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ORIGINAL ARTICLE

Exposure–response relationships between cumulative occupational shoulder exposures and different diagnoses related to surgery for subacromial impingement syndrome

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Abstract

Purpose The aim was to examine associations between cumulative occupational shoulder exposures and different diagnoses related to surgery for subacromial impingement syndrome (SIS).

Methods We re-analysed data from a previous register-based cohort study of the Danish working population (2,374,403 persons) with follow-up 2003–2008. The outcomes were eight different SIS-related diagnosis codes (M19, M75.1-5, and M75.8-9) in combination with SIS-related surgery codes. Occupational shoulder exposures were estimated by combining occupational codes with an expert-rated job exposure matrix. Cumulative exposure estimates were calculated for 10-year time windows and expressed as exposure-years. We used a logistic regression technique equivalent to discrete survival analysis.

Results Exposure–response relationships were found between most occupational shoulder exposures and the different SIS-related diagnosis codes. For arm-elevation-years, M19, M75.1, and M75.4 reached maximum adjusted odds ratio (OR_{adj}) of 2.0–2.4, while the maximum OR_{adj} for M75.3 was 1.6; we found intermediate values for the remaining diagnoses. The relationships were almost similar for repetition-years and shoulder-load-years. For force-years, maximum OR_{adj} of 1.7–1.9 was seen for M19, M75.1, and M75.4, while M75.3 reached a maximum OR_{adj} of 1.3. For HAV-years, M19, M75.1, and M75.4 reached maximum OR_{adj} of 1.5–1.7, while M75.3 reached a maximum OR_{adj} of 1.1.

Conclusion We found associations between all occupational shoulder exposures and the eight different SIS-related diagnoses; exposure–response relationships were found for most diagnoses. The highest risks were seen for M19 (acromioclavicular osteoarthritis), M75.1 (rotator cuff syndrome), and M75.4 (impingement syndrome), and the lowest for M75.3 (calcific tendinitis).

Keywords Acromioplasty · Arm elevation · Cumulative exposure · Force · Job exposure matrix · Repetition

Introduction

Subacromial impingement syndrome (SIS) encompasses a variety of non-traumatic shoulder disorders. Associations between occupational mechanical shoulder exposures and SIS have been examined in several studies, including three systematic reviews (van Rijn et al. 2010; van der Molen et al. 2017; Dalbøge et al. 2019). We have previously found an almost doubled risk of surgery for SIS in relation to high cumulative exposures to work with upper arm elevation > 90° [adjusted odds ratio (OR_{adj}) = 2.1], repetitive shoulder movements (OR_{adj} = 1.9), and forceful shoulder exertions (OR_{adj} = 1.7) (Dalbøge et al. 2014). In the just mentioned study, we lumped together other and unspecified osteoarthritis (M19, which represents acromioclavicular osteoarthritis when combined with surgery codes for SIS), rotator cuff syndrome including rotator cuff tear/rupture not specified as traumatic (M75.1), bicipital tendinitis (M75.2), calcific tendinitis (M75.3), impingement syndrome (M75.4), bursitis (M75.5), other shoulder lesions (M75.8), and shoulder lesion, unspecified (M75.9), diagnosed according to the 10th version of International Classification of Diseases (ICD-10). The rationale was that the selection of one

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particular diagnosis code from this list would be somewhat arbitrary due to a lack of authoritative diagnostic criteria. For example, M75.1 and M75.4 represent the same disorder according to Danish national clinical guidelines (Sundhedsstyrelsen [The Danish Health and Medicines Authority] 2013), and if surgery is registered under the diagnoses M75.8 and M75.9, this might well be explained by failure to update the diagnosis code at discharge. On the other hand, the probability of a diagnosis of M19 and M75.3 is most likely increased in case of imaging results or intraoperative findings pointing to these pathoanatomic diagnoses, which speaks for diagnosis code-specific analyses.

In Denmark, only rotator cuff syndrome including rotator cuff tear/rupture not specified as traumatic (M75.1), bicipital tendinitis (M75.2), and impingement syndrome (M75.4) are on the list of occupational diseases, while acromioclavicular osteoarthritis (M19) with spurs affecting the subacromial tissues and calcific tendinitis (M75.3) are considered competing causes [Arbejdsmarkedets Erhvervssikring [Labour Market Insurance] (2019), https://www.retsinformation.dk/Forms/R0710.aspx?id=183350]. However, it is a clinical experience that acromioclavicular osteoarthritis (M19) is often present in patients with rotator cuff syndrome/impingement syndrome. [This was an original part of the rationale for decompression surgery (Neer 1983).] This challenges the distinction between M19 and M75.1/M75.4 in compensation claim cases of SIS. We are not aware of studies, which have evaluated the association between different SIS-related diagnoses and cumulative occupational shoulder exposures. This knowledge would be of value not only in a Danish context, but also in other countries, where SIS-related diagnoses are increasingly strong candidates for prescription as occupational diseases (van der Molen et al. 2017).

The aim of this study was to examine associations between cumulative occupational shoulder exposures and different diagnoses related to surgery for SIS. We hypothesised that we would find steeper exposure–response relationships for acromioclavicular osteoarthritis (M19) and rotator cuff syndrome/impingement syndrome (M75.1 and M75.4) than for calcific tendinitis (M75.3).

Methods

Design and population

We re-analysed data from our previous cohort study, which was based on data from four Danish registers (the Civil Registration System, the Supplementary Pension Fund Register, the Employment Classification Module, and the National Patient Register) and an expert-rated job exposure matrix, The Shoulder JEM (Dalbøge et al. 2014). The cohort included all persons born 1933–1977 and living in Denmark at the end of 2002 with no prior shoulder surgery (1996–2002). Follow-up started in 2003 for persons with ≥ 5 years of full-time employment since 1993; persons with < 5 years of full-time employment by 2003 entered follow-up the year after they reached 5 years of full-time employment. The Danish Data Protection Agency approved the study (J. No.: 2012-41-1187). In Denmark, register studies do not need approval from the Committee System on Biomedical Research Ethics (Request No. 130/2009).

Outcomes

The outcomes were SIS-related diagnoses (ICD-10 codes M19, M75.1-5, and M75.8-9) without a subordinate code of M75.0 (adhesive capsulitis of shoulder) in combination with a SIS-related surgery code (KNBA, KNBE-H, and KNBK-M) based on the Nordic Medico-Statistical Committee Classification (Dalbøge et al. 2014, 2017, 2018).

Exposures

Occupational shoulder exposures included upper arm elevation > 90°, repetitive shoulder movements, forceful shoulder exertions, hand–arm vibrations (HAVs), and "shoulder load", a joint measure of the three first mentioned exposures (Dalbøge et al. 2014, 2017; Svendsen et al. 2013). To obtain cumulative exposure estimates for 10-year exposure time windows, we combined individual year-by-year occupational codes according to the Danish version of the International Standard Classification of Occupations from 1988 with The Shoulder JEM (Dalbøge et al. 2014). The JEM, which provided exposure intensity estimates based on expert ratings, has been validated against technical measurements with positive results (Dalbøge et al. 2016).

Cumulative exposure estimates were calculated according to the pack-year concept of smoking. One arm-elevation-year was defined as working with the arm(s) elevated > 90° for 0.5 h/day for 1 year, 1 repetition-year was defined as performing moderately repetitive work for 4 h/day for 1 year or highly repetitive work for 1 h/day for 1 year, 1 force-year was defined as working with a force score of 2 for 1 year [range 1 (low) to 5 (near maximal)], and one HAV-year was defined as working with a hand-held vibrating tool with low acceleration for 1 h/day or with moderate acceleration for 0.5 h/day for 1 year. Shoulder load was scored 0 (low), 1 (medium), and 2 (high), and 1 shoulder-load-year was defined as a shoulder load score of 1 for 1 year (Dalbøge et al. 2014). The exposure estimates were categorised as described previously (Dalbøge et al. 2014).

Covariates

We obtained register information on sex, age, region of residence, and calendar year of start of follow-up, which we included as covariates (Dalbøge et al. 2014).

Statistical analyses

Follow-up time was calculated from 1 January 2003 for persons with more than 5 years of full-time employment by that date and continued until the first of the following events: surgery for SIS, censoring due to surgery for any other shoulder disorder, the person's 70th birthday, death, disappearance or emigration, or 31 December 2008. Persons with less than 5 years of full-time employment entered follow-up the year after they reached 5 years of full-time employment. We applied models with time-varying exposures using a 1-year lag time. To study the association between cumulative exposures and each of the eight SIS-related diagnoses, we performed logistic regression as discrete survival analysis (Richardson 2010); the resulting OR can be interpreted as a hazard ratios. In the regression analyses, we adjusted for sex, time-varying age (five categories), region of residence (five categories), and calendar year of start of follow-up. Tests for trend were performed using exposure categories as continuous variables. All analyses were performed on Statistics Denmark's research platform using STATA V.15 (Stata Corp, College Station, Texas, USA).

Results

The cohort included 2,374,403 persons (51.3% men) with a total follow-up time of 13,332,922 person-years. The mean age was 47.4 years (SD = 11.2) for men and 47.2 years (SD = 10.8) for women; 57% of the men and 67% of the women were employees at intermediate level. A total of 14,118 first-time events of surgery for SIS occurred during follow-up.

Table 1 shows the diagnostic distribution and the results of the analyses of associations between cumulative occupational shoulder exposures and the eight different SIS-related diagnosis codes. M19 accounted for 10% of the diagnoses, M75.1 for 15%, M75.2 for 1%, M75.3 for 2%, M75.4 for 62%, M75.5 for 2%, M75.8 for 2%, and M75.9 for 6%. Exposure–response relationships were found between most of the occupational shoulder exposures and the SIS-related diagnosis codes. For arm-elevation-years, M19, M75.1, and M75.4 reached maximum OR_{adj} of 2.0-2.4, while the maximum OR_{adj} for M75.3 was 1.6; intermediate values were seen for the remaining diagnoses. Almost similar results were found for repetition-years and shoulder-load-years. For force-years, maximum OR_{adj} for M19, M75.1, and M75.4 ranged between 1.7 and 1.9, while M75.3 reached a maximum OR_{adj} of 1.3. For HAV-years, M19, M75.1, and M75.4 reached maximum OR_{adj} of 1.5–1.7, while M75.3 reached a maximum OR_{adj} of 1.1.

Discussion

We found an association between all occupational shoulder exposures and the eight different SIS-related diagnoses; exposure–response relationships were found for most diagnoses. The highest OR_{adj} was found for M19 (acromioclavicular osteoarthritis), M75.1 (rotator cuff syndrome), and M75.4 (impingement syndrome), and the lowest for M75.3 (calcific tendinitis).

The strength of the study was that the cohort included the entire Danish working population with almost complete follow-up and that information on outcomes, exposures, and covariates was obtained from high-quality registers and a validated JEM. The use of JEM-based exposure estimates allowed retrospective exposure assessment without recall bias, which might have influenced the results if self-reported exposure estimates had been applied (Dalbøge et al. 2014).

The diagnoses M75.1 to M75.9 have clinical characteristics in common (Watts et al. 2017), but probably differ with respect to pathoanatomic findings. Bicipital tendinitis (M75.2) was represented by only 98 cases, so the results regarding this diagnosis are uncertain. Calcific tendinitis (M75.3) accounted for 2% of the diagnoses in the present study, which is much less than the prevalence of calcific deposits of > 20% in a recent magnetic resonance imaging study of patients referred for orthopaedic evaluation on suspicion of SIS (Kvalvaag et al. 2017). Calcific deposits may be endogenous or a secondary manifestation of tendon degeneration, which could potentially be work-related (Descatha et al. 2012). Based on the just mentioned percentages and the relatively flat exposure–response relationships in the present study, it seems that in Denmark, the diagnosis calcific tendinitis tends to be used in case of endogenous calcific deposits. More in-depth studies with imaging data are needed to clarify the relationships between occupational shoulder exposures and specific types of calcific deposits.

The finding of exposure–response relationships between occupational shoulder exposures and acromioclavicular osteoarthritis (M19) agrees with the few previous studies in this field of research (Stenlund et al. 1992; Nordander et al. 2009, 2016), although it may be questioned if the clinical diagnosis "acromioclavicular syndrome" (Nordander et al. 2009, 2016) represents acromioclavicular osteoarthritis. Our results suggest that acromioclavicular osteoarthritis might be work-related and question the current subtract for acromioclavicular osteoarthritis with spurs affecting the subacromial tissues in compensation claim cases of SIS in Denmark, but

Table 1 Associations between cumulative occupational shoulder exposures and diagnoses related to surgery for subacromial impingement syndrome

ICD-10 diagnosis	M19*		M75.1		M75.2		M75.3		M75.4		M75.5		M75.8		M75.9	
	Other and unspecified osteoarthritis ($n = 1451$)		Rotator cuff syndrome ($n = 2084$)		Bicipital tendinitis (n = 98)		Calcific tendinitis of shoulder ($n = 297$)		Impingement syndrome of shoulder ($n = 8763$)		Bursitis of shoulder ($n = 325$)		Other shoulder lesions ($n = 309$)		Shoulder lesion, unspecified ($n = 791$)	
Exposure	OR_{adj}	95% CI	OR_{adj}	95% CI	OR_{adj}	95% CI	OR_{adj}	95% CI	OR_{adj}	95% CI	OR_{adj}	95% CI	OR_{adj}	95% CI	OR_{adj}	95% CI
Arm-elevation-years																
0	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–
> 0–2	1.3	1.1–1.6	1.5	1.3–1.7	1.6	0.9–2.8	1.3	0.9–1.7	1.4	1.4–1.5	1.2	0.9–1.7	1.2	0.9–1.7	1.6	1.3–1.9
> 2–5	1.6	1.4–2.0	1.6	1.4–1.9	1.3	0.7–2.6	1.5	1.1–2.2	1.5	1.4–1.6	1.6	1.1–2.3	1	0.7–1.5	1.6	1.3–2.0
> 5–10	2.1	1.8–2.6	1.9	1.7–2.2	1.7	0.9–3.4	1.6	1.1–2.3	1.8	1.7–2.0	1.6	1.1–2.4	1.3	0.9–2.0	1.8	1.4–2.2
> 10–56	2.2	1.9–2.6	2.4	2.1–2.8	1.7	0.9–3.1	1.6	1.1–2.3	2	1.9–2.2	1.7	1.2–2.4	1.6	1.1–2.2	1.8	1.5–2.3
	p for trend < 10^{-3}		p for trend < 10^{-3}		p for trend = 0.110		p for trend = 0.005		p for trend < 10^{-3}		p for trend < 10^{-3}		p for trend = 0.016		p for trend < 10^{-3}	
Repetition-years																
0	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–
> 0–1	1.3	1.1–1.6	1.3	1.1–1.4	1.5	0.8–2.7	1.3	0.9–1.8	1.2	1.1–1.3	1.1	0.8–1.6	0.8	0.6–1.2	1.3	1.0–1.6
> 1–2	1.8	1.5–2.1	1.6	1.4–1.8	1.9	1.0–3.6	1.2	0.8–1.9	1.6	1.5–1.7	1.2	0.8–1.8	0.9	0.6–1.4	1.3	1.0–1.7
> 2–10	1.8	1.6–2.1	1.7	1.5–1.9	1.3	0.7–2.3	1.2	0.9–1.7	1.5	1.4–1.6	1.5	1.1–2.0	1.3	1.0–1.8	1.6	1.3–1.9
> 10–68	2.4	2.0–2.7	2.2	1.9–2.5	1.4	0.8–2.7	1.5	1.0–2.1	1.9	1.8–2.0	1.6	1.2–2.3	1.6	1.2–2.2	1.8	1.5–2.2
	p for trend < 10^{-3}		p for trend < 10^{-3}		p for trend = 0.231		p for trend = 0.036		p for trend < 10^{-3}		p for trend = 0.001		p for trend = 0.001		p for trend < 10^{-3}	
Force-years																
< 5	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–
5	0.6	0.5–0.7	0.6	0.5–0.8	1.1	0.6–2.2	0.8	0.5–1.2	0.6	0.7–0.8	0.6	0.4–0.9	0.9	0.6–1.3	0.6	0.5–0.8
> 5–7.5	1	0.9–1.2	1.2	1.0–1.3	1.2	0.7–2.3	1.3	1.0–1.9	1.2	1.1–1.3	1.1	0.8–1.5	1.1	0.8–1.5	1.1	0.9–1.4
> 7.5–10	1.4	1.2–1.7	1.6	1.4–1.8	1.2	0.6–2.5	1.2	0.9–1.8	1.5	1.4–1.6	1.5	1.1–2.1	1	0.6–1.4	1.5	1.2–1.9
> 10–20	1.8	1.5–2.2	1.9	1.6–2.2	1.8	0.9–3.6	1.3	0.9–2.1	1.7	1.6–1.8	1.4	1.0–2.1	1.8	1.3–2.6	1.4	1.1–1.7
	p for trend < 10^{-3}		p for trend < 10^{-3}		p for trend = 0.094		p for trend = 0.028		p for trend < 10^{-3}		p for trend < 10^{-3}		p for trend = 0.003		p for trend < 10^{-3}	
HAV-years																
0	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–
> 0–5	1.5	1.3–1.7	1.2	1.1–1.4	1.1	0.7–1.9	1.2	0.9–1.6	1.3	1.2–1.4	1.4	1.1–1.7	1.2	0.9–1.5	1.2	1.1–1.5
> 5–58	1.7	1.4–1.9	1.6	1.4–1.8	2	1.2–3.5	1.1	0.7–1.7	1.5	1.4–1.6	1.2	0.8–1.8	1.5	1.0–2.0	1.5	1.2–1.8
	p for trend < 10^{-3}		p for trend < 10^{-3}		p for trend = 0.020		p for trend = 0.333		p for trend < 10^{-3}		p for trend = 0.081		p for trend = 0.026		p for trend < 10^{-3}	

Table 1 (continued)

ICD-10 diagnosis	M19*		M75.1		M75.2		M75.3		M75.4		M75.5		M75.8		M75.9	
	Other and unspecified osteoarthritis ($n=1451$)		Rotator cuff syndrome ($n=2084$)		Bicipital tendinitis (n = 98)		Calcific tendinitis of shoulder ($n=297$)		Impingement syndrome of shoulder ($n=8763$)		Bursitis of shoulder ($n=325$)		Other shoulder lesions ($n=309$)		Shoulder lesion, unspecified ($n=791$)	
Exposure	OR_{adj}	95% CI	OR_{adj}	95% CI	OR_{adj}	95% CI	OR_{adj}	95% CI	OR_{adj}	95% CI	OR_{adj}	95% CI	OR_{adj}	95% CI	OR_{adj}	95% CI
Shoulder-load-years																
0	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–	1.0	–
> 0–5	1.4	1.2–1.7	1.5	1.3–1.7	1.2	0.6–2.3	1.6	1.1–2.2	1.4	1.3–1.5	1.4	1.0–2.0	1.3	0.9–1.8	1.2	0.9–1.5
> 5–10	1.8	1.6–2.0	1.8	1.6–2.0	1.3	0.8–2.1	1.2	0.9–1.7	1.6	1.5–1.7	1.7	1.3–2.2	1.4	1.1–1.9	1.6	1.4–1.9
> 10–15	2.2	1.8–2.7	2	1.7–2.4	1.2	0.5–3.0	1.4	0.8–2.5	1.8	1.6–2.0	1.2	0.7–2.1	2.2	1.5–3.3	1.7	1.3–2.3
> 15–20	2.2	1.8–2.6	2.4	2.1–2.7	1.4	0.7–2.7	1.8	1.2–2.8	2	1.9–2.1	2	1.4–2.9	1.6	1.1–2.3	1.6	1.2–2.0
	p for trend $< 10^{-3}$		p for trend $< 10^{-3}$		p for trend $= 0.266$		p for trend $= 0.006$		p for trend $< 10^{-3}$		p for trend $< 10^{-3}$		p for trend $< 10^{-3}$		p for trend $< 10^{-3}$	

The odds ratios (ORs) can be interpreted as hazard ratios. OR_{adj} was adjusted for sex, age, region of residence, and calendar year at start of follow-up

* This diagnosis represents acromioclavicular osteoarthritis when combined with surgery codes for SIS

HAV Hand–arm vibration

again, more in-depth studies with imaging data are warranted to clarify this issue.

In conclusion, we found associations between cumulative occupational shoulder exposures and the eight different SIS-related diagnoses; exposure–response relationships were found for most diagnoses. The highest risks were seen for acromioclavicular osteoarthritis and rotator cuff syndrome/impingement syndrome, and the lowest for calcific tendinitis.

Authors contribution AD performed the analysis and drafted the paper in close collaboration with SWS, PF, and JHA. All authors have reviewed the paper for important intellectual content, approved the final version of the manuscript, and took responsibility for the integrity of the work as a whole.

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Compliance with ethical standards

Conflict of interest The authors declare no conflicts of interest.

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