.3 (0.9-6.3) ▪ men OR=2.3(0.6-8.2) ▪ women OR=2.5 (0.6-11.0) 4-13 year vs. none ▪ total OR=2.8 (1.4-6.0) ▪ men OR=2.5 (0.8-7.1) ▪ women OR=3.6 (1.4-9.5) 14-23 year vs. none ▪ total OR=3.7 (1.9-7.1) ▪ men OR=4.7 (1.9-11.9) ▪ women OR=2.2 (0.7-7.4) >23 year vs. none ▪ total OR=1.8 (0.8-4.1) ▪ men OR=2.3 (0.8-6.6) ▪ women OR=1.3 (0.4-4.7) Heavy lifting (>20 kg,>10 times/day) 1-3 year vs. none ▪ total OR=1.5(0.6-4.1) ▪ men OR=1.4(0.5-4.5) ▪ women OR=1.2 (0.2-9.2) 4-13 year vs. none ▪ total OR=3.0 (1.6-5.8) ▪ men OR=1.6 (0.6-4.1) ▪ women OR=6.0 (2.8-12.6)	psychosocial factors assessed Data collected about factors during leisure time Data collected about past occupational exposure Data collected on Hx shoulder disorders Exposure measured in same way in controls Exposure assessment blinded to disease status Method for assessing shoulder Appropriate stats model (univariate/multivariate) Measures of associations presented (ORs/RRs) and 95% Cis Analysis is controlled for confounding or effect modification	N/A + + + + N/R + + + +	

		14-23 year vs. none ▪ total OR=2.8 (1.4-5.7) ▪ men OR=3.2 (1.4-7.5) ▪ women OR=1.8 (0.4-6.9) >23 year vs. none ▪ total OR=1.8 (0.8-4.2) ▪ men OR=1.6 (0.6-4.6) ▪ women OR=2.3 (0.6-8.8) Working with a vibrating tool (>2 h/day) 1-3 year vs. none total OR=0.6(0.1-4.6) men OR=0.8(0.1-6.1) 4-13 year vs. none total OR=2.5 (1.0-5.9) men OR=2.7 (1.0-7.2) 14-23 year vs. none total OR=3.5 (1.5-7.8) men OR=4.2 (1.8-9.8) >23 year vs. none total OR=1.4 (0.5-4.4) men OR=1.8 (0.6-5.9) **Author Conclusions:** In conclusion, every eighth employed person in Finland experiences shoulder pain without clinical findings.	Number of cases in multivariate is at least 10x number of independent variables in analysis	N/A	
Nordander et al. (2009) Ergonomics	**Participants:** Combination of epidemiological data on musculoskeletal morbidity in 43 occupational	**Outcome Measures:** Prevalence ratios (PR): repetitive/constrained vs. varied/mobile work	Specific, clear objective Main features of study population described	+ -	• Cross-sectional study so can only indicate association not causation – on its own this study

52(10): 1226-39 **Study design:** Cross-sectional **Research Question:** To calculate the risk for musculoskeletal disorders among workers with repetitive/constrained work as compared to workers with varied mobile work **Funding:** Swedish Medical Research Council, the Swedish Council for Work Life & Social Research, AFA Insurance, the Medical Faculty of Lund University and the County Councils of	groups collected by or in cooperation with the research group between 1986 and 2005. Inclusion: all occupational groups with at least 30 men or women with homogenous work tasks Groups were divided into two categories: repetitive/constrained and varied/mobile work Repetitive work = a cycle time of <30s or >50% of the cycle time involved the same fundamental cycle Constrained work implied that >50% of working time involved prolonged awkward postures **Methodology:** *Standardised physical examination* of the neck and upper limbs of 31 of the 43 groups *Questionnaire* *Criteria for supraspinatus tendonitis:* shoulder pain; local tenderness over tendon insertion; pain on resisted isometric abduction *Criteria for infraspinatus*	• Supraspinatus tendonitis Men: PR=2.7 (95%CI: 1.3-5.4) Female: PR=2.5 (1.4-4.2) • Infraspinatus tendonitis Men: PR=4.0 (1.6-9.9) Women: PR=3.1 (1.6-6.4) **Author Conclusions:** Repetitive/constrained work showed elevated risks when compared to varied/mobile work in all settings. Females and males showed similar risk elevations.	Cases and controls derived from same population with clear definitions of each stated Participation rate ≥80%/ if 60 – 80% is not selective Response at any follow-up is ≥80% or if non-response is not selective Data for physical load at work Methods described More than one dimension of load assessed (duration, frequency, amplitude) Data presented about psychosocial factors More than one psychosocial factors assessed Data collected about factors during leisure time	+ N/A N/R - + - N/A N/A –	presents only limited evidence of a causal relationship at best • Combination of epidemiological data across a long time duration, and the method of data collection differed among groups • Confounders were not considered. • Control for confounding was not described. **SIGN evidence level** *(NB, although not usually used for CS studies has been used here so level of evidences is comparable with other study designs)*: **2-**

Southern Sweden	*tendonitis:* shoulder pain; local tenderness over tendon insertion; pain on resisted isometric outward rotation		Data collected about past occupational exposure Data collected on Hx shoulder disorders Exposure measured in same way in controls Exposure assessment blinded to disease status Method for assessing shoulder Appropriate stats model (univariate/multivariate) Measures of associations presented (ORs/RRs) and 95% Cis Analysis is controlled for confounding or effect modification Number of cases in multivariate is at least 10x number of independent variables in analysis	– + + – + + + - N/A	

<table>
<tr>
<td>

Rechardt et al. (2010)

Musculoskeletal Disorders, 11, 165 - 177

Study design:

Cross-sectional

Research Question:

Assess the associations of lifestyle and metabolic factors, carotid intima-media thickness with shoulder pain and chronic rotator cuff tendinitis

Physical load factors included in appendices

Funding:

Finnish Academy and Finnish work

</td>
<td>

Participants:

n = 6,237 (recruited from 80 health centre districts out of 7,977 potential subjects)

Inclusion criteria:

30 years or older who participated in national Finnish health survey between 2000 – 2001

Exclusion criteria:

Missing information on shoulder disorders, rheumatoid arthritis and positive rheumatoid factor

Methodology:

2 pilot studies 7 and 3 months before study performed to pilot methods and provide detailed written instructions and video on examination techniques.

Participants examined with structured protocol that included an interview with trained nurse and standardised physical by trained physician

Rotator cuff defined by descriptions of shoulder pain meeting specific categories and examination by physician

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Results:

Work related physical risk factors only included here

<u>*Unilateral or bilateral shoulder pain univariable odds*</u>: (Appendix 1)

Men:

<table>
<tr><th></th><th>Unilateral</th><th></th><th>Bilateral</th><th></th></tr>
<tr><th>Characteristic</th><th>OR</th><th>95%CI</th><th>OR</th><th>95%CI</th></tr>
<tr><td>Working with hands above the shoulder level</td><td>1.6</td><td>1.2-2.2</td><td>2.5</td><td>1.8-3.5</td></tr>
<tr><td>Manual handling of loads ≥ 5 kg</td><td>1.3</td><td>0.9-1.7</td><td>3.4</td><td>2.4-4.7</td></tr>
<tr><td>Manual handling of loads ≥ 20 kg</td><td>1.6</td><td>1.2-2.1</td><td>2.7</td><td>2.0-3.6</td></tr>
<tr><td>Using vibrating tools</td><td>1.4</td><td>1.0-2.0</td><td>2.9</td><td>2.0-4.2</td></tr>
<tr><td>High handgrip forces</td><td>1.4</td><td>1.0-1.8</td><td>2.9</td><td>2.0-4.1</td></tr>
<tr><td>Repetitive movements of the hands or wrists</td><td>1.3</td><td>0.9-1.7</td><td>1.7</td><td>1.2-2.3</td></tr>
</table>

Women:

<table>
<tr><th></th><th>Unilateral</th><th></th><th>Bilateral</th><th></th></tr>
<tr><th>Characteristic</th><th>OR</th><th>95%CI</th><th>OR</th><th>95%CI</th></tr>
<tr><td>Working with hands above the shoulder level</td><td>1.8</td><td>1.4-2.4</td><td>3.2</td><td>2.4-4.2</td></tr>
<tr><td>Manual handling of loads ≥ 5 kg</td><td>1.9</td><td>1.5-2.5</td><td>2.8</td><td>2.1-3.8</td></tr>
<tr><td>Manual handling of loads ≥ 20 kg</td><td>1.8</td><td>1.4-2.4</td><td>2.5</td><td>1.9-3.4</td></tr>
<tr><td>Using vibrating tools</td><td>2.2</td><td>1.2-3.8</td><td>3.9</td><td>2.2-6.6</td></tr>
</table>

</td>
<td>

Specific, clear objective

Main features of study population described

Cases and controls derived from same population with clear definitions of each stated

Participation rate ≥80%/ if 60 – 80% is not selective

Response at any follow-up is ≥80% or if non-response is not selective

Data for physical load at work

Methods described

More than one dimension of load assessed (duration, frequency, amplitude)

Data presented about psychosocial factors

More than one psychosocial factors assessed

</td>
<td>

+

+

+

+

N/R

+

+

+

N/A

N/A

</td>
<td>

Moderate quality cross-sectional study that shows that the odds of high load and repetitive movements on shoulder pain and rotator cuff tendinitis are higher in women than men.

No discussion of controls in study so unknown if treated same as cases

Methods based on literature and piloted before performed

No specific occupations/leisure activities mentioned

SIGN evidence level
(NB, although not usually used for CS studies has been used here so level of evidences is comparable with other study designs): **2-**

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</tr>
</table>

<table>
<tr>
<td>environment fund</td>
<td>Physical work load factors used as a control to normalise comparisons for metabolic factors and carotid IMT and were not reported on for main part of paper and only included in appendices for this paper</td>
<td>
<table>
<tr><td>High handgrip forces</td><td>1.9</td><td>1.5-2.5</td><td>2.9</td><td>2.1-3.9</td></tr>
<tr><td>Repetitive movements of the hands or wrists</td><td>1.7</td><td>1.3-2.1</td><td>2.3</td><td>1.7-3.1</td></tr>
</table>
<u>Gender specific rotator cuff tendinitis univariable odds</u>: (Appendix 2)
<table>
<tr><th></th><th>Men</th><th></th><th>Women</th><th></th></tr>
<tr><th>Characteristic</th><th>OR</th><th>95%CI</th><th>OR</th><th>95%CI</th></tr>
<tr><td>Working with hands above the shoulder level</td><td>1.5</td><td>0.9-2.3</td><td>2.0</td><td>1.3-3.1</td></tr>
<tr><td>Manual handling of loads ≥ 5 kg</td><td>1.2</td><td>0.7-2.0</td><td>1.8</td><td>1.1-2.9</td></tr>
<tr><td>Manual handling of loads ≥ 20 kg</td><td>1.4</td><td>0.8-2.2</td><td>2.6</td><td>1.6-4.0</td></tr>
<tr><td>Using vibrating tools</td><td>1.1</td><td>0.6-1.9</td><td>2.4</td><td>1.1-5.5</td></tr>
<tr><td>High handgrip forces</td><td>1.6</td><td>0.9-2.6</td><td>1.9</td><td>1.2-3.0</td></tr>
<tr><td>Repetitive movements of the hands or wrists</td><td>1.6</td><td>0.9-2.5</td><td>1.2</td><td>0.7-1.9</td></tr>
</table>
Author Conclusions:
Associations of abdominal obesity, some metabolic factors and carotid intima thickness with shoulder pain. Mechanical factors such as injuries or physical work load exposures play a role in shoulder injury.
</td>
<td>Data collected about factors during leisure time

Data collected about past occupational exposure

Data collected on Hx shoulder disorders

Exposure measured in same way in controls

Exposure assessment blinded to disease status

Method for assessing shoulder

Appropriate stats model (univariate/multivariate)

Measures of associations presented (ORs/RRs) and 95% Cis

Analysis is controlled for confounding or effect modification

Number of cases in multivariate is at least</td>
<td>-
-
+
+
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+
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+</td>
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</table>

			10x number of independent variables in analysis	N/A	

Borstad ***et al.* (2012)**

American Journal of Industrial Medicine, 55, 605-615

Study design

Cross-sectional

Research Question:

To compare risk factors for shoulder pain without and with rotator cuff syndrome

Funding:

French Institute

Participants:

3,710 workers (2,161 men, mean age 38.5±10.4 years; 1,549 women mean age 38.9±10.3 years)

Selected at random through a 2 stage sampling procedure:

1. Half-days of the OPs schedule were chosen for sampling by investigators

2. Each OP was asked to randomly select 1/10 workers on those selected days to be recruited into the study

Less than 10% did not participate. Design indicates only individuals who were healthy enough to work were included, no other specific inclusion/exclusion criteria were mentioned.

Participants:

Results:

Workers with “shoulder pain” or RCS were more often exposed to biomechanical factors and psychosocial factors at work than workers without pain.

Physical risk factors results:

Men

	Shoulder pain without RCS		Shoulder pain with RCS	
Risk factor	**OR**	**95%CI**	**OR**	**95%CI**
Work pace dependent on automatic rate	1.4	1.1-1.9	1.4	0.8-2.3
High perceived physical demand (Borg Scale≥13)	1.4	1.1-1.7	2.2	1.4-3.4
Sustained/repeated arm posture in abduction (≥2h/d)				
No	1		1	
>60⁰	1.6	1.2-2.2	1.1	0.6-2.1
>90⁰	0.9	0.6-1.4	2.4	1.4-4.1
Both	1.8	1.2-2.7	2.6	1.4-5.0

Women

	Shoulder pain without RCS		Shoulder pain with RCS	
Risk factor	**OR**	**95%CI**	**OR**	**95%CI**

Specific, clear objective	**Y**
Main features of study population described	**Y**
Cases and controls derived from same population with clear definitions of each stated	**Y**
Participation rate ≥80%/ if 60 – 80% is not selective	**Y**
Response at any follow-up is ≥80% or if non-response is not selective	**N/R**
Data for physical load at work	**Y**
Methods described	**Y**
More than one dimension of load assessed (duration, frequency, amplitude)	**N**

Cross-sectional study that examines shoulder pain either with or without RCS. Undertaken in a limited population of workers over a range of employment sectors in France.

Authors used standardised procedures however open to bias as only sampled from working population and factors outside of work not taken into account – may lead to underestimation of effects.

Biomechanical factors and symptoms measured via questionnaire – may have bias in risk estimates.

Potential leisure activities that could be linked to RCS and shoulder pain not assessed (may not be such an issue since found not to be a risk in previous literature)

SIGN evidence level

for Public Health Surveillance, and the French National Research Agency

Industy	%
Service	58.7
Meat and manufacturing	34.0
Construction	5.8
Agriculture	1.5

Participants were assessed for musculoskeletal symptoms in neck/shoulders and upper-limbs using standardised questionnaire. Mannequin used to denote different regions for pain. VAS used to categoise pain. RCS diagnosed via standardised exam by OPs.

Methodology:

Exposure related to work status and occupational risk factors assessed with self-administered questionnaire.

Biomechanical factors assessed for typical working day in the past 12 months. Response categories presented on 4-level Likert-type scale.

High perceived physical demand (Borg Scale≥13)	1.3	1.0-1.7	1.4	0.9-2.1
Sustained/repeated arm posture in abduction (≥2h/d)				
No	1		1	
$>60^0$	1.3	0.8-1.9	1.8	1.0-3.4
$>90^0$	0.9	0.6-1.5	1.2	0.6-2.4
Both	1.2	0.7-2.2	3.1	1.5-6.7
Repetitiveness of tasks				
Never	1		1	
<2 hr/day	1.1	0.8-1.6	1.1	0.6-2.2
Between 2 and 4 hr/day	1.3	0.9-1.9	1.6	0.8-3.0
≥4 hr/day	1.5	1.1-1.9	2.3	1.4-3.8

Author Conclusions:

Age was more strongly associated with RCS than shoulder pain without RCS for both genders. Biomechanical and psychosocial factors were associated with "shoulder pain" and RCS and differed between genders.

Data presented about psychosocial factors	**Y**
More than one psychosocial factors assessed	**N**
Data collected about factors during leisure time	**N**
Data collected about past occupational exposure	**Y**
Data collected on Hx shoulder disorders	**N**
Exposure measured in same way in controls	**Y (prev 12 months)**
Exposure assessment blinded to disease status	**Y (prev 12 months)**
Method for assessing shoulder	**Y**
Appropriate stats model (univariate/multivariate)	**N (self assess questnr)**
Measures of associations presented (ORs/RRs) and 95% Cis	**Y**

(NB, although not usually used for CS studies has been used here so level of evidences is comparable with other study designs): **2-**

			Analysis is controlled for confounding or effect modification Number of cases in multivariate is at least 10x number of independent variables in analysis	N	
Rosenbaum et al. (2013) American Journal of Industrial Medicine, 56, 226 – 234 **Study design:** Cross-sectional **Research Question** To improve understanding of immigrant Latino manual workers occupational health, focusing on upper body musculoskeletal	**Participants:** n = 516: 289 poultry workers, 227 non-poultry workers (Latino immigrants recruited from 5 counties in western North Carolina. 1,526 resitdents were screened across this area. 957 were eligible, 516 completed interview and data collection clinic) **Inclusion criteria:** Self-identified as latino/Hispanic, worked 35hr or more/week in manual labor job, 18 yrs or older. **Exclusion criteria** Employees of poultry production farms **Methodology:** Two encounters:	n = 76 (14.7%) had rotator cuff syndrome RCS most common injury in poultry workers (n = 49, 17.0% of poultry workers). N = 27 (11.9%) of non-poultry workers had RCS. No differences between poultry and non-poultry workers in any of the clinical outcomes No differences in outcomes among poultry workers with different types of work *Job task and poultry-only injury prevalence* **Task** — **Prevalence N(% of those performing task)** Pack/sanitation/chill/other — 19(17.8) Cut/evisceration/wash/trim/ debone — 17(13.3) Receive/hang/kill/pluck — 4(18.2) Multiple Jobs — 9(28.1) **Author Conclusions:** Epicondylitis, rotator cuff syndrome and low	Specific, clear objective Main features of study population described Cases and controls derived from same population with clear definitions of each stated Participation rate ≥80%/ if 60 – 80% is not selective Response at any follow-up is ≥80% or if non-response is not selective Data for physical load at work Methods described More than one dimension of load	Y Y Y N/R N Y N	Low-quality Cross-sectional study that focused on a specific work population of one ethnicity that was targeted for a specific research question. Specific physical risk factors not discussed in paper and job tasks only described in context of specific jobs within poultry industry Small overall numbers Odd ratios not calculated Open to bias: population bias, **SIGN evidence level** *(NB, although not usually used for CS studies has been used here so level of evidences is comparable with other study designs)*: **2--**

injury **Funding:** Centers for Disease Control, National Institute for Occupational Safety and Health	1. Interviewer administered survey questionnaire at participants home. 2. Data collection clinic within 30 days of home interview. Two board certified physicians conducted examinations Rotator cuff syndrome was defined as pain in should for >2 days in previous month and followed up on with external exam Descriptive statistics used to describe study sample	back pain are common in immigrant Latino workers, and may negatively impact long-term health and contribute to occupational health disparities	assessed (duration, frequency, amplitude)		
			Data presented about psychosocial factors	**N**	
			More than one psychosocial factors assessed	**N**	
			Data collected about factors during leisure time	**N**	
			Data collected about past occupational exposure	**N**	
			Data collected on Hx shoulder disorders	**N**	
			Exposure measured in same way in controls	**Y**	
			Exposure assessment blinded to disease status		
			Method for assessing shoulder	**Y**	
			Appropriate stats model (univariate/multivariate)	**N/A**	

<table>
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<td>Measures of associations presented (ORs/RRs) and 95% Cis

Analysis is controlled for confounding or effect modification

Number of cases in multivariate is at least 10x number of independent variables in analysis</td>
<td>N

N</td>
<td></td>
</tr>
<tr>
<td>Roquelaure et al. (2011)

Scandinavian Journal of Environment and Health. 37(6) 502 – 511

Study design:

Cross-sectional

Research Question:

To examine the risk factors for RCS among workers exposed to various levels of</td>
<td>Participants:

N = 3,710 workers: 2,161 Men, 1,549 women.

Study based on surveillance data collected by OPs in working population in Loire Valley in France. 18% OPs (83) participated.

Exclusion criteria: <10% - no shows, refusals, duplications

Methodology:

Presence non-specific shoulder pain verified by standardised questionnaire.

Cases where shoulder symptoms present underwent physical exam</td>
<td>Results:

Association with RCS, adjusted for Age:

Univariate model (P<0.20):

<table>
<tr><th></th><th>Men</th><th></th><th>Women</th><th></th></tr>
<tr><th>Characteristic</th><th>OR</th><th>95%CI</th><th>OR</th><th>95%CI</th></tr>
<tr><td>High repetitiveness (≥4hrs/day)</td><td>2.3</td><td>1.6-3.3*</td><td>2.2</td><td>1.5-3.1*</td></tr>
<tr><td>Work dependant on automatic rate</td><td>1.7</td><td>1.0-2.7*</td><td>1.9</td><td>1.1-3.3*</td></tr>
<tr><td>High perceived workload(RPE)</td><td>2.6</td><td>1.8-3.9*</td><td>1.6</td><td>1.1-2.4*</td></tr>
<tr><td>Sustained or repeated arm postures in abd (≥2hrs/day)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>$>60^{0}$</td><td>1.5</td><td>0.8-2.7</td><td>2.4</td><td>1.4-4.2</td></tr>
<tr><td>$>90^{0}$</td><td>3.2</td><td>2.0-5.2</td><td>1.7</td><td>0.9-3.3</td></tr>
<tr><td>Both</td><td>3.1</td><td>1.8-5.5</td><td>3.9</td><td>2.0-7.7</td></tr>
<tr><td>Holding hand behind trunk (≥2hr/day)</td><td>1.2</td><td>0.6-2.5</td><td>2.1</td><td>1.0-4.2</td></tr>
<tr><td>Use of handtools</td><td></td><td></td><td></td><td></td></tr>
</table>
</td>
<td>Specific, clear objective

Main features of study population described

Cases and controls derived from same population with clear definitions of each stated

Participation rate ≥80%/ if 60 – 80% is not selective

Response at any follow-up is ≥80% or if non-response is not selective

Data for physical load at work</td>
<td>Y

Y

Y

N/R

N/R

Y</td>
<td>Cross-sectional study of a large group of participants from a working population in France. RCS physically assessed if indicated (prtpt reported shoulder pain) by an Occupational Physician.

No history of shoulder injuries or participants other activities noted that could leave open for bias.

Assessors not blinded and only one measure of load used (RPE) which is subjective and open to recall bias by partcipants diagnosed with RCS.

However some variables were normalised for age</td>
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</table>

shoulder contraints

Funding:

French Institute for Public Health Surveillance and the French National Research Agency

performed by OP using standardised clinical procedure.

Statistical analysis:

<u>Stage 1</u>: Univariate for potential explanatory and non-significant variables. P>0.2 were excluded from further analyses

<u>Stage 2:</u> Multivariate analyses on 5 groups of potential determinants including working postures and biomechanical constraints

Bilateral RCS was treated as 1 case

	Men OR	Men 95%CI	Women OR	Women 95%CI
<2hrs/day	1.7	1.0-3.0	0.9	0.5-1.8
2-4 hrs/day	1.7	1.1-2.8	1.5	0.9-2.5
≤4 hrs/day	1.8	1.2-2.9	2.0	1.3-3.2
Use of vibrating handtools(≥2hrs/day)	1.7	1.1-2.5*	2.3	1.1-4.8

Multivariate models (p<0.05)

	Men		Women	
Characteristic	**OR**	**95%CI**	**OR**	**95%CI**
Sustained or repeated arm postures in abd (≥2hrs/day)				
>60⁰	0.9	0.5-1.8	1.8*	1.0-3.2
>90⁰	2.3	1.3-3.9*	1.6	0.8-3.1
Both	2.0	1.1-3.7*	3.6	1.8-7.3*
High repetitiveness of task ≥4hrs/day	1.6	1.0-2.4*	1.7	1.1-2.5*
High perceived workload (RPE) ≥13	2.0	1.3-3.1*		

Multivariate models stratified by age (p<0.05): Men

	20-44yrs		45-59yrs	
Characteristic	**OR**	**95%CI**	**OR**	**95%CI**
Sustained or repeated arm postures in abd (≥2hrs/day)				
>60⁰	1.0	0.4-2.3	0.9	0.3-2.4
>90⁰	2.5	1.1-5.7*	2.2	1.1-4.4*
Both	2.6	1.1-6.3*	1.7	0.7-3.9
High repetitiveness of task ≥4hrs/day	2.4	1.3-4.4*	1.0	0.5-1.9
High perceived workload (RPE) ≥13	1.3	0.7-2.3	2.8	1.5-5.2*

Methods described	**Y**
More than one dimension of load assessed (duration, frequency, amplitude)	**N (just RPE)**
Data presented about psychosocial factors	**Y**
More than one psychosocial factors assessed	**Y**
Data collected about factors during leisure time	**N**
Data collected about past occupational exposure	**N**
Data collected on Hx shoulder disorders	**N**
Exposure measured in same way in controls	**Y**
Exposure assessment blinded to disease status	**N**
Method for assessing shoulder	**Y**
Appropriate stats	

within the multivariate models. And stratified by age.

Focus was on factors within occupations that might lead to RCS rather than occupations causing RCS

SIGN evidence level

(NB, although not usually used for CS studies has been used here so level of evidences is comparable with other study designs): **2-**

<table>
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Women

<table>
<tr><th></th><th colspan="2">20-44yrs</th><th colspan="2">45-59yrs</th></tr>
<tr><th>Characteristic</th><th>OR</th><th>95%CI</th><th>OR</th><th>95%CI</th></tr>
<tr><td>Sustained or repeated arm postures in abd (≥2hrs/day)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>$>60^{0}$</td><td>2.2</td><td>1.0-5.1</td><td>1.5</td><td>0.6-3.3</td></tr>
<tr><td>$>90^{0}$</td><td>2.2</td><td>0.8-5.7</td><td>1.1</td><td>0.4-2.8</td></tr>
<tr><td>Both</td><td>3.1</td><td>1.1-8.7*</td><td>4.5</td><td>1.6-12.5*</td></tr>
<tr><td>High repetitiveness of task</td><td></td><td></td><td></td><td></td></tr>
<tr><td>≥4hrs/day</td><td>1.4</td><td>0.7-2.6</td><td>2.0</td><td>1.1-3.5*</td></tr>
</table>

Authors Conclusions:

Personal and work-related physical and psychosocial factors were associated with RCS for both genders in this working population

</td>
<td>model (univariate/multivariate)

Measures of associations presented (ORs/RRs) and 95% Cis

Analysis is controlled for confounding or effect modification

Number of cases in multivariate is at least 10x number of independent variables in analysis</td>
<td>Y

Y

Y</td>
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<td>

Silverstein et al, 2006

Scandinavian Journal of Work, Environment and Health, 21: 99 – 108

Study Design

Prospective cohort

Research

</td>
<td>

Participants

N= 733 (baseline – 64.5% of those eligible)

N = 436 workers from 12 different worksites at one year follow-up (41% loss due to: laid-off, employment terminated, left job, did not want to participate, unavailable because on vacation, sick leave, 2 were deceased)

A higher percentage of those lost to follow-up were in the high

</td>
<td>

RCS at baseline was 7.6% (5.1-10.1%) for right and 4.8 %(3.0-7%) for the left compared to higher shoulder symptoms (18.6% and 11.2% right and left respectively).

Main findings from study with relation to physical work factors included in Table below from study. No ORs or Cis for physical risk factors reported for this study.

Females reported a greater proportion of symptoms but lower proportion of cases than men

</td>
<td>Specific, clear objective

Main features of study population described

Cases and controls derived from same population with clear definitions of each stated

Participation rate ≥80%/ if 60 – 80% is not selective

Response at any follow-</td>
<td>Y

Y

Y

Y

N</td>
<td>Study focused on manufacturing and healthcare facilities

Study includes description of large population that were lost to follow-up (41%). Demographics of those lost to follow-up compared to those remaining show no significant difference

Low participation rate partially due to participants being discouraged to take</td>
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</table>

Question

To assess the prevalence, incidence and persistence of non-traumatic rotator cuff tendinitis and shoulder symptoms over a 1-year period in a working population and the predictive value of symptoms and physical findings

Funding:

United States National Institute for Occupational Safety and Health and Washington State Dept of Labour and Industries

lifting group

Workplace assessment: Walkthrough by study ergonomists to categorise jobs into force and repetition categories. Hand activity leves used to categorise partiicpants, individual assessments videotaped

Exclusion: Shoulder problems from result of sudden injury (n=35)

RCS definition: Nontraumatic rotator cuff tendinits with at least one positive shoulder test (resisted abduction, internal rotation, external rotation, painful arc) and shoulder pain/burning in last 12 months of more than 1 week

Table 4. Observed exposures by right shoulder status at baseline (N=436).[a]

Higher level	All participants attending 1-year follow-up (N=436) (%)	No symptoms or physical findings (N=298) (%)	Physical findings without symptoms (N=36) (%)	Past symptoms (N=21) (%)	Current symptoms (N=48) (%)	Clinical case (N=33) (%)	P-value[b]
Upper-arm abduction >60 degrees >7.0% of the time	23.6	22.5	36.1	23.8	27.1	15.2	0.29
Upper-arm flexion >45 degrees >4.0% of the time	31.0	29.2	36.1	38.1	33.3	33.3	0.81
Lifting, time-weighted average >44.1 N	13.5	13.1	22.2	4.8	14.6	12.1	0.46
Lifting, peak >66.7 N	21.6	21.5	30.6	19.1	16.7	21.2	0.66
Hand exertion duration >6 seconds	22.7	24.2	19.4	14.3	18.8	24.2	0.81
Hand exertion frequency >20/min	18.1	16.4	16.7	19.1	25.0	24.4	0.51
Frequency of high forces[c] >6/min	24.3	23.5	19.4	28.6	18.8	42.4	0.13

[a] Time-weighted or peak lifting was dichotomized according to published guideline limits, as in appendix B of the Washington State ergonomics rule (19). The cut point for upper-arm abduction, upper-arm flexion, duration of hand exertion, frequency of hand exertion, and high frequency of high force exertions was close to the 75th percentile of these exposure variables.

[b] Chi-square test for the five shoulder status groups, $\alpha=0.05$.

[c] High forces were defined as ≥8.9 N of the pinch force or object weight (corresponding to 2 lb or 0.9 kg) or as 44.1 N of the power grip, object weight, or push–pull force (corresponding to 10 lb or 4.5 kg) according to the Washington State ergonomics rule (19).

Author conclusions: Symptoms and physical findings alone appear to predict clinical case status within 1 year. Frequent follow-up is necessary to capture in health and exposure

up is ≥80% or if non-response is not selective

Data for physical load at work	Y
Methods described	Y
More than one dimension of load assessed (duration, frequency, amplitude)	Y
Data presented about psychosocial factors	Y
More than one psychosocial factors assessed	Y
Data collected about factors during leisure time	N
Data collected about past occupational exposure	Y
Data collected on Hx shoulder disorders	Y
Exposure measured in same way in controls	Y
Exposure assessment	Y

part in study

ORs and 95% CI reported for same cohort in subsequent studies

Possible selection bias: workers in study were actively working when seen by researchers – those with symptoms and physical findings may be milder cases than those off work

SIGN Level of evidence: 2+

		status in prospective studies	blinded to disease status Method for assessing shoulder Appropriate stats model (univariate/multivariate) Measures of associations presented (ORs/RRs) and 95% Cis Analysis is controlled for confounding or effect modification Number of cases in multivariate is at least 10x number of independent variables in analysis	**Y** **N** **N**	
Silverstein et al, 2008 Journal of Occupational and Environment Medicine, 50: 1062 – 1076 **Study design:**	**N = 733 included** Same group of participants used for previous 2006 paper from same author, the 2006 paper described prevalence of RCS in different work places but did not discuss physical risk factors. **Recruited from:**	No differences in RCS vs non RCS cases in individual characteristics (age, BMI Gender, Race, Smoking status, hobbies etc). Those with high job security had a lower prevalence of RCS. *Adj Odds Ratios, (variable with significant associations included)* **Variable** **OR(95% CI)** **Freq of shoulder movement**	Specific, clear objective Main features of study population described Cases and controls derived from same population with clear definitions of each stated Participation rate	**Y** **Y** **Y**	High quality cross-sectional study. Examiners for different areas blinded to other variables Possible selection bias: workers in study were actively working when seen by researchers – those with symptoms and physical findings may be milder cases

Cross-sectional **Research Question:** To identify factors associated with rotator cuff syndrome (RCS) among active workers **Funding;** National Institute for Occupational Safety and Health	Manufacturing and Healthcare sites Initial walkthrough conducted by study ergonomists to categorize jobs. Facilities with at least 3/6 exposure categories eligible for inclusion **Information collection:** *Worker's health:* questionnaire (interviewers blinded to exposure and physical examinations) *Physical exposure:* Ergonomists *Health assessment:* Performed by trained health team staff (Dr, nurse, physio) Questionnaire interview on Demographics, health history, work history, body map Physical examination conducted bilaterally RCS diagnosed though current symptoms and RCS tests, no Hx of acute trauma to shoulder or RA	**(times/min)** 10≤X<20 1.76(.83-3.71) ≥ 20 1.01 (0.43-2.38) **Frequency of forceful exertions (times/min)** 1≤X<5 1.35(.68-2.71) ≥5 2.02(1.01-4.07) **Duty cycle of forceful exertions (% time)** 3≤X<15 3.27(1.52-7.02) ≥15 1.80(.81-4.03) **Lifting force – time weighted average (% time)** >0 1.79(.95 – 3.38) **Upper arm flexion $\geq 45^0$ (% time)** ≥18 2.16(1.22 – 3.83) **Upper arm flexion $\geq 45^0$ and duty cycle of forceful exertion (% time)** Intermediate 2.14(0.94-4.89) High-High 2.59(1.12-6.01) **Upper arm flexion $\geq 45^0$ and pinch grip force (% time)** Intermediate 1.09(.53 – 2.25) High-high 2.75(1.32-5.73) **Upper arm extension $>5^0$ or upper arm flexion $\geq 45^0$ and pinch grip force(% time)** Intermediate .81(.40-1.64) High-high 2.21(1.09-4.49) **Upper arm flexion or abduction $\geq 45^0$ and duty cycle of forceful**	≥80%/ if 60 – 80% is not selective Response at any follow-up is ≥80% or if non-response is not selective Data for physical load at work Methods described More than one dimension of load assessed (duration, frequency, amplitude) Data presented about psychosocial factors More than one psychosocial factors assessed Data collected about factors during leisure time Data collected about past occupational exposure Data collected on Hx shoulder disorders	**NR** **NR** **Y** **Y** **Y** **Y** **Y** **Y** **N** **Y**	than those off work Non-participants may have been concerned with employer not approving of participation, especially those from diverse cultural backgrounds Few subjects were doing exactly the same thing – needed to generalise results Extreme forces and postures usually avoided anyway as this can be less efficient and affect quality of product – affect ability to identify exposure/response relationships **SIGN evidence level** *(NB, although not usually used for CS studies has been used here so level of evidences is comparable with other study designs)*: **2-**

	Physical load assessment: Subjects observed by ergonomists onsite and videotaped using two synchronized cameras from two angles. **Exclusion criteria:** Working part-time, working in a mobile job or with more than four tasks, temporary staff also excluded. Also: Too few participants in some departments (n=42), did not meet criteria for exposure(n=20). Other: 32 did not enrol because they didn't know, were too busy/not interested, not asked/not around, 3 had other reasons	**exertion (% time)** Intermediate 2.41(1.1-4.94) High-high 1.33(.57-3.11) **Upper arm flexion or abduction ≥45⁰ and pinch grip force (% time)** Intermediate .81(0.42-1.57) High-high 2.02(1.00-4.1) *Associations between combined physical work load factors, OR adjusted for age, gender and BMI* **Variable** — **OR_{adj}(95%CI)** **Upper arm flexion ≥45⁰ and duty cycle of forceful exertion (% time)** Flexion ≥15% OR duty cycle <9% 2.14(0.94-4.89) Flexion ≥15% AND duty cycle ≥9% 2.59(1.12-6.01) **Upper arm flexion ≥45⁰ and pinch grip force (% time)** Flexion ≥15% OR pinch >0% 1.09(0.53 – 2.25) Flexion ≥15% AND pinch >0% 2.75(1.32-5.73)	Exposure measured in same way in controls Exposure assessment blinded to disease status Method for assessing shoulder Appropriate stats model (univariate/multivariate) Measures of associations presented (ORs/RRs) and 95% Cis Analysis is controlled for confounding or effect modification Number of cases in multivariate is at least 10x number of independent variables in analysis	Y Y Y Y Y Y	
Silverstein et al, 2009 Scandanavian Journal of Work, Environment and Health.	Same cohort of participants as was used in 2008 paper Data stratified analysed before but genders are separated for this paper	A greater proportion of women reported shoulder symptoms but there was no significant difference in prevalence of RCS between men and women after physical examination. Results for both Shoulder symptoms and RCS	Specific, clear objective Main features of study population described Cases and controls derived from same population with clear	Y Y Y	Bias: men and women may be subjected to different exposures at work – e.g. men are in jobs with higher structural constraints and more women were rotating

<table>
<tr>
<td>35:113 – 126

Research Question: To explore whether “adjustment” for gender make important exposure differences between men and women in a study of RCS and CTS work exposures

Funding:

Not-stated</td>
<td></td>
<td>cases are presented but only RCS will be reported in the following tables:

Men show almost no significant association for variables.

Women
<table>
<tr><th>Variable</th><th>OR(95% CI)</th></tr>
<tr><td>Frequency of forceful exertions (times/min)</td><td></td></tr>
<tr><td>1≤X<5</td><td>1.75(0.63-4.84)</td></tr>
<tr><td>≥5 vs. <1 times/min</td><td>3.35(1.19-9.42)</td></tr>
<tr><td>Duty cycle of forceful exertions (% time)</td><td></td></tr>
<tr><td>3≤X<15, <3% tme</td><td>3.16(1.06-9.44)</td></tr>
<tr><td>≥15, 3% time</td><td>2.91(0.94-9.01)</td></tr>
<tr><td>Lifting force – time weighted average (% time)</td><td></td></tr>
<tr><td>>0 vs. 0% time</td><td>3.76(1.46-9.68)</td></tr>
<tr><td>Upper arm flexion ≥45⁰ (% time)</td><td></td></tr>
<tr><td>≥18 vs. <18% time</td><td>3.12(1.12-7.68)</td></tr>
<tr><td>Upper arm extension ≥5⁰ or flexion ≥45⁰ (% time)</td><td></td></tr>
<tr><td>20 – 34 vs <20% time</td><td>6.16(1.76 – 21.57)</td></tr>
<tr><td>≥35 vs <20% time</td><td>2.97(0.69 – 12.82)</td></tr>
<tr><td>Upper arm flexion ≥45⁰ and pinch grip force(% time)</td><td></td></tr>
<tr><td>Flexion ≥15% <u>or</u> pinch grip vs flexion<15% and no pinch grip % time</td><td>2.48(0.66-9.41)</td></tr>
<tr><td>Flexion ≥15% <u>and</u> pinch grip vs flexion<15% and no pinch grip % time</td><td>7.06(1.94-25.66)</td></tr>
<tr><td>Vibration and pinch grip force</td><td></td></tr>
<tr><td>Flexion or abduction ≥20% <u>or</u> pinch grip vs. flexion or abduction <20% and no pinch grip</td><td>2.83(1.16-6.88)</td></tr>
</table>
</td>
<td>definitions of each stated

Participation rate ≥80%/ if 60 – 80% is not selective

Response at any follow-up is ≥80% or if non-response is not selective

Data for physical load at work

Methods described

More than one dimension of load assessed (duration, frequency, amplitude)

Data presented about psychosocial factors

More than one psychosocial factors assessed

Data collected about factors during leisure time

Data collected about past occupational exposure</td>
<td>NR

NR

Y

Y

Y

Y

Y

Y</td>
<td>SIGN evidence level
(NB, although not usually used for CS studies has been used here so level of evidences is comparable with other study designs): 2-</td>
</tr>
</table>

Variable	OR(95% CI)
% time	
Flexion or abduction ≥20% **and** pinch grip vs. flexion or abduction <20% and no pinch grip % time	4.80(0.90-25.77)
Upper arm flexion or abduction ≥45⁰ and pinch grip force (% time)	
Flexion or abduction ≥20% **or** pinch grip vs flexion or abduction <20% and no pinch grip % time	1.25(0.43-3.63)
Flexion or abduction ≥20% **and** pinch grip vs flexion or abduction <20% and no pinch grip % time	3.72(1.28-10.81)

Men

Variable	OR(95% CI)
Frequency of forceful exertions (times/min)	
1≤X<5	1.05(.41-2.71)
≥5 vs. <1 times/min	1.38(.54-3.52)
Duty cycle of forceful exertions (% time)	
3≤X<15, <3% time	3.16(1.09-9.17)
≥15, 3% time	1.25(.41-3.82)
Lifting force – time weighted average (% time)	
>0 vs. 0% time	.85(.37-1.93)
Upper arm flexion ≥45⁰ (% time)	
≥18 vs. <18% time	1.63(.76-3.51)
Upper arm extension ≥5⁰ or flexion ≥45⁰ (% time)	
20 – 34 vs <20% time	.77(.31-1.92)
≥35 vs <20% time	.89(.34-2.32)
Upper arm flexion ≥45⁰ and pinch grip force(% time)	
Flexion ≥15% **or** pinch grip vs flexion<15%	.71(.29-1.75)

Data collected on Hx shoulder disorders	**N**
Exposure measured in same way in controls	**Y**
Exposure assessment blinded to disease status	**Y**
Method for assessing shoulder	**Y**
Appropriate stats model (univariate/multivariate)	**Y**
Measures of associations presented (ORs/RRs) and 95% Cis	**Y**
Analysis is controlled for confounding or effect modification	**Y**
Number of cases in multivariate is at least 10x number of independent variables in analysis	**Y**

and no pinch grip % time	
Flexion ≥15% **and** pinch grip vs flexion<15% and no pinch grip % time	1.44(.53-3.94)
Vibration and pinch grip force	
Flexion or abduction ≥20% **or** pinch grip vs. flexion or abduction <20% and no pinch grip % time	1.33(.61-2.90)
Flexion or abduction ≥20% **and** pinch grip vs. flexion or abduction <20% and no pinch grip % time	1.98(.22-18.13)
Upper arm flexion or abduction ≥45⁰ and pinch grip force (% time)	
Flexion or abduction ≥20% **or** pinch grip vs flexion or abduction <20% and no pinch grip % time	.62(.26-1.48)
Flexion or abduction ≥20% **and** pinch grip vs flexion or abduction <20% and no pinch grip % time	1.22(.45-3.31)

Women and men – dominant-side rotator cuff syndrome , OR adjusted for age and BMI

Variable	Female, OR(95%CI)	Male, OR(95%CI)
Upper arm flexion ≥45⁰ and forceful pinch (% time)		
Flexion ≥15% or forceful pinch >0	2.41(0.63-9.17)	.65(.26-1.63)
Flexion ≥15% and forceful pinch >0	6.68(1.81-24.66)	1.45(.53-4.00)

<table>
<tr>
<td>Stenlund et al, 1993

Scandinavian Journal of Work, Environment Health, 19, 43 – 40

Study design

Cross-sectional

Research Question:

Determine whether signs of tendinitis or muscle attachment inflammation in the shoulders was related to different workloads, years of manual work, hours of exposure to vibration, or job title

Funding

Swedish Labour</td>
<td>Participants:

Representatives from study groups:

n = 54 bricklayers

n = 55 rockblasters

n = 98 foremen

26 – 70 years

Representatives from chosen from union work files, then invited to participate via phone.

Exclusion criteria:

Did not want to participate because live at a distance or abroad, language difficulties.

Method:

Questions developed by examine worklife, exposure, years of manual work, outside sports activities etc and used by trained nurses when interviewing participants.

Exposure: analysed based on sum of – loads lifted during work years, sum of hours exposed to</td>
<td>Results:

Initial results only adjusted for age, dexterity, smoking and sports activities

<table>
<tr><th>Variable</th><th>Right side OR; 95%CI</th><th>Left side OR; 95%CI</th></tr>
<tr><td>Lifted Load: 0-709,710-25999>25999</td><td>1.04(0.5-2.18)</td><td>1.55(0.58-4.12)</td></tr>
<tr><td>Vibration: 0-8999,9000-255199 > 255199 hrs</td><td>1.86(1.00-3.44)</td><td>2.49(1.06-5.87)</td></tr>
<tr><td>Manual work: 0-9, 10-28, >28 years of manual work</td><td>0.96(0.51-1.83)</td><td>2.31(0.85-6.28)</td></tr>
</table>

Results controlled for hours of participation in sports

<table>
<tr><th>Variable</th><th>Right side OR; 95%CI</th><th>Left side OR; 95%CI</th></tr>
<tr><td>Lifted Load: 0-709,710-25999>25999t</td><td>1.02(0.59-1.76)</td><td>1.81(0.95-3.44)</td></tr>
<tr><td>Vibration: 0-8999,9000-255199 > 255199 hrs</td><td>1.66(1.06-2.61)</td><td>1.84(1.10-3.07)</td></tr>
<tr><td>Manual work: 0-9, 10-28, >28 years of manual work</td><td>1.10(0.68-1.79)</td><td>1.87(1.03-3.40)</td></tr>
</table>

High vs low exposures for each variable did not</td>
<td>Specific, clear objective

Main features of study population described

Cases and controls derived from same population with clear definitions of each stated

Participation rate ≥80%/ if 60 – 80% is not selective

Response at any follow-up is ≥80% or if non-response is not selective

Data for physical load at work

Methods described

More than one dimension of load assessed (duration, frequency, amplitude)

Data presented about psychosocial factors

More than one psychosocial factors</td>
<td>Y
Y

NR

NR

NR

Y

Questionnaire

Y

N

N</td>
<td>Funded by Insurance Company. Performed on a specific group of workers who were all male – selective but also decreased heterogeneity.

Potential confounders (smoking/age/dexterity, sports activities) were included in all logistic regression models.

Shoulder tendinitis not limited to rotator cuff muscles, also included isometric contraction of biceps brachii.

Results unclear in Tables 3 – 5 about what model 1,2 and 3 are (see paper)

Author discussed selection bias – if a worker has tendinitis they would be unable to work in these occupations anyway to it is possible that the results in this study are an underestimation of the current relative risk.</td>
</tr>
</table>

Market Insurance Company,	vibrations, years of manual work. Load: summarised on annual basis. Included: loads lifted per day and weight. **Clinical Examination:** Examiner blinded to exposure. Medical history included	show any significant associations **Author Conclusions:** Vibration exposure yielded an OR on 1.84 and 1.66 for right sides, respectively – vibration exposure or work as a rockblaster seemed to be risk indicators for tendinitis of the shoulder.	assessed Data collected about factors during leisure time Data collected about past occupational exposure Data collected on Hx shoulder disorders Exposure measured in same way in controls Exposure assessment blinded to disease status Method for assessing shoulder Appropriate stats model (univariate/multivariat e) Measures of associations presented (ORs/RRs) and 95% Cis Analysis is controlled for confounding or effect modification	**Y** **Y** **Y** **NR** **Y** **Y** **Y** **Y** **Y**	

			Number of cases in multivariate is at least 10x number of independent variables in analysis		
Sutinen et al, 2006 International Archives of Occupational Environmental Health. 79, 665 – 671 **Study design:** Cohort study: ?Prospective **Research Question:** Follow-up study that evaluated the prevalence of Hand-arm vibration syndrome and the cumulative exposure to vibration among	**Participants:** n = 52 Forestry workers Follow-up study that started in 1976. Total exposure was recorded during 11 cross-sectional surveys and from these a "lifetime dose" of vibration energy was calculated. **Follow-up from original study** 139 in original cohort, 19 excluded because of not working in those 19 years. Those having active or inactive vibration "white finger" where matched according to vibration exposure and age. **Exclusion:** Not have worked in the 19 years between initial examination and follow-up, missing data **Inclusion:** Subjects with more than 1,500h of chain sawing in three	19 year old cohort of Finnish forestry workers Numbness was associated with right rotator cuff syndrome (p=0.034). **Factors predicting right rotator cuff syndrome: logistic regression model** Lifelong vibration energy: $OR_{(age\ adjusted)}$ 1.04; 95% CI (1.00 – 1.07) **Author conclusions:** Hand-arm vibration is associated with right rotator-cuff syndrome forestry workers	Specific, clear objective Main features of study population described Cases and controls derived from same population with clear definitions of each stated Participation rate ≥80%/ if 60 – 80% is not selective Response at any follow-up is ≥80% or if non-response is not selective Data for physical load at work Methods described More than one dimension of load assessed (duration, frequency, amplitude) Data presented about	**Y** **Y** **NR** **NR** **NR** **N** **Y** **N** **N**	Examined the effects of vibration in a small cohort Vibration based on a calculative measure that cumulates all vibration over length of the cohort High loss to follow-up, possible reasons why or how this could affect the final outcome of the study were not taken into account. Other risk factors that could lead to shoulder pain and be linked to forestry work such as load or posture not included. It should be noted that risk factors were not the focus of this study. This study focused on the links between vibration and numbness in forestry workers. **SIGN evidence level** *(NB, although not usually used for CS studies has been used here so level of evidences is comparable with other study*

a cohort of forestry workers **Funding:** Finnish National Board of Forestry and North Karelian Hospital and Forestry Workers Fund in Finland	consecutive years before examinations **Lifetime dose calculation:** Vibration was measured from the chainsaw and does calculated using a formula derived from another study that took into account daily and total yearly frequency. **Medical History** Structured questionnaire of upper limb and neck pain history, and occupational history of vibration exposure. Clinical examination performed by physicians Rotator cuff diagnosed based on painful arch, pain resisted abduction or external rotation, intermittent pain and tenderness locally in shoulder region		psychosocial factors More than one psychosocial factors assessed Data collected about factors during leisure time Data collected about past occupational exposure Data collected on Hx shoulder disorders Exposure measured in same way in controls Exposure assessment blinded to disease status Method for assessing shoulder Appropriate stats model (univariate/multivariate) Measures of associations presented (ORs/RRs) and 95% Cis	 **N** **N** **Y** **N** **Y** **N** **Y** **Y** **Y**	*designs)*: **2-**

<table>
<tr>
<td></td>
<td></td>
<td></td>
<td>Analysis is controlled for confounding or effect modification

Number of cases in multivariate is at least 10x number of independent variables in analysis</td>
<td>Y – only age adjusted</td>
<td></td>
</tr>
<tr>
<td>Svendsen et al, 2004a
Occupation Environmental Medicine. 61, 844 – 853.
Study design:
Cross-sectional
Research Question:
To determine quantitative exposure-response relations between work with highly elevated arms and supraspinatus tendinitis, shoulder pain with and without</td>
<td>Participants:
N = 1,886
Population derived from a cohort of male machinists, car mechanics, and house painters. Within a geographical area appropriate companies were identified.
Inclusion:
Machine shops were only included If had more than five journeymen and if they had computer operated numerically controlled tools.
Exclusion:
Questionnaire respondents who had worked less than one year as a journeyman, in one of the three trades, more than three years in other jobs that had considerable exposure with regards to awkward postures, force and highly repetitive work.
Methods</td>
<td>House painters had the highest prevalence of dominant shoulder complaints and disorders. Prevalence of disorders increased with increasing lifetime upper arm elevation, however associations for a 10 year increase in duration of employment with one of the three trades were negative and not significant: OR .82; 95% CI(.52-1.06).

<table>
<tr><th>Variable</th><th>N</th><th>OR (95% CI)</th></tr>
<tr><td>Current upper arm elevation above 90⁰ (% working hours)</td><td></td><td></td></tr>
<tr><td>0 – 3</td><td>1316</td><td>1.00</td></tr>
<tr><td>3-6</td><td>1213</td><td>0.94(0.37 – 2.39)</td></tr>
<tr><td>6 – 9</td><td>538</td><td>4.7 (2.07 – 10.68)</td></tr>
<tr><td>Trend analysis (for an increment of 1% of working hours)</td><td>3067</td><td>1.4 (1.10 – 1.39)</td></tr>
</table>

Supraspinatus tendinitis in relation to lifetime upper arm elevation above 90⁰ . OR_{adj} for 10 year age categories and pack smoking</td>
<td>Specific, clear objective

Main features of study population described

Cases and controls derived from same population with clear definitions of each stated

Participation rate ≥80%/ if 60 – 80% is not selective

Response at any follow-up is ≥80% or if non-response is not selective

Data for physical load at work

Methods described

More than one dimension of load</td>
<td>Y

Y

NR

Y

NR

N

Y

N</td>
<td>Only looked at once facet of RCS – supraspinatus tendinitis.
Assumed that measure of exposure in subset of workers from each occupation were representative of the whole group.

SIGN evidence level
(NB, although not usually used for CS studies has been used here so level of evidences is comparable with other study designs): 2-</td>
</tr>
</table>

disability **Funding:** Danish National Working Environment Authority, Danish Rheumatism Association, Danish Health Insurance Fund, Research Initiative of Aarhus University Hospital	***<u>Exposure:</u>*** **Survey:** <u>Inclusion</u> was at least one year of employment, male aged between 30 – 65, and four work days in specified week. <u>Excluded</u> if had shoulder complaints that interfered with work performance, or did not want to participate. House painters who used both hands equally well (n = 37) were excluded from total study population. Measures were through sensors for postures, force by a force index, ***<u>Physical exam</u>*** Examiners (n = 2) blinded to exposure status.	(see table below)	assessed (duration, frequency, amplitude)		
			Data presented about psychosocial factors	**Y**	
			More than one psychosocial factors assessed	**Y**	
			Data collected about factors during leisure time	**N**	
			Data collected about past occupational exposure	**Y**	
			Data collected on Hx shoulder disorders	**Y**	
			Exposure measured in same way in controls	**NR**	
			Exposure assessment blinded to disease status	**CS**	
			Method for assessing shoulder	**Y**	
			Appropriate stats model (univariate/multivariate)	**Y**	

Lifetime exposure (mth; dominant shoulder)	OR_{curde}	OR_{adj} (95% CI)
0-6	1.00	1.00
6 – 12	0.80	0.73 (0.27 – 1.94)
12 – 24	1.33	1.33 (0.57 – 2.99)
≥24	2.74	1.87(0.79 – 4.44)
Trend analysis (for 6 month increments)		1.14(0.97 – 1.35)

<table>
<tr><td></td><td></td><td></td><td>Measures of associations presented (ORs/RRs) and 95% Cis

Analysis is controlled for confounding or effect modification

Number of cases in multivariate is at least 10x number of independent variables in analysis</td><td>Y

Y

</td><td></td></tr>
<tr><td>Svendsen et al, 2004b

Arthritis and Rheumatism. 50, 3314 – 3322

Study design:

Cross-sectional

Research question:

To determine whether work performed in the</td><td>Participants: (subgroup of participants from same cohort as Svendsen et al, 2004a)

n = 132 (out of 196: 71%)

Cohort of male machinists, car mechanics, and house painters. Right-handed and employed in trades for not less than 10 years.

Aged 40 – 50 years

Inclusion criteria:

Age between 40 – 50 years, right handed, worked as a journeyman in 1/3 trades for at least 10 years, of which at least 9 were in the last 15years.</td><td>Supraspinatus tendinopathy was significantly related to lifetime upper arm elevation,

<table>
<tr><th>Lifetime exposure ($>90^0$ elevation of dominant shoulder; months)</th><th>OR_{curde}</th><th>OR_{adj} (95% CI)</th></tr>
<tr><td>0 - <10</td><td>1.00</td><td></td></tr>
<tr><td>10-<20</td><td>0.95</td><td>0.95(0.41-2.20)</td></tr>
<tr><td>≥20months</td><td>2.38</td><td>2.33(0.93 – 5.84)</td></tr>
<tr><td>Continuous (5 month increments)</td><td>1.29</td><td>1.27(1.02-1.60)</td></tr>
</table>
OR_{adj} adjusted for continuous age

<table>
<tr><th>Lifetime shoulder force requirements</th><th>OR_{curde}</th><th>OR_{adj} (95% CI)</th></tr>
<tr><td>Low</td><td>1.00</td><td></td></tr>
<tr><td>Medium</td><td>1.58</td><td>1.24(0.48 – 3.18)</td></tr>
<tr><td>High</td><td>0.79</td><td>0.71(0.30-1.65)</td></tr>
</table>
</td><td>Specific, clear objective

Main features of study population described

Cases and controls derived from same population with clear definitions of each stated

Participation rate ≥80%/ if 60 – 80% is not selective

Response at any follow-up is ≥80% or if non-response is not selective

Data for physical load at work</td><td>Y
Y

NR

NR

NR

Y</td><td>Lifetime use of shoulder with the arm in elevated positions show positive associations with supraspinatus tendinopathy.

Calculations based on a formula using averages and assumptions – open to errors.

Specific identification of tendinopathies

SIGN evidence level
(NB, although not usually used for CS studies has been used here so level of evidences is comparable with other study designs): 2-</td></tr>
</table>

arms in a highly elevated position is associated with alterations in the rotator cuff tendons as assessed by MRI **Funding:** Danish Rheumatism Association, Danish Health Insurance Fund and the Research Initiative of Aarhus University Hospital	**Exclusion criteria:** *Questionnaire based:* Shoulder intensive sports (>3hrs/week in 1990s or >5 hrs/week in 1980s), previous traumatic shoulder injury, diabetes, thyroid disorders, weight >120kg. Pacemaker, suspected metallic foreign objects **Exposure quantification:** Whole day inclinometer measurements for four consecutive days. Force index used for combined posture and force measurements. List of previous jobs were extracted for each participant. Lifetime exposure calculated by measuring average exposure for each job. **MRI exam** Dominant shoulder only. Radiologists blinded to exposure status.		Methods described More than one dimension of load assessed (duration, frequency, amplitude) Data presented about psychosocial factors More than one psychosocial factors assessed Data collected about factors during leisure time Data collected about past occupational exposure Data collected on Hx shoulder disorders Exposure measured in same way in controls Exposure assessment blinded to disease status Method for assessing shoulder Appropriate stats	**Y** **CS** **N** **N** **Y** **Y** **Y** **NR** **CS** **Y**	

			model (univariate/multivariate)	**Y**	
			Measures of associations presented (ORs/RRs) and 95% Cis	**Y**	
			Analysis is controlled for confounding or effect modification	**Y (Age)**	
			Number of cases in multivariate is at least 10x number of independent variables in analysis		

** Used methodological assessment of cross-sectional study checklist devised by van der Windt (2000)*