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DISABLING SHOULDER LESIONS – OCCUPATIONAL AND NON-OCCUPATIONAL RISK FACTORS FOR PROLONGED WORK DISABILITY AND WORKING YEARS LOST

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DOCTORAL DISSERTATION

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ABSTRACT

Background Shoulder diseases are common among working populations, especially among manual workers. Symptomatic shoulder lesions predominantly manifest as pain while loading and abducting the arm, which often continues at rest. Shoulder pain is known to cause disability, absences from work and significant healthcare costs.

Because the pathomechanisms of most shoulder lesions are degenerative, they become more prevalent with age and usually affect individuals in the middle or latter part of their working careers. However, little is known about how a shoulder lesion impacts work participation or how prolonged work disability due to a shoulder lesion could be prevented.

Aims The first objective of this thesis study was to examine the impact of a disabling shoulder lesion on work participation and working life expectancy. Further objectives were to identify the occupational risk factors as well as the occupations with a high risk of disability retirement due to a shoulder lesion. The final aim was to determine the associations of lifestyle factors and cumulative workload factors with SA due to a shoulder lesion.

Methods Studies I–III used large, nationwide, administrative register data enriched with occupation-specific information on work-related factors. Cohorts, which were formed from a 70% random sample of individuals aged 18–70 living in Finland, were followed for nine to ten years. The cohort of Study IV was nationally representative and consisted of participants of the Finnish Health 2000 Survey. This cohort was followed for 15 years.

Results People with prolonged SA due to a shoulder lesion lost a considerable number of their potential working life years, mainly due to preterm old-age retirement and disability retirement. Among both genders, physically heavy work showed the strongest association with disability retirement due to a shoulder lesion. Altogether, physical workload factors explained 46% and 41%, and psychosocial work-related factors 49% and 41% of disability retirement due to a shoulder lesion among men and women, respectively. The risk of disability retirement due to a shoulder lesion was generally higher in manual occupations and heavy physical work significantly explained the excess risk in most of the occupations. Risk factors for SA due to a shoulder lesion included being exposed for at least ten years to physically heavy work, being exposed for more than ten years to at least two specific physical workload factors, and daily smoking. In addition, obesity was a risk factor among men. The modifiable risk factors explained 60% of SA among men and 49% among women.

Conclusions Work participation is notably reduced among people with prolonged SA due to shoulder lesion. Reducing work-related factors to a low level has great potential to prevent disability retirement due to shoulder lesions. Avoiding regular cumulative exposure to physical workload factors also showed potential to prevent SA due to a shoulder lesion.

TIIVISTELMÄ

Taustaa Olkapään sairaudet ovat yleisiä työssä olevilla ja erityisesti ruumiillista työtä tekevillä. Tyypillinen oire on olkapään kipu, kun yläraajaa kuormittaa tai loitontaa, ja usein kipu jatkuu myös levossa kuormituksen jälkeen. Olkapääkivun tiedetään aiheuttavan toimintakyvyn laskua, poissaoloja työstä ja merkittäviä terveydenhuollon kustannuksia.

Koska olkapään pehmytkudossairauksien tausta on tyypillisesti degeneratiivinen, ne yleistyvät iän myötä ja vaikuttavat erityisesti työntekijöihin, jotka ovat työuransa keski- tai loppuvaiheessa. Kovin vähän kuitenkin on tiedetty siitä, miten olkapään pehmytkudossairaus vaikuttaa työhön osallistumiseen tai miten olkapäävaivan aiheuttamaa pitkittynyttä työkyvyttömyyttä voitaisiin ehkäistä.

Tavoitteet Tämän väitöskirjatyön ensimmäinen tavoite oli tutkia, kuinka työkyvyttömyyttä aiheuttava olkapään pehmytkudossairaus vaikuttaa myöhempään työhön osallistumiseen ja työvuosien odotteeseen. Toiseksi haluttiin määrittää ne työperäiset kuormitustekijät, jotka altistavat työkyvyttömyyseläkkeelle siirtymiseen olkapään pehmytkudossairauden vuoksi, ja ne ammatit, joissa työkyvyttömyyseläkkeen riski on erityisen korkea. Kolmantena tavoitteena oli selvittää elintapatekijöitä ja kumulatiivisia työn kuormitustekijöitä, jotka ovat yhteydessä olkapääsairauden aiheuttamaan sairauspoissaoloon.

Menetelmät Tutkimuksissa I-III hyödynnettiin laajaa, kansallista rekisteriaineistoa, johon yhdistettiin tietoa ammattikohtaisista työn kuormitustekijöistä. Kohortit muodostettiin 70 %:n satunnaisotannalla Suomessa asuneista 18–70-vuotiaista henkilöistä. Kohortteja seurattiin yhdeksästä kymmeneen vuoteen. Tutkimuksen IV kohortti oli kansallisesti edustava väestöotos. Se muodostui henkilöistä, jotka olivat osallistuneet Terveys 2000 -tutkimukseen. Tätä viimeistä kohorttia seurattiin 15 vuoden ajan.

Tulokset Henkilöt, joilla oli ollut pitkittynyt sairauspäivärahajakso olkapään pehmytkudossairauden vuoksi, menettivät laskennallisesti jäljellä olevista työvuosistaan huomattavan osan, pääasiassa ennenaikaisen vanhuuseläkkeen ja työkyvyttömyyseläkkeen vuoksi. Fyysisesti raskas työ oli sekä miehillä että naisilla merkittävin riskitekijä olkapääsairauden aiheuttamalle työkyvyttömyyseläkkeelle. Olkapääsairauden aiheuttamista työkyvyttömyyseläkkeistä työn fyysiset kuormitustekijät selittivät miehillä yhteensä 46 % ja naisilla 41 % ja psykososiaaliset kuormitustekijät vastaavasti

49 % ja 41 % Työkyvyttömyyseläkkeen riski oli yleisesti kohonnut ruumiillista työtä tekevillä, ja kuormitustekijöistä erityisesti fyysisesti raskas työ selitti suuren osan lisäriskistä suurimmassa osassa ammateista. Altistuminen fyysisesti raskaalle työlle yli 10 vuoden ajan, alistuminen ainakin kahdelle yksittäiselle fyysiselle työkuormitustekijälle yli 10 vuoden ajan ja päivittäinen tupakointi olivat olkapään pehmytkudossairaudesta aiheutuvan sairauspoissaolon riskitekijöitä. Lisäksi lihavuus oli riskitekijä miehillä. Yhteensä yllä mainitut riskitekijät selittivät miehillä 60 % ja naisilla 49 % olkapääsairauksien aiheuttamista sairauspoissaoloista.

Johtopäätökset Pitkittynyt sairauspoissaolojakso olkapään pehmytkudossairauden vuoksi vähentää huomattavasti työhön osallistumista seuraavina vuosina. Työntekijöiden joutumista työkyvyttömyyseläkkeelle olkapääsairauksien takia voitaisiin ehkäistä minimoimalla erityisesti työn fyysisiä kuormitustekijöitä. Vähentämällä niin kumulatiivista altistumista fyysisille työkuormitustekijöille kuin vähentämällä tupakointia voitaisiin ehkäistä myös olkapään pehmytkudossairauksista aiheutuvia sairauspoissaoloja.

CONTENTS

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following publications:

I Sirén M, Viikari-Juntura E, Arokoski J, Solovieva S. Work participation and working life expectancy after a disabling shoulder lesion. Occup Environ Med. 2019;76(6):363-369.

II Sirén M, Viikari-Juntura E, Arokoski J, Solovieva S. Physical and psychosocial work exposures as risk factors for disability retirement due to a shoulder lesion. Occup Environ Med. 2019;76(11):793-800.

III Sirén M, Viikari-Juntura E, Arokoski J, Solovieva S. Occupational differences in disability retirement due to a shoulder lesion: do work- related factors matter? Int Arch Occup Environ Health. 2020;93(8):983- 993.

IV Sirén M, Viikari-Juntura E, Arokoski J, Solovieva S. Occupational and non-occupational risk factors of sickness absence due to a shoulder lesion. Occup Environ Med. 2020;77(6):393-401.

The publications are referred to in the text by their Roman numerals.

ABBREVIATIONS

AF	Attributable fraction
BMI	Body mass index
CI	Confidence interval
e.g.	Exempli gratia
FCP	Finnish Centre for Pensions
FLEED	Finnish Longitudinal Employer-Employee Data of Statistics Finland
GHQ-12	The 12-item General Health Questionnaire
HR	Hazard ratio
ICD-10	International Classification of Diseases 10th Revision
IR	Incidence rate
JEM	Job exposure matrix
KELA	Kansaneläkelaitos, The Social Insurance Institution of Finland
MRI	Magnetic resonance imaging
PAF	Population attributable fraction
PR	Prevalence rate
RR	Relative risk, risk ratio
RTW	Return to work
SA	Sickness absenc

1 INTRODUCTION

Musculoskeletal disorders, including shoulder diseases, are common, and are one of the leading causes of years lived with disability worldwide (Disease, Injury, & Prevalence, 2016). It is estimated that up to two thirds of the population experience shoulder pain at some period in their lives (Luime et al., 2004). Shoulder pain causes suffering for individuals and results in significant healthcare costs (Croft, Pope, & Silman, 1996; Silverstein, Viikari-Juntura, & Kalat, 2002). Most shoulder pain is explained by degenerative changes in rotator cuff tendons (Cadogan, Laslett, Hing, McNair, & Coates, 2011). These changes are enhanced by internal, physiological and external factors (Seitz, McClure, Finucane, Boardman, & Michener, 2011).

Due to their degenerative nature, rotator cuff diseases become increasingly prevalent with age (Teunis, Lubberts, Reilly, & Ring, 2014). A Dutch study showed that seeking medical advice due to a specific shoulder disease peaks between the ages of 45 and 64 (van der Windt, Koes, de Jong, & Bouter, 1995). This means that the challenges caused by disability due to shoulder diseases arise during working age. Indeed, shoulder lesions are the second leading diagnosis for a new sickness absence (SA) episode due to musculoskeletal diseases in Finland (Pekkala, Rahkonen, Pietilainen, Lahelma, & Blomgren, 2018). Shoulder diseases thus cause work disability that may prolong SA and eventually lead to preterm exit from work. The impact of shoulder lesions on work participation has not been studied before.

The known risk factors for specific shoulder diseases include occupational work exposures (van der Molen, Foresti, Daams, Frings-Dresen, & Kuijer, 2017). Shoulder load and working with hands above shoulder level have shown the strongest associations with specific shoulder diseases. In addition, manual workers are at a nearly twice the risk of rotator cuff syndrome in comparison to non-manual workers (Melchior et al., 2006). Lifestyle factors, such as obesity and smoking, have also been linked with shoulder diseases but the associations have been weaker and the evidence somewhat inconsistent (Leong et al., 2019). The risk factors for a specific disease and work disability due to this disease may, however, differ.

Long-term exposure to high physical workload is a risk factor for disability retirement due to musculoskeletal diseases among middle-aged men and women (Karpansalo et al., 2002; Kjellberg, Lundin, Falkstedt, Allebeck, & Hemmingsson, 2016). However, studies on the associations of occupational as well as non-occupational factors and prolonged work disability due to specific musculoskeletal diseases are limited. Existing investigations have mainly focused on low back diseases, osteoarthritis or general musculoskeletal diseases.

An informative way to estimate which proportion of absences from work could be prevented by eliminating a risk factor is to calculate an attributable fraction (AF) or population attributable fraction (PAF), if the study population represents a normal population. A Danish study reported that if the men did not lift or carry loads and women did not bend or twist their necks, more than a quarter of all long-term SA could be avoided (Christensen, Lund, Labriola, Villadsen, & Bultmann, 2007). Moreover, in a large multicohort study of musculoskeletal diseases, the combined PAF value for overweight or obesity, smoking and low physical activity was more than 30% (Virtanen et al., 2018).

Extending working careers and increasing work participation advances stable economies in societies. Work participation is also beneficial for individuals as it improves mental and psychosocial well-being as well as financial standing (Waddell & Burton, 2006). To reduce prolonged work disability due to a shoulder lesion, it would be beneficial to recognise the modifiable risk factors and their preventive potential.

2 REVIEW OF THE LITERATURE

2.1 THE SHOULDER COMPLEX

2.1.1 ANATOMY AND FUNCTION

The shoulder is a complicated structure, composed of bone, hyaline cartilage, labrum, ligaments, a capsule, tendons, and muscle. It joins the upper extremity to the trunk and plays an important biomechanical role in daily functions.

The shoulder is functionally formed by three bones (the humerus, clavicle and scapula) and three joints (the glenohumeral joint, acromioclavicular joint and sternoclavicular joint) (Huri & Paschos, 2017) (Figure 1). The glenohumeral joint is located between the glenoid socket of the scapula and the rounded head of the humerus. The socket is surrounded by fibrocartilaginous labrum, which extends the size of the socket (Kadi, Milants, & Shahabpour, 2017). The wide humeral head, and on the other side, the shallow glenoid cavity, together with the thin, loose joint capsule give the glenohumeral joint the highest mobile capacity in the human body (Rockwood, 2017).

The capsule of the glenohumeral joint is so loose that it lacks the ability to restrict movement before extreme positions (Azar, Beaty, Canale, & Cambell, 2017). The glenohumeral ligaments give the shoulder some stability in different positions. Stability is also provided by the coracoacromial arch, which is formed by the coracoid process and the acromion of the scapula, and the ligament combining these two processes (Azar et al., 2017).

Shoulder joint movements consist of flexion-extension, abduction-adduction, and rotation. These movements arise from an intricate coaction between static and dynamic stabilisers, which demand balance and synchronism (Huri & Paschos, 2017). The muscles can be coarsely divided into extrinsic and intrinsic muscles (Azar et al., 2017). The extrinsic muscles (Rhomboid major and minor, Levator scapulae, Trapezius and Serratus anterior muscle) control the movement of the scapula, whereas the intrinsic muscles (Rotator cuff muscles, Deltoid, Pectoral major, Latissimus dorsi and Biceps brachii) control the movement of the glenohumeral joint.

Both the arterial blood flow and the innervation of the shoulder arise from a neurovascular bundle that runs between the first rib and the clavicle bone. The continuation of the subclavian artery, the axillary artery, provides the shoulder's arterial blood flow (Rockwood, 2017). The innervation of the shoulder arises from the brachial plexus (C5-T1). The plexus forms four nerves

that render the motor and sensory function of the shoulder possible. These nerves are the dorsal scapular nerve, the long thoracic nerve, the suprascapular nerve, and the nerve to the subclavius muscle (Huri & Paschos, 2017).

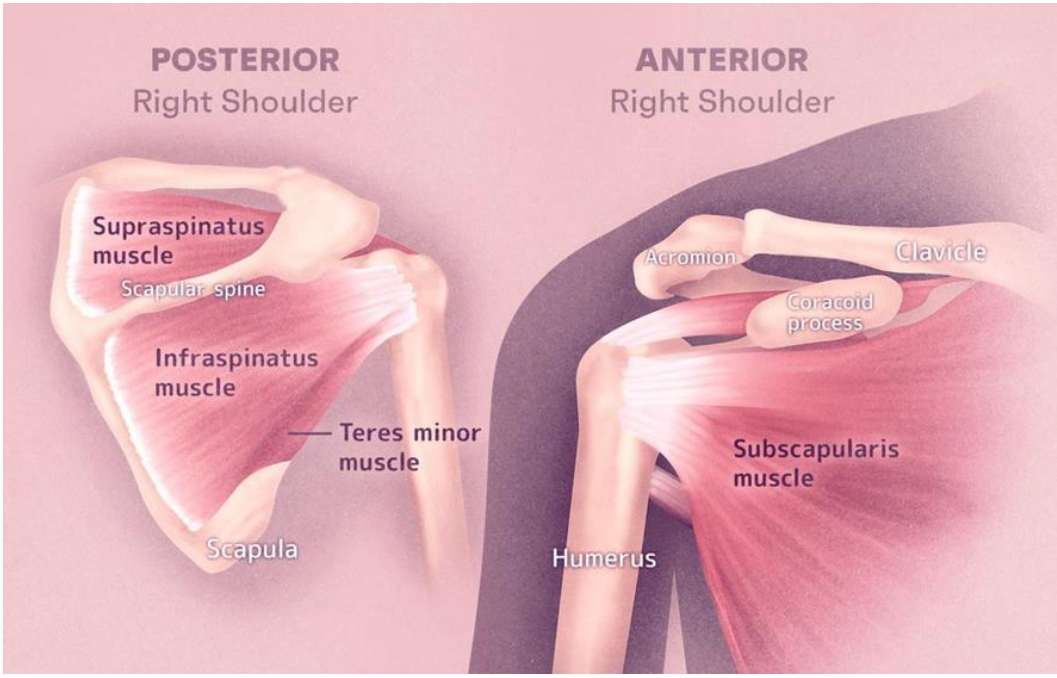

Figure 1 The rotator cuff (with permission of Aleksi Kinnunen).

2.1.2 THE ROTATOR CUFF

As the static stabilators of the shoulder provide the glenohumeral joint with only limited support, the muscles must not only provide movement but also stabilise the joint (Huri & Paschos, 2017). The muscles that actively stabilise and support the glenohumeral joint are called the rotator cuff muscles. These muscles create a downward force on the humeral head to prevent larger muscles from dislocating the humerus during their actions. The rotator cuff is formed by the four tendons of the muscles (supraspinatus muscle, infraspinatus muscle, subscapularis muscle and teres minor muscle) that arise from the scapula and pass anterior, posterior and superior to the glenohumeral joint, inserting on the lesser and greater tubercles of the humerus together with the joint capsule (Rockwood, 2017) (Table 1). The space between the rotator cuff tendons and the upper laying coracoacromial arch is called the subacromial space.

Table 1. *Rotator cuff muscles and their functions.*

Muscle	Origin – Insertion	Function
Supraspinatus	Supraspinous fossa of the scapula – Upper facet of the greater tuberosity of the humerus	Abducts the arm the initial 15 degrees and internally rotates the shoulder
Infraspinatus	Infraspinatus fossa of the scapula – Middle facet of the greater tuberosity of thehumerus	Externally rotates the shoulder
Teres minor	Lateral border of the scapula – Lower facet of the greater tuberosity of the humerus	Externally rotates the shoulder
Subscapularis	Subscapular fossa of the scapula – Lesser tubercle of the humerus	Internally rotates the shoulder

2.2 SHOULDER LESIONS

2.2.1 TERMINOLOGY

The International Classification of Diseases (ICD-10), tenth revision, employs the term shoulder lesions (M75) as an umbrella term for specific shoulder diseases. The subgroups are adhesive capsulitis of the shoulder (M75.0), rotator cuff syndrome (M75.1), bicipital tendinitis (M75.2), calcific tendinitis of the shoulder (M75.3), impingement syndrome of the shoulder (M75.4), bursitis of the shoulder (M75.5), other shoulder lesions (M75.8), and shoulder lesion, unspecified (M75.9). Adhesive capsulitis constitutes its own entity with a specific pathomechanism and clinical picture. The remaining subgroups, however, denote essentially the same condition, that is, symptomatic rotator cuff tendinopathy (also called subacromial pain), and these subgroups remain relatively undistinguishable during clinical assessment (The tendon disorders of the shoulder. Current Care Guidelines, 2014). Clinicians make these diagnoses rather unsystematically. Moreover, adhesive capsulitis initially manifests rather similarly to the remaining subgroups.

2.2.2 PATHOMECHANISM

The prevailing view stipulates that tendinopathy begins to develop when excessive stress exceeds the capacity of the tendon cells (tenocytes) to heal

(Figure 2). Eventually, this leads to the failure of an adequate repair process of the tendon (Spargoli, 2018). Current thinking suggests that the process proceeds in three stages: initially reactive tendinopathy develops, which leads to tendon disrepair, and eventually results in degenerative tendinopathy and possible rupture of the tendon (Cook & Purdam, 2009). Both intrinsic and extrinsic factors play a part in this process.

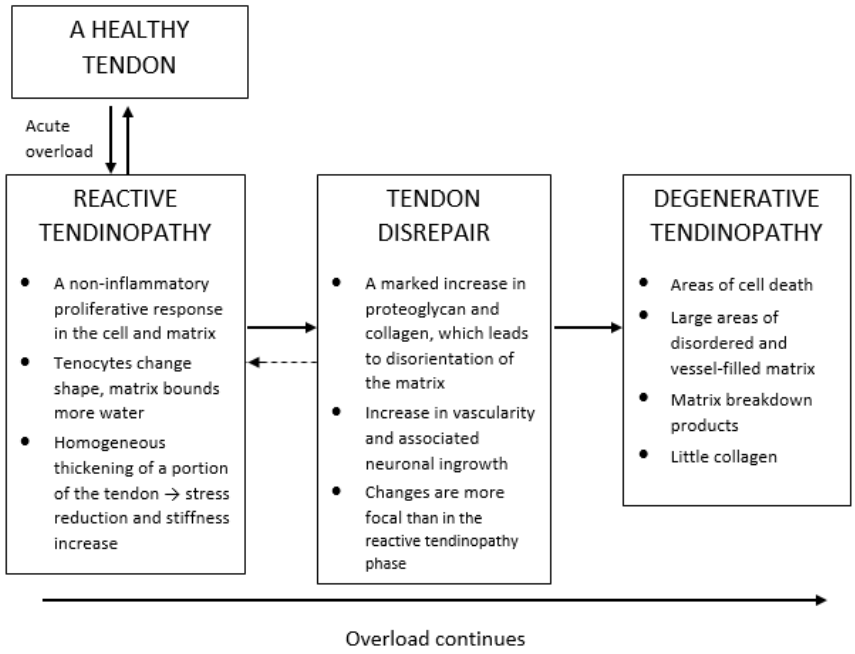

Figure 2 Course of tendon degeneration.

Intrinsic factors refer to elements such as tendon vascularity, mechanical properties, and genetic predisposition, which contribute to tendon degeneration (Seitz et al., 2011). Extrinsic factors refer to biomechanical or anatomical factors that may cause damage to the rotator cuff tendons.

Previously, clinicians have emphasised anatomical details such as the shape of the acromion. The understanding has been that when the arm is elevated, the acromion impinges on the rotator cuff tendons, and a curved or hooked acromion causes an even greater impingement. Observational studies do not support the theory that acromial impingement leads to rotator cuff pathology and it seems that the correlation between the acromial shape and shoulder symptoms is only feeble (Gill et al., 2002; J. Lewis, 2016; Worland, Lee, Orozco, SozaRex, & Keenan, 2003).

Current knowledge, however, agrees with the previous idea that arm elevation and shoulder load play an important role in the development of

rotator cuff tendinopathy, but with a different biologic mechanism. Even moderate arm elevation increases the intramuscular pressure in the supraspinatus and in the infraspinatus muscles (Palmerud, Forsman, Sporrong, Herberts, & Kadefors, 2000). Elevated pressure significantly reduces intramuscular blood flow. A decrease in intramuscular blood flow in turn contributes to reduced recovery from local muscle fatigue. Lifting a load through this movement causes a greater decrease in blood flow impairment than lifting without a load.

Tendinopathy is common (Xu & Murrell, 2008). However, not all tendinopathy causes pain. In studies of various tendons, more than half of all asymptomatic individuals have abnormal tendon imaging findings (Brasseur et al., 2004; Cook et al., 1998; Giombini et al., 2013). This demonstrates that the structural disorientation of a tendon does not convincingly explain the pain. Furthermore, patients with partial rotator cuff tears have reported having more pain than patients with total tears, despite the former having less collagen and tendon damage (Gotoh, Hamada, Yamakawa, Inoue, & Fukuda, 1998). Thus, the nature of tendon pain seems to be complex and quite poorly understood. Formerly, impingement was thought to explain not only the rotator cuff degeneration but also the pain in the shoulder, by irritating the tendons. Studies that have demonstrated that acromioplasty does not have a clinically significant effect on structured and supervised exercise, provide further proof for the theory that subacromial impingement does not cause a symptomatic shoulder disease (Cederqvist et al., 2020; Nazari, MacDermid, Bryant, & Athwal, 2019). Newer theories have proposed nociceptive neurotransmitters, such as substance P, and detrimental neovascularisation as the possible onsets of pain (Gotoh et al., 1998; Levy et al., 2008; Spargoli, 2018).

2.2.3 SYMPTOMS

The symptoms of a shoulder lesion typically begin insidiously without a preceding trauma. The most prevalent symptom is pain localised around the acromion or in the proximal part of the humerus. The pain often worsens during or after external rotation of the shoulder or arm abduction (J. Lewis, 2016). Through pain inhibition, pain commonly causes a reduction of shoulder strength as well as functional impairment (J. S. Lewis, 2009). Pain and activity limitations frequently lead to participation restriction and sleep disruption (Page et al., 2019).

2.2.4 CLINICAL FINDINGS

No single test is adequate to diagnose a shoulder lesion (Hegedus et al., 2008). However, arm abduction typically results in pain at 70–120 degrees (‘the painful arc’) (Garving, Jakob, Bauer, Nadjar, & Brunner, 2017), and passive and active rotations of the shoulder may also cause pain. Investigations

recommend combining several tests to increase the post-test probability of the diagnosis of a shoulder lesion (Michener, Walsworth, Doukas, & Murphy, 2009; Murrell & Walton, 2001; Park, Yokota, Gill, El Rassi, & McFarland, 2005).

2.2.5 RADIOLOGICAL FINDINGS

When shoulder pain becomes prolonged, conventional radiography of the shoulder is the first-line imaging test. Radiography reveals possible osteoarthritis, osseus abnormalities and the presence of calcium deposits (Diercks et al., 2014; 'The tendon disorders of the shoulder. Current Care Guidelines', 2014).

An ultrasound performed by an experienced radiologist is a sensitive and specific imaging test for determining a rotator cuff tear and tendinopathy (Smith, Back, Toms, & Hing, 2011). However, as the reliability of the ultrasound depends a great deal on the radiologist, magnetic resonance imaging (MRI) is the recommended imaging test to find or rule out a rupture in rotator cuff tendons. MRI also has other advantages. In addition to rotator cuff pathology, it effectively reveals bony avulsions, fresh myotendinous junction ruptures, labral- ligamentous complex injuries, synovitis of the shoulder joints and tumours in the bones or soft tissues (Diercks et al., 2014; 'The tendon disorders of the shoulder. Current Care Guidelines,' 2014).

2.2.6 PREVALENCE AND INCIDENCE

The literature lacks qualified studies on the prevalence of specific rotator cuff diseases; any studies that have been conducted have been among rather small and predominantly occupational populations. Several studies have, however, explored the prevalence of shoulder pain. In the general population, the one-year prevalence of shoulder pain ranges from 4.7% to 46%, whereas the lifetime prevalence is 66.7% (Luime et al., 2004). The large variation in these figures is mainly explained by other definitions of shoulder pain (e.g., pain area, duration of pain, restriction in movements) and by the different diagnostic criteria these studies have applied (Luime et al., 2004). Nevertheless, among the working-age population, shoulder pain is the fifth most common cause of musculoskeletal consultation in primary care (Jordan et al., 2010). Rotator cuff tendinopathy is the most prevalent explanation for pain in the shoulder area – in approximately two out of three cases (Cadogan et al., 2011).

The annual incidence of shoulder pain ranges from 0.9% to 2.5% and depends on age group (Luime et al., 2004). The incidence of seeking medical advice for a specific shoulder disease reaches its zenith between the ages of 45 and 64, i.e., working age (van der Windt et al., 1995). The underlying cause for this is the degenerative pathomechanism of shoulder diseases: shoulder diseases are rare among people under 30. While rotator cuff tendinopathy

already exists, work tasks may impose pain-provoking shoulder loads. The load of the shoulders, and consequently the pain that the load causes, is therefore likely to be regulated more easily after retirement.

2.2.7 RISK FACTORS

2.2.7.1 Occupational risk factors

The associations of physical workload factors with symptomatic shoulder diseases are well recognised. A Dutch study assessed that approximately one out of ten symptomatic shoulder soft tissue diseases is attributable to work (van der Molen, Hulshof, & Kuijer, 2019).

Several studies have explored the associations between specific rotator cuff diseases and work-related factors. A meta-analysis found moderate-quality evidence that arm elevation and composite shoulder load (including posture, force and repetition) double the risk of specific shoulder lesions (van der Molen et al., 2017). The same meta-analysis showed that hand force exertion, hand-arm vibration and psychosocial demands may also increase the incidence of subacromial pain, but this evidence was of lower quality.

However, the development of rotator cuff tendinopathy takes time, and cumulative exposure to physical workload factors in particular seems to be a risk factor for specific shoulder diseases. A German systematic review and meta-analysis investigated the dose-response relationship between physical workload and specific shoulder diseases (Seidler et al., 2020). It found a 21% risk increase per 1000 hours of work with hands above shoulder level. A meta-analysis was not possible for other occupational work exposures due to the low number of studies. The investigation did not find compelling differences between the genders. A Finnish study, however, reported that among men, even relatively short-term exposure (1–3 years) to working with hands above shoulder level more than tripled the risk of symptoms attributable to chronic rotator cuff tendinitis (Miranda, Viikari-Juntura, Heistaro, Heliovaara, & Riihimaki, 2005). Women's risk began to increase after a longer exposure time.

Manual workers, both genders, are at almost double the risk of rotator cuff syndrome than non-manual workers (Melchior et al., 2006). However, the studies of the incidence or prevalence of specific shoulder diseases within specific occupations are rather limited. Previous studies largely only report results in selected occupational groups and typically provide no gender-specific results. However, growing proof indicates that the risk of a shoulder disease is elevated in some occupations (Linaker & Walker-Bone, 2015). For instance, agriculture and construction workers appear to be over-represented in rotator cuff operations (Rolf et al., 2006). In addition, studies show that meat-processing workers seem to be at an increased risk of shoulder impingement syndrome (Frost & Andersen, 1999), and that painters have

considerably more supraspinatus tears and shoulder pain than controls (Leow & Maibach, 1998). A Chinese study found rotator cuff diseases to be common among predominantly female nurses (Chung et al., 2013).

2.2.7.2 Non-occupational risk factors

Multiple investigations have shown that age is a significant risk factor for rotator cuff diseases (Applegate et al., 2017; Bodin et al., 2012; Frost & Andersen, 1999; Miranda et al., 2005; Roquelaure et al., 2011). A meta-analysis reported that being over 50 increased the odds of rotator cuff tendinopathy by 3.31 times (Leong et al., 2019). Tendons degrade with age (Iannotti et al., 1991). Previous studies have reported fibrovascular proliferation changes as well as a drop in total glycosaminoglycan and proteoglycan content among the elderly (Kumagai, Sarkar, Uhthoff, Okawara, & Ooshima, 1994; Riley et al., 1994).

Various medical conditions, including dyslipidaemias, diabetes, rheumatoid diseases and thyroid diseases, are associated with tendinopathy (Scott, Backman, & Speed, 2015). Of these conditions, diabetes has shown the strongest contribution to degenerative rotator cuff diseases (Leong et al., 2019; Lin et al., 2015; Miranda et al., 2005; Viikari-Juntura et al., 2008), whereas the contribution of other medical conditions is more uncertain. A few studies, however, have reported that hyperlipidaemia (Lai & Gagnier, 2018; Lin et al., 2015) and high blood pressure (Applegate et al., 2017) are risk factors for rotator cuff tendinopathy.

The contribution of chronic diseases to the development of rotator cuff tendinopathy implies that these diseases trigger metabolic changes that play a part in the degeneration process. In addition to chronic diseases, lifestyle factors are also likely to alter the metabolism of the tendons. It therefore stands to reason that both weight-related factors and smoking have shown weak associations with specific rotator cuff diseases (Rechardt et al., 2010; Viikari-Juntura et al., 2008).

2.2.8 TREATMENT

Shoulder pain often becomes chronic. A total of 41% of patients experience persistent or recurrent pain after one year (van der Windt et al., 1995). However, pain associated with degenerative shoulder lesions can also be self-limiting. It has been reported that three years after the initiation of symptoms, 9.3% and after ten years, 27% of patients have recovered spontaneously without any treatment (Bosworth, 1941).

Conservative treatment should be the first line approach for degenerative shoulder diseases. Conservative treatment includes non-steroidal anti-inflammatory medication, corticosteroid injections, and physical therapy. Oral non-steroidal anti-inflammatory medication is effective in reducing short-

term pain caused by rotator cuff tendinopathy but it does not improve function (Boudreault et al., 2014). Corticosteroid injections relieve pain and improve function in the short term (3–6 weeks) but not in the long term (over 24 weeks) When symptoms first begin (Lin, Hsiao, Tu, & Wang, 2018), physical therapy has shown good results for pain and function, even though the favourable effect of exercising is not completely understood (Littlewood, Ashton, Chance-Larsen, May, & Sturrock, 2012). However, changes in scapular kinematics, deficits in strength and postural alterations have been associated with symptomatic rotator cuff tendinopathy and the goal of physical therapy is to relieve pain and improve the function of the shoulder by correcting these modifiable impairments (Edwards et al., 2016; Spargoli, 2018). It has also been suggested that exercising may facilitate tendon remodelling and reverse some of the harmful neovascularisation (Maffulli, Longo, & Denaro, 2010; Spargoli, 2018). A recent study, however, questioned the effectiveness of progressive physical therapy in relieving the symptoms of rotator cuff disorder. Over a 12-month follow-up, no difference was found between those who had attended a single individual face-to-face session with a physiotherapist and those who had attended up to six individual face-to-face sessions (Hopewell et al., 2021).

In Finland, the number of acromioplasty operations as a treatment for shoulder lesions has considerably decreased in the past decade, and their benefit has been questioned (Paloneva, Lepola, Karppinen, et al., 2015; Saltychev, Aarimaa, Virolainen, & Laimi, 2015). At the same time, the incidence of rotator cuff repair operations has increased (Paloneva, Lepola, Aarimaa, et al., 2015). This tendency reflects the current national guidelines, which primarily recommend surgical treatment only for a traumatic rotator cuff rupture that is accompanied with significant strength loss in an active person *('The tendon disorders of the shoulder. Current Care Guidelines,' 2014*). However, the guidelines continue that if conservative treatment fails in a person with a degenerative rotator cuff rupture that causes severe pain or notable loss of function, an operation may be considered.

2.3 WORK DISABILITY IN RELATION TO SHOULDER LESIONS

2.3.1 PREVALENCE

In Europe, musculoskeletal diseases, including shoulder diseases, produce more SA and health-related early retirement than any other disease category (Bevan et al., 2009). As population ageing will become a crucial issue in the coming decades (World Report on Aging and Heath, 2015) and the pathomechanism of musculoskeletal diseases is for the most part degenerative, disabling musculoskeletal diseases are likely to become even

more prevalent and cause even more work disability. Previous studies of work disability due to musculoskeletal diseases, however, have mainly concentrated on low back diseases or osteoarthritis (Shanahan, 2019; Steenstra et al., 2017; Violante, Mattioli, & Bonfiglioli, 2015). The knowledge of the impact of shoulder diseases on work disability is rather limited.

A large Finnish register-based study showed that in 2014, 3.6% (men) and 5.0% (women) of the study population had long-term SA due to a musculoskeletal disease (Pekkala, Blomgren, Pietilainen, Lahelma, & Rahkonen, 2017). In Finland, shoulder lesions are the second most common cause of a new SA episode in musculoskeletal diseases, after lower back diseases (Pekkala et al., 2018).

2.3.2 RISK FACTORS

Physical workload factors appear to be particularly important risk factors for work disability. A Danish population-based study showed that exposure to high physical workload is a notable risk factor for shortened working life (Pedersen, Schultz, Madsen, Solovieva, & Andersen, 2020). High physical workload has been associated with SA due to musculoskeletal diseases as well as with permanent work disability when combined with pain (Sommer, Svendsen, & Frost, 2016). Among middle-aged men and women, long-term exposure to high physical workload is associated with disability retirement due to musculoskeletal disorders.

Of the psychosocial workload factors, low job control has the strongest association with absence from work due to musculoskeletal diseases (Foss et al., 2011; Janssens et al., 2014). Lifestyle factors have also been reported to have an association with SA due to musculoskeletal diseases. In a large multicohort study, overweight and obesity, smoking, and low physical activity together explained 30.8% of SA due to musculoskeletal diseases (Virtanen et al., 2018).

The predictors of work disability due to shoulder diseases have not been systematically studied. Furthermore, no intervention studies on this topic exist. However, manual workers are at a considerably higher risk of a new SA episode due to a shoulder lesion than non-manual workers of both genders (Pekkala et al., 2017). A systematic review reported that a non-traumatic history, disease severity and previous SA due to a shoulder problem were significantly associated with delayed return to work (RTW) or future SA (Desmeules, Braen, Lamontagne, Dionne, & Roy, 2016). Thus, it is reasonable to assume that other occupational as well as non-occupational risk factors may predispose to long-term work disability and finally to preterm exit from paid employment due to specific shoulder diseases. Knowing these modifiable risk factors could potentially prevent work disability caused by shoulder problems.

2.4 PREVENTATIVE STRATEGIES

Preventive health strategies have been traditionally grouped into three stages (Kisling & Das, 2020): primary, secondary, and tertiary prevention. These strategies aim to not only prevent the onset of a disease through risk reduction, but also to reduce the complications of a manifested disease. As musculoskeletal diseases are common in the general population and only a few can avoid the symptoms they cause, shifting the focus of prevention from clinical symptoms to related disability has been suggested (Loisel, 2009). The prevention of disability can be approached using the same above-mentioned three-level scale. Disability is not only caused by disease; it also includes psychosocial, work-related, and system-related determinants.

The objective of primary prevention is to stop a disease from ever emerging. The measures are aimed at a healthy population or at an individual who is susceptible to the disease. With musculoskeletal diseases, these measures typically include interventions in detrimental lifestyle factors, reducing the overload of musculoskeletal structures and preventing injuries (Mody & Brooks, 2012).

The focus of secondary prevention lies in the early detection of a disease. The goal is to stop the disease worsening, or to lessen complications and limit disabilities before the disease becomes severe. Preventing SA due to a disease can be incorporated into one of the goals of secondary prevention of disability among working-age people. Secondary prevention of musculoskeletal diseases and musculoskeletal disease-related disability can include reducing or eliminating external loads, matching the physical demands of the job with the employee's physical capacities, organisational interventions (such as job rotation and increasing autonomy at workplace), improving individual stress-coping skills, and exercising (*Musculoskeletal Disorders and the Workplace: Low Back and Upper Extremities,* 2001).

Intervention studies exploring the prevention of musculoskeletal diseases, however, typically examine employees both with and without the studied disease. Therefore, it is not feasible to distinguish whether they study primary or secondary intervention. As a shoulder lesion often arises from work-related causes, it has been suggested that workplace interventions could prevent symptomatic shoulder diseases. Reducing work tasks with a lifting component decreased Finnish kitchen workers' future shoulder pain (Pehkonen et al., 2009). However, there is a lack of broader literature to guide clinicians to implement such interventions, especially when they should be targeted at disability. The effectiveness of workplace interventions in the prevention of upper extremity musculoskeletal disorders and symptoms has, nevertheless, been investigated more systematically. A review found strong evidence that resistance training and moderate evidence for stretching programmes, mouse feedback and forearm supports prevent upper extremity musculoskeletal disorders or their symptoms (Van Eerd et al., 2016). There was also moderate

evidence that job stress management training or office workstation adjustment had no effect.

Tertiary prevention aims to reduce the negative impact of an already-established disease by enhancing function and reducing disease-related complications. Another goal of tertiary prevention is to improve the quality of life for people with a disease. The strategies of secondary and tertiary prevention partially overlap. However, tertiary prevention is more interdisciplinary and individualised than secondary prevention (Weigl, Cieza, Cantista, & Stucki, 2007). It is intended for the small proportion of people whose physical incapacity has led to a chronic, prolonged disability. Tertiary prevention of disability seeks to avoid the high costs associated with the permanent loss of productivity of disabled workers. Therefore, preventing disability retirement due to a disease is also one of the aims of tertiary prevention.

3 AIMS OF THE STUDY

The overall aim of this thesis study was to examine the impact of a disabling shoulder lesion on work participation and to explore the preventive potential of work-related factors as well as lifestyle factors to reduce long-term work disability due to this condition. The specific objectives were as follows:

- To examine the impact of a disabling shoulder lesion on work participation and working life expectancy (I).
- To assess the longitudinal associations of physical and psychosocial work exposures with work disability due to a shoulder lesion (II, IV).
- To determine the longitudinal associations of lifestyle factors with SA due to a shoulder lesion (IV).
- To identify occupations with a high risk of disability retirement due to a shoulder lesion and to examine the contribution of physical and psychosocial work-related factors to the occupation-specific excess rate of disability retirement (III).
- To explore the preventive potential of modifiable risk factors to reducework disability due to a shoulder lesion (II, IV).

4 MATERIAL AND METHODS

4.1 STUDY POPULATIONS AND STUDY DESIGNS

All the studies were longitudinal and utilised national registers. In Studies I–III, the source population consisted of a 70% random sample from the Population Register Centre of individuals aged 18–70, living in Finland on 31 December 2004. In Study IV, the source population consisted of participants of the nationally representative Health 2000 Survey carried out in 2000–2001.

People aged 30–59 years who were employed or self-employed on 1 January 2006 and had received full-time SA benefit due to a shoulder lesion in 2006 were selected for Study I. People with SA due to any shoulder problem in 2005 were excluded. The study sample consisted of 7644 participants, who were followed from the first day of their first SA due to a shoulder lesion till 31 October 2014.

People aged 30–59 who held gainful employment on 1 January 2005 were eligible for Studies II and III. People who lacked an occupational title and who began to receive any retirement-related benefit before 1 January 2005 were excluded. The final cohort consisted of 1 135 654 people (574 617 men and 561 037 women). They were followed from 1 January 2005 till the occurrence of full disability retirement, other pension, death, or end of follow-up (31 October 2014), whichever came first.

Study IV consisted of people aged 30–62 who had participated in the Health 2000 Survey (Health 2000 Survey, 2008) and were employed or self-employed while participating in the survey. Those who lacked information on work-related factors were excluded. The study sample consisted of 4344 participants (2051 men and 2293 women) who were followed from the first day of their participation in the Health 2000 Survey to their first SA due to a shoulder lesion, retirement, death, or end of study period (31 December 2015), whichever came first.

4.2 REGISTER DATA

Studies I–III utilised administrative register data from The Social Insurance Institution of Finland (KELA) the Finnish Centre for Pensions (FCP) and Statistics Finland that were linked with basic information from the Population Register Centre. The data were anonymised.

All diagnoses were classified according to the International Classification of Diseases by the World Health Organization (WHO), tenth revision (ICD-10), the Finnish version of the ICD classification, 1996.

4.2.1 THE SOCIAL INSURANCE INSTITUTION OF FINLAND REGISTER DATA (I–IV)

KELA registers provide information on SA benefits, national pensions, and rehabilitation allowances. For SA, data are available on the start and end dates as well as on primary diagnoses for all full-time working spells extending over ten weekdays (Sundays excluded) and all part-time working spells. All full- and part-time national pensions are recorded, with their start and possible end dates. For disability pensions, start and possible end dates, as well as the primary and secondary diagnoses are available. Information is also available on all the rehabilitation allowances paid by KELA.

4.2.2 THE FINNISH CENTRE FOR PENSIONS REGISTER DATA (I– III)

The FCP register provides information on earnings-related pensions granted in Finland. It also offers information on the start and possible end dates of all these pensions. Disability pension can be granted as permanent or temporary as well as full or partial. Primary and secondary diagnoses are registered for all disability retirement events. This register also records rehabilitation allowances compensated by the pension providers. Another FCP register provides data on all employment and unemployment periods.

4.2.3 THE FINNISH LONGITUDINAL EMPLOYER-EMPLOYEE DATA OF STATISTICS FINLAND (I–III)

The Finnish Longitudinal Employer-Employee Data of Statistics Finland (FLEED) contains several registers that provide background data on the working-age population. FLEED sample data consist of information on a sample of people aged 15–70 living in Finland between 1988 and 2012 (excluding Åland). These people have been followed over time, and the register has recorded data on all of them for all the years during which they have been aged between 15 and 70 and living in Finland. The FLEED registers include data on the person's basic characteristics, such as family, area of residence, occupation, employment relationships, periods of unemployment, annual income, and education.

To classify the occupations in Study III, the Classification of Occupations 2001 by Statistics Finland (Table 2) was applied. This classification is based on the International Standard Classification of Occupations (ISCO-88).

Table 2. *Occupational groups according to Classification of Occupations 2001 by Statistics Finland and common examples of occupations included in each group.*

Occupational group	Common examples of occupations
Managers	chief executives; senior officials; legislators; administrative, commercial, production and service managers
Professionals	science and engineering professionals; health professionals (e.g., medical doctors, veterinarians, matrons, and ward sisters); teaching, business and administration professionals; information professionals; legal, social and cultural (e.g., economists and priests) professionals
Physical and engineering science technicians	engineering technicians, draughtpersons
Environmental officers and nurses	environmental and occupational health inspectors and associates; health associate professionals (e.g., nurses, physical therapists, dental assistants)
Finance and sales associate professionals and administrative secretaries	credit and loan officers; insurance representatives; buyers; trade brokers; real estate agents; office, legal and medical secretaries
Office clerks	general secretaries; keyboard operators
Customer services clerks	bank tellers; money collectors; receptionists; survey and market research interviewers
Services workers	personal service workers (e.g., hairdressers, cooks, waiters); personal care workers (e.g., childcare workers and practical nurses); protective service workers (e.g., firefighters, police officers, security guards)
Shop workers	shop, street, and market salespersons
Agricultural and fishery workers	farmers; lumberjacks; fishers
Construction workers, electricians, and plumbers	
Metal and machinery workers	welders; blacksmiths; machinery mechanics and repairers
Craft workers	handicraft and printing workers; food processing and garment workers
Chemical, wood and metal processing workers	
Machine operators and assemblers	
Professional drivers	bus, train, and taxi drivers
Building caretakers, cleaners, assistant nurses ,and kitchen workers Unskilled transport, construction and manufacturing workers	

4.3 HEALTH 2000 SURVEY DATA (IV)

Health 2000 is a nationally representative combination of a health interview and health examination survey that was carried out between the 2000 and 2001 and coordinated by the Finnish Institute for Health and Welfare. The study comprised several interviews, a physical examination, and self-administered questionnaires. The study design is described elsewhere in detail (Health 2000 Survey, 2008). For Study IV, the Health 2000 Survey data provided information on height and weight, long-term illnesses, smoking, frequency of leisure time physical activity, psychological distress at baseline, presence of insomnia-related symptoms at baseline, and occupational factors (occupation/occupations, years in each occupation, physical workload factors in each occupation). Information on SA with their diagnoses from KELA was linked to Health 2000 data.

4.4 GENDER-SPECIFIC JOB EXPOSURE MATRICES (I–III)

Two gender-specific job exposure matrices (JEMs) were used: one for physical and one for psychosocial work-related factors (Solovieva et al., 2012; Solovieva et al., 2014). The matrices contained major physical and psychosocial workload factors in more than 80% of all occupations (grouped according to the Classification of Occupations 2001 by Statistics Finland) in Finland. The physical workload factor JEM provides information on the likelihood of a specific exposure in a specific occupational group, and the psychosocial workload factor JEM shows dichotomised exposure measures. Both matrices have shown fairly good validity (Solovieva et al., 2012; Solovieva et al., 2014).

4.5 SOCIAL SECURITY BENEFITS IN FINLAND TO COMPENSATE FOR WORK DISABILITY, OLD AGE AND WORK LOSS

4.5.1 SICKNESS ABSENCE

Sickness allowance is paid to compensate for lost income due to incapacity to work. A person can receive full sickness allowance for a maximum of 300 working days for two years due to the same medical condition. The first ten weekdays (Sundays excluded) of full sickness allowance are typically paid by

the employer and are therefore not registered. Full-time SA days are compensated by KELA from the 11th day onwards.

A person who is medically assessed as incapable to work but could perform about half of their duties, has the option of partial sickness allowance. Partial sickness allowance is possible after the employer period of 10 days of SA. Returning to work part-time must not compromise the employee's health or recovery. Working hours must be cut down to 40–60% of the original level. A person can receive partial sickness allowance for a maximum of 120 days and have an additional 50 days once they have been at work for at least consecutive 30 days.

4.5.2 RETIREMENT

A pension provides security against old-age illness, disability, and loss of a spouse. The Finnish pension system includes national pensions, earnings-related pensions and pensions paid on the grounds of an industrial accident or traffic insurance.

In Finland, the national pension covers all people residing in Finland if they meet the minimum requirements relating to time of residence. The national pension secures the pensioners' income if their earnings-related pension is small or if they have earned no earnings-related pension at all. National pension benefits include 1) old-age pension, 2) disability pension and 3) survivors' pension (for the surviving spouse). At the time of the studies, people who had reached the age of 63 were entitled to a national old-age pension. However, early old-age pension was possible already after reaching the age of 60 if the person accepted that the pension would be permanently lower than the old-age pension they would receive by retiring at the age of 63.

The earnings-related pension scheme covers all employees, self-employed persons, and farmers whose employment exceeds the minimum requirements laid down by the law. A pension accrues on the basis of the annual earnings accrual rate. Earnings-related pensions include 1) old-age pension 2) partial old-age pension, 3) disability pension, 4) years-of-service pension, and 5) survivors' pension.

At the time of the studies, all Finnish residents aged 18–62, were entitled to a disability pension if they had considerable, prolonged decreased work disability caused by a physician-verified chronic illness, disability or injury. Disability retirement can be temporary or permanent, as well as full or partial. Temporary disability is granted when the worker's work ability can still possibly be restored through treatment or rehabilitation. To receive a full disability pension, sickness allowance must usually be paid for a maximum of 300 days.

4.5.3 UNEMPLOYMENT

When a person becomes unemployed, he or she can receive unemployment benefits from KELA or an unemployment fund. Unemployment allowance includes earnings-related unemployment allowance and basic unemployment allowance. If a person does not have the right to unemployment allowance, he or she can obtain a labour market subsidy. A person who is not able to work due to a disease but who is not entitled to sickness allowance or disability pension can apply for unemployment benefits.

4.5.4 REHABILITATION

Rehabilitation allowance provides economic security during rehabilitation. Rehabilitation allowance is paid during medical rehabilitation and adaptation training courses as well as during vocational rehabilitation.

Medical rehabilitation and adaptation training courses help people and their families adjust to the changes brought about by an illness or impairment and to achieve rehabilitation goals. KELA pays rehabilitation allowance during these courses to compensate for earnings losses.

Vocational rehabilitation is a statutory right in Finland. It is granted to those who have been assessed as facing a threat of disability retirement within the next few years due to a disease or an injury and who are expected to benefit from it. Vocational rehabilitation can include a vocational rehabilitation assessment, work trials, training, and counselling. Rehabilitation allowance for vocational rehabilitation can be granted by a pension provider or by KELA.

4.6 OUTCOMES

In Study I, the first outcome was preterm exit from paid employment (i.e., transition to permanent disability retirement or old-age retirement prior to the age of 63). The follow-up began from the day following the last day of SA due to a shoulder lesion. The participants were followed over time in terms of the proportion of time that they spent each year in the following eight work participation statuses: 1) at work, 2) on partial work disability (including part-time SA and partial disability retirement), 3) on SA due to a shoulder lesion, 4) on time-restricted full work disability (including SA for reasons other than shoulder lesion and rehabilitation), 5) unemployed, 6) economically inactive, 7) on permanent full disability retirement, and 8) on old-age retirement. Sustained RTW was defined as returning to regular duties for a minimum of 28 consecutive days immediately after SA.

The second outcome of Study I was working life years lost due to 1) ill-health-related cause while employed, 2) temporal unemployment or economical inactivity and 3) permanent retirement (including full disability retirement and preterm old-age retirement).

The outcome of Studies II and III was a primary diagnosis of either permanent or temporary full disability retirement due to a shoulder lesion (ICD-10 code M75). In Study IV, the outcome was SA due to a shoulder lesion (ICD-10 code M75 excluding M75.0, M75.8 and M75.9).

4.7 DETERMINANTS

4.7.1 OCCUPATIONAL RISK FACTORS

All the studies included physical work-related factors as potential predictors (Table 3). Of the physical work-related factors, heavy lifting, working with hands above shoulder level and work demanding high handgrip force were estimated in all the studies. Studies II–IV also assessed physically heavy work and working in a forward bent posture. However, Study IV focused on cumulative exposure to physical workload factors. These exposures were calculated for each physical workload factor as the total number of years of exposure throughout the working career. In the statistical analyses, cumulative exposures were categorised into three classes based on the number of years exposed: (1) less than one year, (2) 1–10 years, (3) more than ten years. The assessment of the physical exposures was based on the physical JEM in Studies I–III. For the analyses, the continuous JEM values were dichotomised as 0–0.39 (non-exposed) and 0.40–1.00 (exposed). Study IV assessed the physical workload factors at baseline though a home interview.

Table 3. *Physical work exposures and their definitions.*

Work exposure	Definition
Physically heavy work	Work including lifting and carrying heavyloads, excavating, hammering or shovelling
Heavy lifting/Handling heavy loads	Lifting, carrying or pushing items heavier than20 kg at least ten times a day
Working with hands above shoulder level	On average at least one hour per day
High handgrip force/Forceful hand movements	Including squeezing, twisting, holding burdensor tools for at least one hour per day on average
Working in a forward bent posture	For at least one hour per day on average

Of the psychosocial factors, high job demands and low job control were included as potential predictors in all of the studies. Studies II and III also included monotonous work, and Study IV low social support as potential predictors. Furthermore, in Studies II and IV, job strain was assessed using the quadrant approach (R. A. Karasek & Theorell, 1990). This approach defines workers according to job demands and job control as having high strain, low strain, and a passive or active job. The assessment of the psychosocial work-related factors was based on the psychosocial JEM in Studies I–III. In Study IV, psychosocial exposures were estimated during an interview using the Finnish version of the Job Content Questionnaire (R. Karasek et al., 1998).

The duration of the initial SA, having sustainably returned to work after the SA, and sector of employment were also included as potential predictors in study I. The duration of SA was classified as (1) <30, (2) 31–105, (3) 106–180, or (4) >180 calendar days. The sector of employment was defined as (1) public sector, (2) private sector or (3) other.

4.7.2 NON-OCCUPATIONAL RISK FACTORS

All studies had age, gender, and level of education as predictors. The level of education was defined as (1) higher or lower tertiary (>12 years),
(2) secondary (9–12 years) or (3) primary (<9 years). In Studies I–III information on education was obtained from FLEED and in Study IV through a home interview.

Geographical region and income were used as potential predictors in Study I. The geographical regions comprised (1) Southern Finland, (2), Western Finland, (3), Eastern Finland, and (4) Northern Finland. Income consisted of both the wage and capital income of the individual and was categorised into (1) high, (2) medium and (3) low. In Study I, participation in vocational rehabilitation was also a predictor.

In Study IV, BMI, daily smoking, presence of chronic disease, clinically defined shoulder disease, leisure-time physical activity, psychiatric stress at baseline and insomnia-related symptoms at baseline were considered possible risk factors. A trained nurse measured height and weight. BMI was classified into three categories: (1) normal (<25.0), overweight (25.0–29.9) and (3) obese (>30.0). Smoking was assessed by asking the following questions: 1) 'Have you ever smoked in your life?' with two possible responses 'No' and 'Yes' and 2) 'Do you currently smoke (cigarettes, cigars or a pipe)?' with three possible responses 'daily', 'occasionally' and 'not at all'. The participants were classified as 1) current daily smokers if they smoked daily at the time of the interview and 2) not current daily smokers if they smoked occasionally at the time of the interview or had never smoked. A trained nurse collected information on long-term illness during the home interview. Prevalent chronic disease was defined on the basis of at least one positive response. Leisure time activity was assessed using a self-administered questionnaire (the Gothenburg scale (Wilhelmsen, Tibblin, & Werko, 1972)) and dichotomized into regular (at least once a weak) and irregular. Psychological distress was estimated at baseline using the Finnish version of the 12-item GHQ (Goldberg, 1972). Insomnia- related symptoms in the preceding 30 days were also assessed. These symptoms were elicited at baseline by a single question on a scale from 1 (not at all) to 5 (very much). This question was dichotomised, with three as the cut-off point.

Table 4. *Outcomes, potential predictors, and follow-up times of the studies.*

	Outcomes	Potential predictors	Follow-up time
Study I	Preterm exit from paid employment Lost working life years	Age Gender Duration of SA due to a shoulder lesion Level of education Region of Finland Sector of employment Income Sustained RTW after SA due to a shoulder lesion Participation in vocational rehabilitation *Work-related physical factors:* Heavy lifting Working with hands above shoulder level Work demanding high handgrip force *Work-related psychosocial factors:* High job demands Low job control	1 January 2006– 31 October 2014
Study II	Disability retirement due to a shoulder lesion	Age Gender Level of education *Work-related physical factors:* Physically heavy work Heavy lifting Working with hands above shoulder level Work demanding high handgrip force Working in a forward bent posture *Work-related psychosocial factors:* High job demands Low job control Monotonous work *Job strain* Low strain job Active job Passive job High strain job	1 January 2005– 31 October 2014
	Disability retirement due to a shoulder lesion	Age Gender Level of education Occupation *Work-related physical factors:* Physically heavy work Heavy lifting Working with hands above shoulder level Work demanding high handgrip force Working in a forward bent posture *Work-related psychosocial factors:* High job demands Low job control Monotonous work	1 January 2005– 31 October 2014

Study IV	SA due to a shoulder lesion	Age Gender Level of education BMI Presence of chronic disease Clinically defined shoulder disease Leisure-time physical activity	First day of participation in Health 2000 Survey – 31 December 2015

4.8 STATISTICAL ANALYSES

Statistical analyses were carried out using SAS version 9.4 (Study I) and STATA version 14.0 (Studies II–IV). In all analyses, the statistical significance level was set at a p-value less than 0.05, and 95% confidence intervals (CIs) for the estimates were calculated when applicable.

To estimate sustained RTW after SA due to a shoulder lesion, Cox survival analysis was applied with a follow-up which began on the first compensated day of SA and ended on the last day of SA (Study I). The Kaplan–Meier curve was adopted to draw a sustained RTW curve. The proportional hazard assumption, visually determined through inspection of the log-log hazards plots, was satisfactory.

To estimate the time expected (in years) to be spent in different work participation statuses (Study I), the Sullivan method for healthy life expectancy was applied (Sullivan, 1971), calculating the 30–55-year age range at five-year intervals. Working life expectancy among people with a disabling shoulder lesion, equalled to the time expected to be spent at work was compared with the working life expectancy of the general population (Nurminen, 2012).

Age-adjusted incidence rates (IR) of disability retirement due to a shoulder lesion and their estimated 95% CIs by gender and occupational group were calculated using Poisson distribution and presented as the number of incidence events per 100 000 person-years (Study III).

As all the studies had dichotomised outcome variables, logistic regression analyses were used to estimate the association between risk factors and outcomes of interest. Furthermore, the following competing risk factors were considered in the regression models: full disability retirement due to causes other than a shoulder lesion (Studies II and III) or any disability retirement (Study IV), old-age retirement and death (Studies I–IV).

To estimate the associations between potential determinants and preterm exit from paid employment, Cox regression was used, and the associations were reported as relative risks (RRs) with 95% CIs (Study I). The associations of occupational and non-occupational risk factors with work disability due to a shoulder lesion were estimated by Cox proportional hazards regression analyses and reported as hazards ratios (HRs) with 95% CIs (Studies II–IV).

In Study III, the excess risks of disability retirement due to a shoulder lesion in a specific occupational group in comparison to professionals (reference group) was calculated. The contribution of physical and psychosocial work-related factors to the excess risk of disability retirement was determined by scrutinising different regression models and calculating the percentage of attenuation of HR from the different models. Five models were analysed.

To estimate the proportion of disability retirement cases (Study II) and cases of SA (Study IV) that could be attributed to modifiable occupational and non-occupational risk factors, the PAF, sometimes AF, was calculated. For the dichotomised risk factor in question, the following formula was used:

$$PAF = \frac{p(\mathrm{RR}-1)}{p(\mathrm{RR}-1)+1}$$

where p is the prevalence of risk factor in the general population and RR is the relative risk of disability retirement or SA associated with the risk factor.

Furthermore, in Study IV, for the risk factors with more than two categories (e.g., cumulative workload factors, age, BMI), the following formula was used:

$$PAF = = \frac{\sum_{i=1}^{n} p_i RR_i - 1}{\sum_{i=1}^{n} p_1 RR_1}$$

where p_i is the proportion of population with exposure at level i, RRi corresponds to the relative risk at exposure level i, and n denotes the number of exposure levels.

Finally, in Study IV, the overall PAF was calculated using the sum formula (Miettinen, 1974):

PAFoverall= 1- (1-PAF1)(1-PAF2) …. (1-PAFn).

4.9 ETHICAL ASPECTS

Studies I–III were fully register based. According to Finnish legislation, research utilising anonymised register data does not need to undergo a review by an ethics committee. The data of Statistics Finland were linked to the KELA and the FCP data. Statistics Finland stored and anonymised all the data. The data were analysed via remote access system.

The data of Study IV were collected in the Health 2000 Study. The Section of Epidemiology and Public Health of the Ethics Committee of the Hospital District of Helsinki and Uusimaa approved the study (407/E3/2000) on 31 May 2000. Participation in the study was voluntary, and all participants were asked to sign an informed consent form. The consent included permission to use their data in studies of health and various diseases and their determinants, including linkage to the registers.

5 RESULTS

5.1 EPIDEMIOLOGICAL ASPECTS OF WORK DISABILITY DUE TO A SHOULDER LESION (I, II, IV)

The one-year cumulative incidence of SA due to a shoulder lesion in 2006 was 0.6% and the 15-year cumulative incidence was 5.5%. SA was most common in the 50–59-year age group and least common among those aged 30–39. Women had slightly higher 15-year cumulative incidence than men (5.9% and 5.2%, respectively).

The nine-year cumulative incidence of disability retirement due to a shoulder lesion was 0.2%. Men had higher cumulative incidence than women (0.25% and 0.19%, respectively).

5.2 SUSTAINED RETURN TO WORK AND WORK PARTICIPATION AFTER A DISABLING SHOULDER LESION (I)

After the initial prolonged SA, more than three quarters (76.9%) of the participants returned to work sustainably. The median time to sustained RTW was 26.0 (95% CI 24.7 to 27.3) days. The majority returned to work within four months (Figure 3).

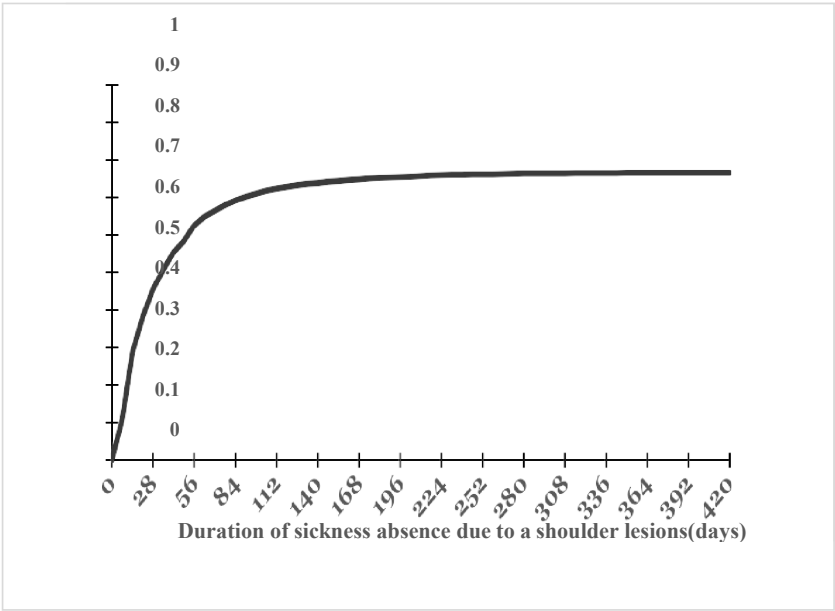

Figure 3 Time to sustained RTW after prolonged sickness absence due to a shoulder lesion.

At work remained the predominant work participation status during the nine-year follow-up, even though its share declined from 77.7% to 46.7% (Figure 4). During the first year of follow-up, time-restricted full work disability (including SA due to reasons other than a shoulder lesion) was the most common cause of reduced time at work, and 7.8% of the time people had this status. Its share, however, gradually declined, and at the end of the follow-up, it had reduced by more than half. After five years, permanent disability retirement and from six years onwards, old-age retirement was the leading cause of not working. Throughout the follow-up, only a very minor proportion of SA was due to a shoulder problem.

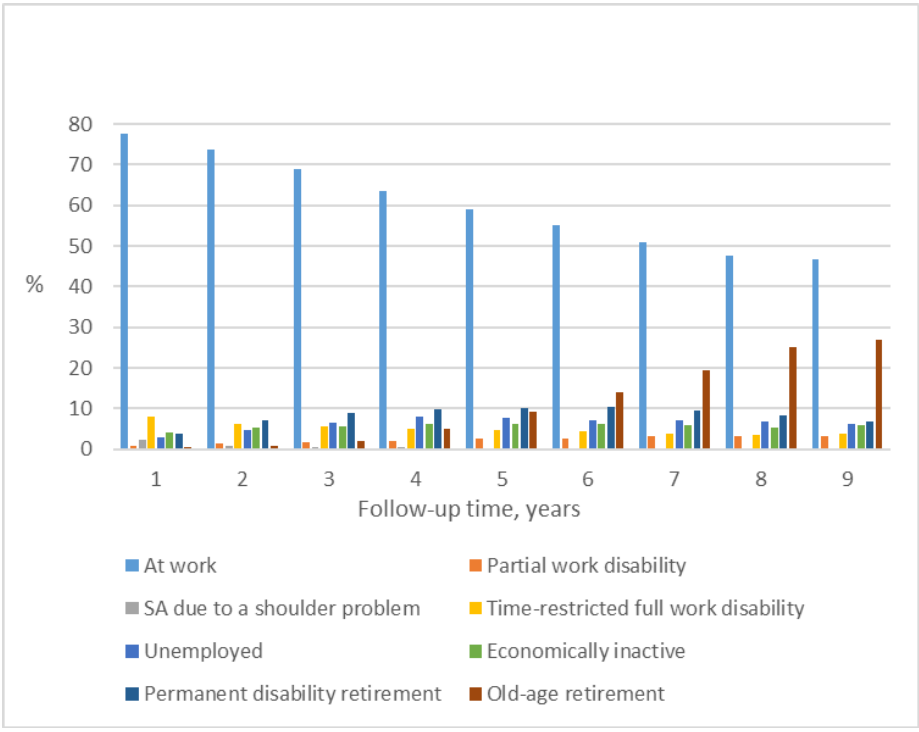

Figure 4 Time during follow-up with different work participation statuses after prolonged SA due to shoulder lesion.

5.3 PRETERM EXIT FROM WORK AND LOST WORKING YEARS (I)

During the nine-year follow-up, 19.9% of the study population had left paid employment before the statutory retirement age of 63, and the majority (79%) of them were receiving a permanent disability pension.

Depending on age, 18.2–22.5% of potential working life years were estimated as being lost due to early old-age retirement or disability retirement (Table 5). The older the people were by the onset of prolonged SA due to a shoulder lesion, the more time they were expected to spend on health-related benefits; and the younger they were, the more time they were expected to spend being unemployed or economically inactive. At work was estimated to remain the most common work participation status in all age groups, however, only 35–55% of potential working life years were expected to be spent at work after a disabling shoulder lesion. For example, a 30-year-old person was expected to spend 17.7 of the potential 33 working life years at work and a 55-year-old 2.8 of the potential 8 years.

Table 5. *Absolute years and proportions of potential working life years expected to be spent with different work participation statuses by the age of onset of prolonged sickness absence due to a shoulder lesion*

Age	At work		On health-related benefits		Unemployed or economically inactive		Permanently out of work	
years	years	%	years	%	years	%	years	%
30	17.7	53.6	0.2	0.1	6.0	18.2	6.0	18.2
35	15.4	55.0	0.4	1.4	4.7	16.8	5.3	18.9
40	12.4	53.9	0.6	2.6	3.4	14.8	4.4	19.1
45	9.5	52.8	0.7	3.9	2.4	13.3	3.4	18.9
50	6.3	48.5	0.7	5.4	1.4	10.8	2.6	20.0
55	2.8	35.0	0.8	10.0	0.7	8.6	1.8	22.5

The working life expectancy of people with prolonged SA due to a shoulder lesion is 23–35% less than that of the general population. (Figure 5). This difference was at its greatest when SA had started at the age of 55 and smallest when SA had started at the ages of 45 and 50

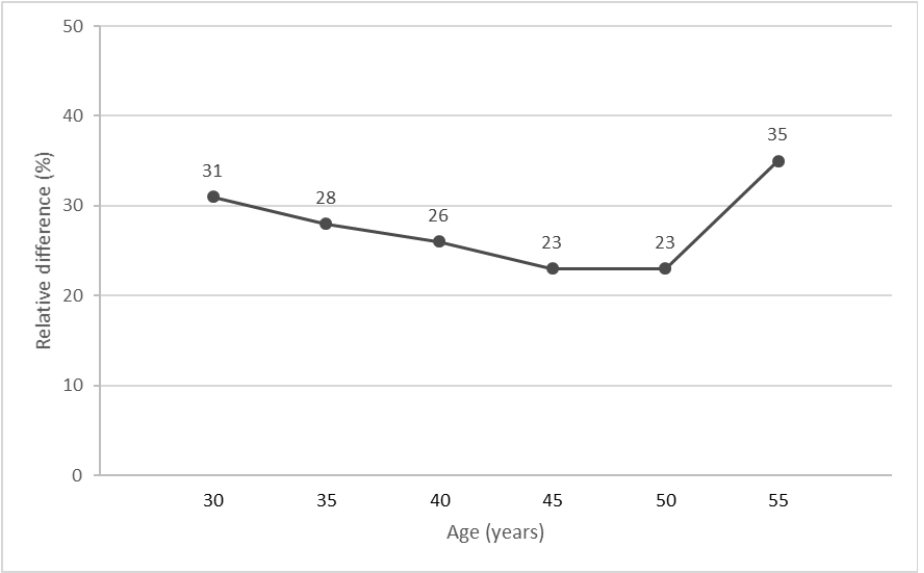

Figure 5 Relative difference in working life expectancy between people with prolonged SA due to shoulder lesion and general Finnish population at the age of 30–55.

5.4 CO-MORBIDITY (I, II)

A notable co-morbidity, especially musculoskeletal co-morbidity, was observed in the whole group of people who received a disability pension after prolonged SA due to a shoulder lesion and those who received a disability pension due to a shoulder lesion.

The primary or secondary diagnosis of 74.3% of those who had received a disability pension after prolonged SA due to a shoulder lesion was a musculoskeletal disease. Musculoskeletal diagnosis-based disability pensions were considerably more infrequent among the base population (43.8% of granted disability pensions). However, only 35.7% those who received a disability pension after prolonged SA due to a shoulder lesion had a shoulder lesion as their primary or secondary diagnosis. Other musculoskeletal diseases were also common reasons for retirement. Primary or secondary diagnosis was a spine-related disease for 27.4% and osteoarthritis for 23.1% of those who were receiving a disability pension. The fourth most common cause of disability retirement was a mental disorder (16.2%).

A secondary diagnosis was given to 61.5% of those who received a disability pension due to a shoulder lesion. Musculoskeletal diseases accounted for 71.2% of these secondary diagnoses, and was clearly the most common diagnostic group. Mental disorders were the second most common diagnostic group, at 5.7%.

5.5 DETERMINANTS OF SICKNESS ABSENCE DUE TO A SHOULDER LESION (I, IV)

5.5.1 OCCUPATIONAL DETERMINANTS

Compared with the general population, people with prolonged SA due to a shoulder lesion worked more commonly in the public sector and in manual occupations. Their work also more often included heavy lifting and working with hands above shoulder level, and required tight handgrip force and low job control.

5.5.1.1 Cumulative work exposures

Among both genders, the prevalence of SA due to a shoulder lesion generally increased after exposure to any of the observed physical workload factors exceeded ten years.

Among both genders, all cumulative work exposures predicted SA due to a shoulder lesion in the age- and gender-adjusted model. When the model was further adjusted for all the variables except education and leisure-time physical activity, cumulative exposure to physically heavy work over ten years (HR 1.91 95% CI 1.14-3.21) and cumulative exposure to forceful hand movements over ten years (HR 2.32 95% CI (1.32-4.07) remained risk factors for SA due to a shoulder lesion for the whole study population.

In the fully-adjusted model including composite cumulative exposure to specific physical exposures, two to four exposures with time of exposure exceeding ten years were associated with an increased risk of SA due to a shoulder lesion among both genders (Figure 6A and B). Cumulative exposure to physically heavy work over ten years also increased the risk among women.

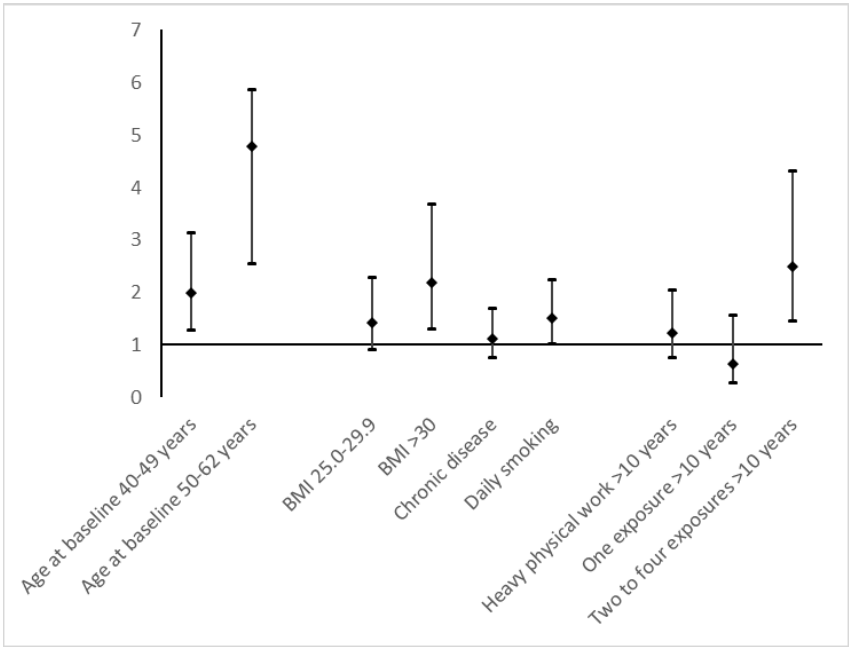

Figure 6A Fully-adjusted HR with 95% CIs for SA due to shoulder lesion among men.

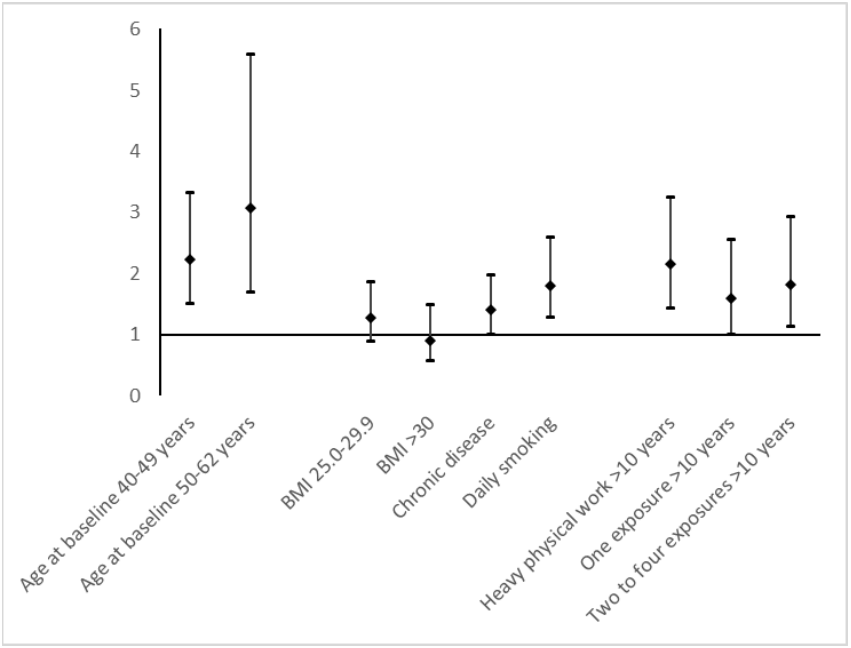

Figure 6B Fully-adjusted HR with 95% CIs for SA due to shoulder lesion among woman.

5.5.2 NON-OCCUPATIONAL DETERMINANTS

People with prolonged SA due to a shoulder lesion were most commonly aged 50–59. They were more often female in comparison to the general population. They also more often had a lower education level and lived in the Eastern or Northern part of Finland. Obese men and women who smoked daily as well as women with insomnia-related symptoms at baseline were over-represented. Those with a clinically defined shoulder disease at baseline had the highest prevalence of SA.

Age was associated with SA due to a shoulder lesion with a dose-response relationship. In a model that was adjusted for all variables except education and leisure-time physical activity, the risk of SA among 40–49-year-olds increased more than twofold and among 50–62 year-olds fourfold compared to those aged 30–39. In the same model, daily smokers were also at an increased risk of SA due to shoulder lesion (RR 1.7 95% CI 1.3-2.21). In a sub-analysis, insomnia-related symptoms at baseline were associated with SA.

In the fully-adjusted model, age and daily smoking were risk factors for SA due to a shoulder lesion among both genders (Figure 6A and 6B). Daily smoking increased the risk of SA 1.5 times among men and 1.8 times among women. Obesity was also a risk factor among men (HR 2.18 95% CI 1.29-3.68).

5.6 DETERMINANTS OF DISABILITY RETIREMENT DUE TO A SHOULDER LESION (II, III)

5.6.1 OCCUPATIONAL DETERMINANTS

All the studied physical and psychosocial work-related factors showed a statistically significant association with disability retirement due to a shoulder lesion among both genders in an age-adjusted model. However, when all physical exposures were included in the model simultaneously, physically heavy work showed a statistically significantly increased risk among both genders (HR 2.90, 95% CI 2.37-3.55 and HR 3.21 95% CI 2.80-3.90 among men and women, respectively) working with hands above shoulder level among men (HR 1.57 95% CI 1.35-1.81) and working in a forward bent posture among women (HR 1.21, 95% CI 1.03-1.42). Among men, the association between heavy physical work and the outcome as well as the association between working with hands above shoulder level and the outcome was seen in all age groups. Among women, heavy physical work also increased the risk of disability retirement due to a shoulder lesion in all age groups, but working in a forward bent posture only increased the risk in the below-50 age groups.

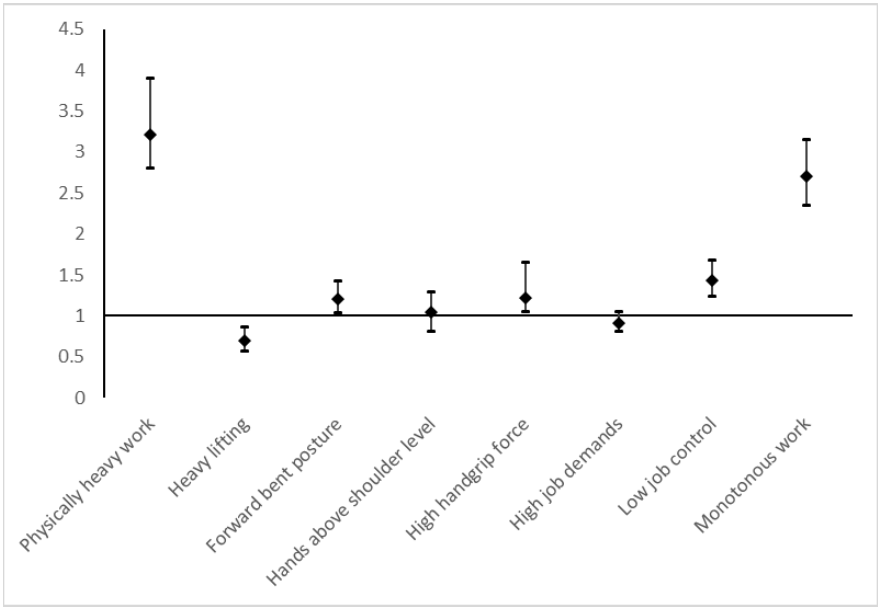

Figure 7A Age and mutually adjusted (physical for other physical factors and psychosocial for other psychosocial factors) HR with 95% CIs for disability retirement due to shoulder lesion among men.

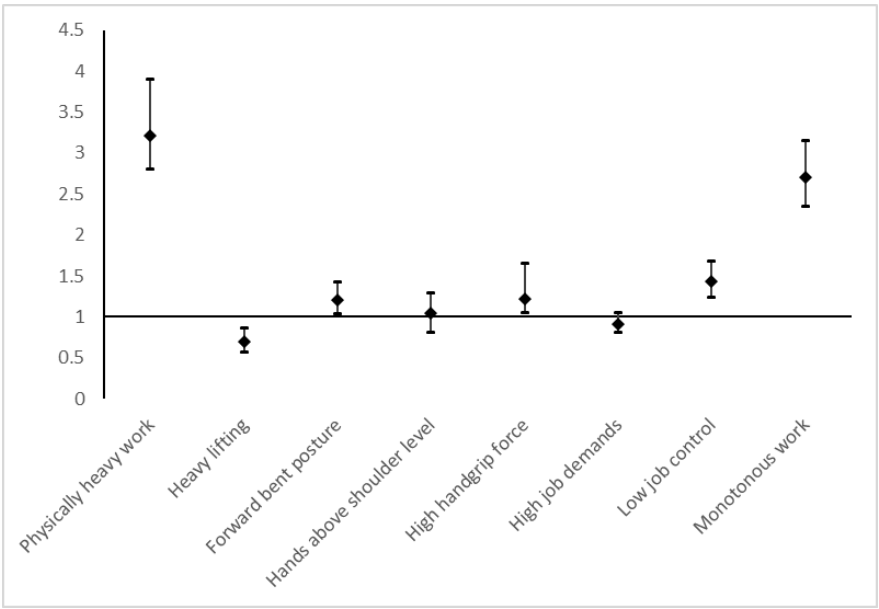

Figure 7B Age and mutually adjusted (physical for other physical factors and psychosocial for other psychosocial factors) HR with 95% CIs for disability retirement due to shoulder lesion among women.

When all three psychosocial work-related factors were simultaneously included in the model, among men, low job control and among women, monotonous work had the highest HR. Among men, having an active, passive, or high strain job had a strong association with disability retirement due to a shoulder lesion whereas among women, this association was observed only with high strain jobs.

Further adjustment for education weakened the observed associations among women in particular. The associations of either physical or psychosocial work- related factors with disability retirement due to a shoulder lesion did not considerably vary in the different educational strata, in the private or public sector or in the three most common industries.

5.6.2 OCCUPATIONAL DIFFERENCES

Among men, construction workers, electricians and plumbers had the highest IR (IR 94, 95% CI 77-114), whereas among women, building caretakers, cleaners, assistant nurses, and kitchen workers showed the highest IR (IR 93, 95% CI 75-116) of full disability retirement due to a shoulder lesion. Other occupations with an IR higher than the population average included metal and machine workers (men), service workers (women), agricultural and fishery workers (women), craft workers (women), chemical, wood and metal processing workers (both genders), and unskilled manual workers (both genders).

In comparison to the professionals, the age-adjusted risk of disability retirement due to a shoulder lesion was increased in all other occupations among women and in all other occupations excluding managers and customer services clerks among men (Figure 8A and 8B). Among men, construction workers, electricians, and plumbers were at the highest risk of disability retirement (HR 32.5, 95% CI 20.7-51.2) and unskilled transport, construction and manufacturing workers at the second highest risk (HR 23.7, 95% CI 14.5-38.6). Among women, the highest risks were observed among unskilled transport, construction, and manufacturing workers (HR 30.9, 95% CI 17.2-55.6), and, chemical, wood and metal processing workers (HR 30.7, 95% CI 16.2-58.1).

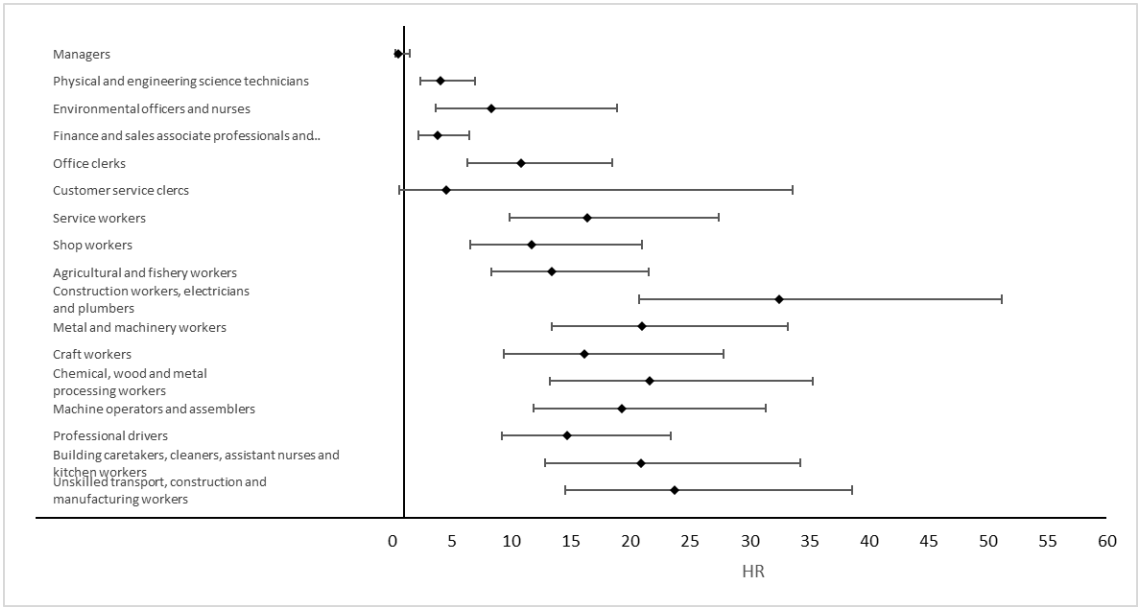

Figure 8A Age-adjusted HR and 95% confidence intervals (CIs) of full disability retirement due to shoulder lesion in different occupations among men. Reference group is professionals (HR=1).

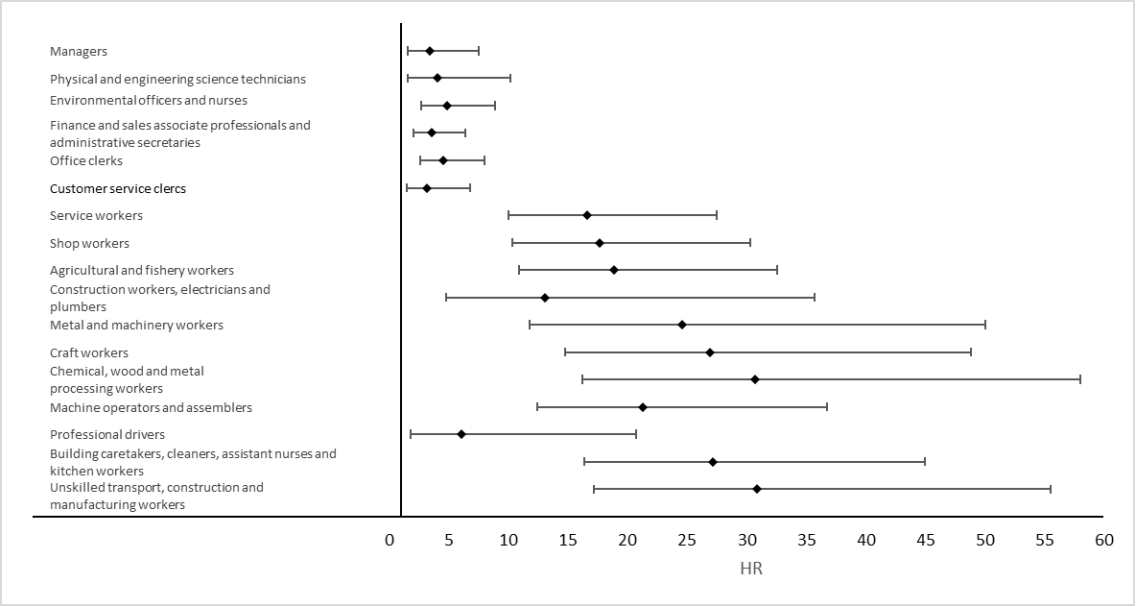

Figure 9A Age-adjusted HR and 95% CI of full disability retirement due to shoulder lesion in different occupations among women. Reference group is professionals (HR=1).

Education largely accounted for the occupational differences in disability retirement. Among men, education explained more than 64% of the risk in most occupations. Among women, education explained even more of the risk – over 74% in most occupations.

5.7 DETERMINANTS OF PRETERM EXIT FROM WORK (I)

5.7.1 OCCUPATIONAL DETERMINANTS

Working in the private sector predicted preterm exit from work during the follow-up. Of the work exposures studied, only heavy lifting was associated with an increased risk of preterm exit from paid employment in the age- and gender- adjusted model, but it decreased to the borderline value in the fully-adjusted model.

5.7.2 NON-OCCUPATIONAL DETERMINANTS

Higher age, male gender, a longer initial SA, lower education, and not being able to return to work sustainably during the follow-up were all determinants for preterm exit from paid employment due to a shoulder lesion. Participation in vocational rehabilitation doubled the risk of preterm exit from work.

5.8 PREVENTATIVE POTENTIAL OF MODIFIABLE RISK FACTORS TO REDUCE WORK DISABILITY DUE TO A SHOULDER LESION (II–IV)

5.8.1 POPULATION ATTRIBUTABLE FRACTIONS OF OCCUPATIONAL AND NON-OCCUPATIONAL RISK FACTORS – SICKNESS ABSENCE

In the fully-adjusted model, the overall PAF of all the studied modifiable risk factors was 49%. These risk factors accounted for 60% of SA among men and 49% among women. Among men, the highest PAF was observed for two to four physical exposures, with time of exposure exceeding ten years (34%), followed by obesity (30%) and daily smoking (14%) (Figure 9). Among women, PAF was the highest for cumulative exposure to physically heavy work over ten years (23%), followed by two to four physical exposures with exposure exceeding ten years (22%) and daily smoking (15%).

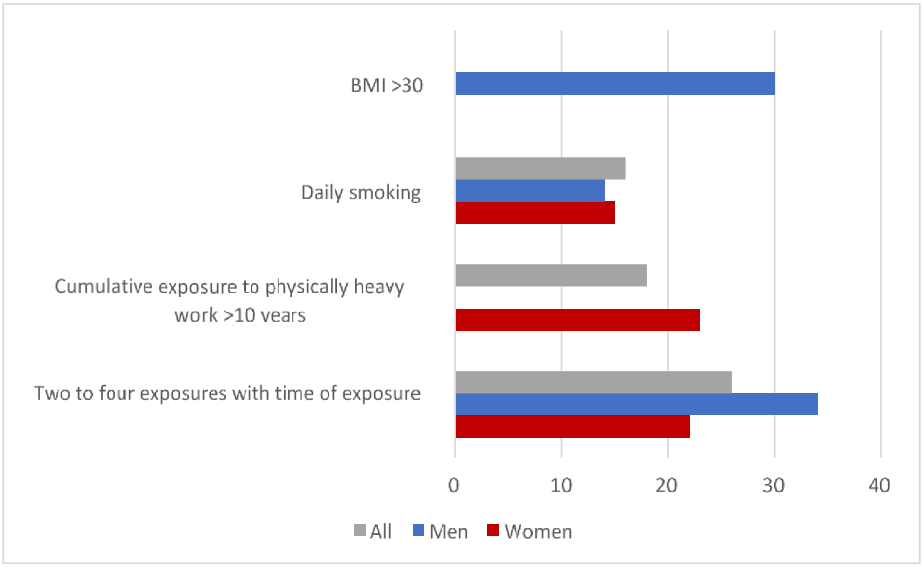

Figure 9 PAF of potential risk factors for disability SA due to a shoulder lesion, fully-adjusted model.

5.8.2 POPULATION ATTRIBUTABLE FRACTIONS OF WORK-RELATED FACTORS – DISABILITY RETIREMENT

A total of 46% and 41% of cases of disability retirement due to a shoulder lesion were attributed to physical work exposures among men and women, respectively, when all physical exposures were considered (Figure 10). In addition, when all psychosocial work-related factors were taken into account, 49% and 35% of disability retirement was attributed to these factors among men and women, respectively. The composite exposure – heavy physical work – had the strongest impact on disability retirement among both men and women (41% and 37%, respectively). Of the independent psychosocial work-related factors, low job control among men and monotonous work among women had the highest AF (39% and 20%, respectively).

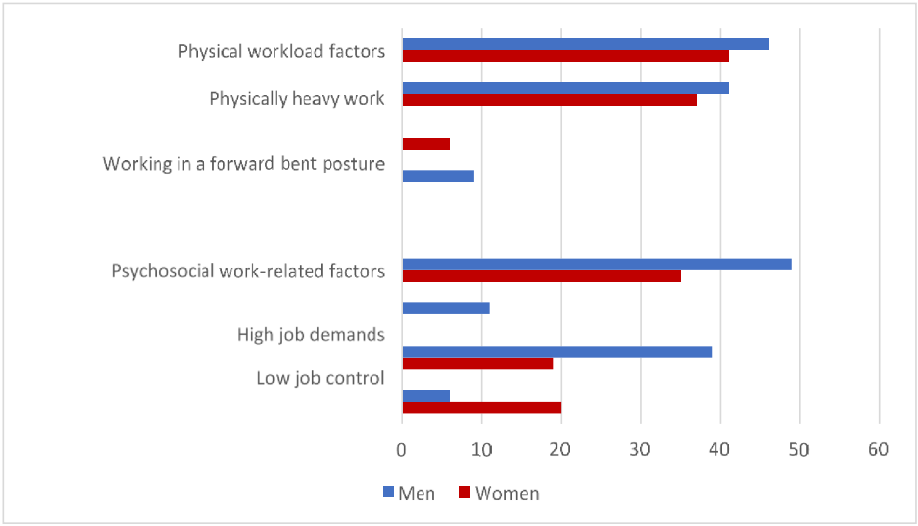

Figure 10 Attributable fractions (AF) of work-related factors for disability retirement due to shoulder lesion.

5.8.3 CONTRIBUTION OF PHYSICAL AND PSYCHOSOCIAL WORK-RELATED FACTORS

The contribution of work-related factors to disability retirement due to a shoulder lesion varied among the occupational groups after occupational factors were controlled for. The contribution of physical work exposures was the highest among male agricultural and fishery workers (82.6%, 95% CI 82.2-83.0%), followed by construction workers, electricians and plumbers (78.4%, 95% CI 78.1-78.8%). Among women, the highest contribution of physical work exposures was among construction workers, electricians, and plumbers (91.4%, 95% CI 90.2-92.6%), and the second highest among agricultural and fishery workers (66.9%, 95% CI 66.2-67.6%). Physical work exposures totally explained the excess risk of disability retirement among male finance and sales associate professionals and administrative secretaries as well as male agricultural and fishery workers and female construction workers, electricians, and plumbers.

Of the physical work exposures, a composite exposure – heavy physical work – made the greatest contribution to the excess risk of disability retirement due to a shoulder lesion among both genders (Figure 11A and 11B). A substantially high contribution was observed among both genders of construction workers, electricians, and plumbers, as well as among male agricultural and fishery workers and unskilled transport, construction, and manufacturing workers. Among women, none of the specific physical work exposures explained 50% or more of the excess risk of disability retirement.

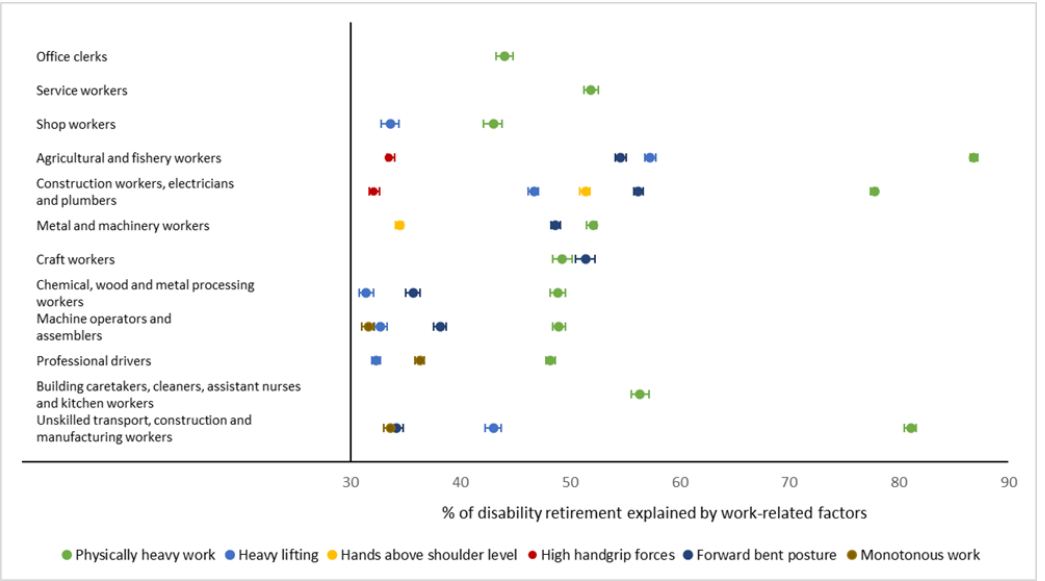

Figure 11A Physical and psychosocial work-related factors explaining at least 30% of disability retirement due to a shoulder lesion. Values and 95% CIs in different occupations among men. The values are adjusted for age, education, and mutual work-related factors (physical for other physical factors and psychosocial for other psychosocial factors).

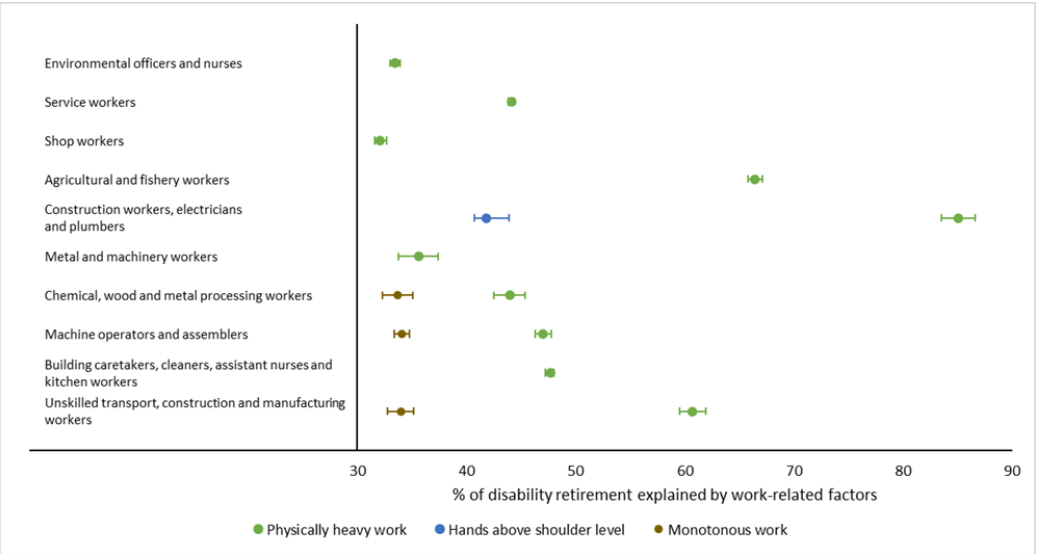

Figure 11B Physical and psychosocial work-related factors explaining at least 30% of disability retirement due to a shoulder lesion. Values and 95% CIs in different occupations among men. The values are adjusted for age, education, and mutual work-related factors (physical for other physical factors and psychosocial for other psychosocial factors).

The combined contribution of psychosocial workload factors was lower than the combined contribution of physical work exposures in all occupations except male professional drivers. Of the specific psychosocial work-related factors, only monotonous work showed a contribution to the excess risk of disability retirement due to a shoulder lesion. The excess risk was seen among unskilled transport, construction, and manufacturing workers (both genders), machine operators and assemblers (both genders), professional drivers (men) as well as chemical, wood, and metal processing workers (women).

6 DISCUSSION

6.1 SUMMARY OF MAIN FINDINGS

Although most people with prolonged SA due to a shoulder lesion returned to work within four months, their work participation during the nine-year follow-up was notably reduced. They were expected to spend only 35–55% of their potential working life years at work. Compared with the general population, people with prolonged SA due to a shoulder lesion were expected to lose 1.8–8.1 years of working life, depending on their age.

Both physical and psychosocial work-related factors made a considerable contribution to work disability due to a shoulder lesion among both genders. Of all studied physical exposures, a composite exposure – heavy physical work – made the strongest contribution among both genders. The association between the exposure and the outcome was seen in all age groups. Among both genders, the risk of SA due to a shoulder lesion increased after exposure to any of the physical workload factors exceeded ten years. Of the psychosocial work-related factors, low job control among men and monotonous work among women made the strongest contribution to disability retirement due to a shoulder lesion. High job demands and high job strain increased the risk of SA due to a shoulder lesion among men but none of the psychosocial factors predicted future SA among women. The non-occupational risk factors of SA due to a shoulder lesion included age and daily smoking among both genders and obesity among men. Leisure-time physical activity was not associated with future SA.

Among men, occupations with a high risk of disability retirement due to shoulder lesion included construction workers, electricians and plumbers, and metal and machine workers. Among women, occupations with a high risk included building caretakers, cleaners, assistant nurses, and kitchen workers, as well as service workers and agricultural and fishery workers. Furthermore, the incidence of disability retirement among chemical, wood, and metal processing workers and unskilled manual workers among both genders was above the population average. The overall contribution of physical exposures to disability retirement was higher than the overall contribution of psychosocial work-related factors.

Overall, around 40% of work disability cases were attributed to physical work-related factors, with values being higher for men than women. A total of 49% (men) and 35% (women) of disability retirement cases can be prevented by eliminating work-related psychosocial factors. In particular, the risk of disability retirement due to a shoulder lesion could be reduced by 39% among men and 19% among women if the level of job control at the workplace was

increased. Among the non-occupational modifiable risk factors, obesity had the highest preventive potential of SA due to a shoulder lesion among men, with one third of the SA cases being attributed to obesity. In addition, 15% of the SA cases could be reduced among both genders by avoiding daily smoking. Physical exposures completely explained the excess risk of disability retirement due to a shoulder lesion among male finance and sales associate professionals, administrative secretaries, and agricultural and fishery workers. Of the psychosocial work-related factors, only monotonous work contributed to disability retirement.

6.2 COMPARISON WITH PREVIOUS STUDIES

6.2.1 WORK PARTICIPATION AFTER A SHOULDER LESION

Hardly any preceding knowledge exists on the short- and long-term impact of specific shoulder diseases on work participation. In addition, the considerable methodological differences between the previous studies and the studies included in this thesis, in addition to differing social security systems, make comparing results difficult.

At the end of the nine-year follow-up, 19.9% of those with previous prolonged SA due to a shoulder lesion had left paid employment prior to the statutory retirement age, and the majority were receiving a permanent disability pension. A French study followed a cohort of a random sample of employees aged 20–59 who attended a mandatory health examination in which they were diagnosed with an upper limb musculoskeletal disease (Serazin, Ha, Bodin, Imbernon, & Roquelaure, 2013). Rotator cuff syndrome was the most common diagnosis, although all upper limb diseases were merged in the analysis (Ha et al., 2009). After a follow-up of 5–7 years, 20.7% of the cohort members had ceased working, most of them due to retirement.

Altogether 76.9% of people with a disabling shoulder lesion returned to work sustainably within 14 months, 50% of them returning after less than one month (26 days) of SA. This finding is in line with that of a French study reporting that the average duration of SA due to rotator cuff syndrome was 30.8 days (Wilson d'Almeida, Godard, Leclerc, & Lahon, 2008). Compared with other common musculoskeletal diseases, RTW after SA due to a shoulder lesion was a little sooner than after SA due to knee osteoarthritis (median time to sustained RTW 31 days) and much sooner than after SA due to hip osteoarthritis (median time to sustained RTW 84 days) (Kontio, Viikari-Juntura, & Solovieva, 2020). However, RTW after SA due to a shoulder lesion was slower than after back pain-related SA. A meta-analysis reported that 68.2% of people with SA due to back pain had returned to work at one month and 90.7% at one to six months (Wynne-Jones et al., 2014).

Compared with those with prolonged SA due to osteoarthritis, people with prolonged SA due to a shoulder lesion were expected to spend more time at work and as economically inactive or unemployed (Kontio et al., 2020). From another perspective, they were expected to spend less time on ill health-related benefits and in early old-age retirement or permanent disability retirement. The relative difference between the working life years of people with prolonged SA due to a shoulder lesion and those in the general population was estimated to be at its highest when the initial SA had begun at the age of 55 and second highest when the SA has begun at the age of 30. As regards osteoarthritis, the relative difference increases with age and is estimated to be at its highest when the SA has started at the ages of 45, 50 and 55.

The disparity between the work participation and working life expectancy of people with different disabling musculoskeletal diseases may have several reasons. The diseases themselves differ in symptoms, the age of the individuals they affect, and how they proceed and affect the ability to function. For example, a person with a shoulder lesion is typically already in the middle or the latter part of their working career. The person can usually work without difficulties in an occupation that does not require high shoulder load and has a fairly good chance of rehabilitating their shoulder. In contrast, a person with symptomatic osteoarthritis in the large joints of the lower limbs cannot expect to reach painlessness via rehabilitation. Arthritis and its symptoms are likely to progress with time. When the form of osteoarthritis becomes severe, this person is most likely to be treated with arthroplasty.

The treatment and likelihood of successful rehabilitation of different diseases also influence the approach of the authorities who grant sickness benefits and disability pensions. These benefits are generally granted less often to people with a shoulder lesion than to people with osteoarthritis. If a person with a symptomatic shoulder lesion cannot work but does not receive SA or disability pension, they will naturally end up being unemployed or economically inactive.

The aim of vocational rehabilitation within the earnings-related pension scheme is to support a person's work participation and reduce disability retirement. A recent Finnish study reported that vocational rehabilitation only had a modest effect on work participation among people with musculoskeletal-related work disability (Leinonen, Viikari-Juntura, et al., 2019). Moreover, vocational rehabilitation did not appear to reduce the expected disability retirement years among rehabilitees with predominantly musculoskeletal diseases (Leinonen, Solovieva, Husgafvel-Pursiainen, Laaksonen, & Viikari-Juntura, 2019). In the light of these findings, it is not unexpected that participating in vocational rehabilitation after prolonged SA due to a shoulder lesion doubled the risk of preterm exit from work during the nine years of follow-up.

Predictors of a successful outcome for vocational rehabilitation include younger age, male gender, good general health, and an early start for rehabilitation (Leinonen, Viikari-Juntura, et al., 2019; Marnetoft, Selander,

Bergroth, & Ekholm, 2001; Selander, Marnetoft, & Asell, 2007). The finding that vocational rehabilitation after prolonged SA due to a shoulder lesion not only fails to protect from preterm exit from paid employment but is also a risk factor, might be because people with shoulder problems are typically in the latter part of middle age. At an older age, the variety of the options for vocational rehabilitation, as well as a person's motivation for vocational rehabilitation, can be more limited than at a younger age. People with prolonged SA due to a shoulder lesion also often have co-morbid conditions that might further impair their ability to work. Shoulder lesions are considered common and their symptoms are often seen as transient, and people who would benefit from vocational rehabilitation often need to wait too long to enter the process. Early intervention is pivotal to vocational rehabilitation, because the longer a person is off work, the greater the obstacles to RTW become.

6.2.2 CO-MORBIDITY

Although a shoulder lesion was the most common single cause of disability retirement, only a third of those who received a disability pension after prolonged SA due to shoulder lesion had a shoulder disease as their primary or their secondary diagnosis for retirement. Both spine-related diseases and osteoarthritis were common diagnoses for disability retirement. Overall, a musculoskeletal disease was the primary or secondary cause of disability retirement in three out of four cases. This implies a considerable musculoskeletal co-morbidity that has also been reported before. Patients with chronic low back pain also have a significantly higher frequency of other musculoskeletal pain conditions (Gore, Sadosky, Stacey, Tai, & Leslie, 2012), and 35% of people with osteoarthritis suffer from some co-occurring musculoskeletal disease (Swain, Sarmanova, Coupland, Doherty, & Zhang, 2020). Moreover, a Finnish study showed that 93% of female kitchen workers with shoulder pain also had pain in the neck, 75% had pain in the forearm or hands, 50% in the low back, 40% in the knees and 44% in the ankles (Haukka et al., 2006). The explanation for musculoskeletal co-morbidity most likely lies at least partially in the same risk factors for these diseases, for example, physical exposures (heavy lifting, heavy physical work), obesity and smoking.

According to Study I, mental disorders were the fourth common cause of disability retirement among people with prolonged SA due to a shoulder lesion. This finding is in line with previous studies that have reported co-occurrence of shoulder pain with mental disorders and sleep disturbances (Cho, Jung, Park, Song, & Yu, 2013; Rajala, Keinanen-Kiukaanniemi, Uusimaki, & Kivela, 1995). Musculoskeletal pain has generally been linked to mental disorders (Magni, Moreschi, Rigatti-Luchini, & Merskey, 1994). In adolescence, multisite musculoskeletal pain is significantly associated with anxiety disorders and in middle age with higher GHQ scores (Eckhoff,

Straume, & Kvernmo, 2017; Neupane, Lallukka, Pietilainen, Rahkonen, & Leino-Arjas, 2020).

6.2.3 AGE AND GENDER DIFFERENCES

SA due to a shoulder lesion was most common among 50–59-year-olds, and the least common among 30–39-year-olds. This pattern, in which the incidence of SA increases with age, is biologically plausible, as shoulder lesions become more prevalent with age. As an example, one Finnish study showed that at the age of 50–64, the risk of chronic rotator cuff tendinitis increased over four times that at the age of 30–39 (Miranda et al., 2005). Older age is also associated with a poorer outcome of upper extremity diseases, including shoulder diseases (Descatha et al., 2009). The incidence of disability retirement due to a shoulder lesion, however, reached its peak already at the ages of 50–54 and decreased after the age of 55. In one working population, the incidence of seeking medical advice due to a shoulder disease peaked already before the age of 50 (Bodin et al., 2012). It is possible that the majority of people with the most disabling shoulder symptoms and potential co-existing co-morbid conditions have already retired and have never entered the age group after 55 years. The prognostic factors of RTW with shoulder diseases have been studied to some extent, and higher age seems to be a strong predictor of delayed RTW after rotator cuff surgery (Nove-Josserand et al., 2011).

The prevalence or incidence of degenerative rotator cuff diseases does not convincingly differ between the genders (Bodin et al., 2012; Miranda et al., 2005). However, the findings of the current study suggest clear gender differences in work disability due to a shoulder lesion. It is noteworthy that the prevalence of prolonged SA due to a shoulder lesion was higher among women than among men, and that the opposite tendency was seen for disability retirement due to a shoulder lesion. The incidence of disability retirement due to musculoskeletal diseases, however, is reported to be higher for women than men (Polvinen et al., 2016). The gender differences in disability retirement due to a shoulder lesion could be explained by men being more frequently exposed to heavy physical loads than women. Indeed, disability retirement was attributed to physically heavy work to a larger extent among men than women in almost all the studied occupational groups. Men also generally have a lower education level than women, which might diminish the opportunities to change jobs or for re-education in cases of work disability. This could also explain why disability retirement due to a shoulder lesion but not due to all musculoskeletal diseases is more common among men than women. Because shoulder pain is often related to certain tasks involving the upper extremities, successful work modifications that lead to continuing work may also be more feasible for people with a shoulder lesion than, for example, people with severe back pain. Several studies have reported that women are at a higher risk of all-cause SA than men (Allebeck & Mastekaasa, 2004; Laaksonen et al., 2010;

Smeby, Bruusgaard, & Claussen, 2009). This might be because women better recognise signs of illness and more actively seek medical advice (McDonough & Walters, 2001). In a Finnish study, physical functioning and self-reported diagnosed diseases explained gender differences in SA of all lengths (Laaksonen et al., 2010). It has also been suggested that women could be more susceptible to the impact of physical and psychosocial work-related factors or have more stress factors in their personal lives (Chandola et al., 2004; Laaksonen et al., 2010).

6.2.4 MODIFIABLE RISK FACTORS

6.2.4.1 Occupational risk factors

The associations between work-related factors and work disability due to specific shoulder diseases have not been studied before. Therefore, the results are not directly comparable with previous findings.

The results of this thesis study are in line with the findings of systematic reviews reporting associations between arm elevation, shoulder load (including lifting), repetitive work and specific shoulder diseases (da Costa & Vieira, 2010; van der Molen et al., 2017; van Rijn, Huisstede, Koes, & Burdorf, 2010). These reviews did not, however, observe gender differences. Physically heavy work made the highest contribution to excess risk of disability retirement due to a shoulder lesion among both genders (Studies II and III). The association between working with hands above shoulder level and disability retirement was seen among men only.

The prevalence of SA due to a shoulder lesion generally increased after doing physically demanding work for at least ten years. For example, the prevalence of SA was 5.0% among workers with up to ten years of exposure to working with hands above shoulder level and doubled (10.3%) among workers with more than ten years of exposure. This finding is partially in line with a recent meta-analysis reporting that the risk of a shoulder disease increases by 21% per 1000 hours of working with the hands above the shoulder level (Seidler et al., 2020). If a person has a regular job that includes working with hands above shoulder level for one hour per day, 1000 hours will be fulfilled after working for a little less than four and half years. The studies included in this meta-analysis, however, were heterogenous and most of them included rotator cuff surgery as an outcome. Rotator cuff surgery is quite a severe outcome and is typically preceded by SA. However, those who end up having rotator cuff surgery can be selected and may have tried in advance to prevent long-term work disability. It is nevertheless likely that the cumulative effect of daily working with hands above shoulder level for several years does not only increase the risk of shoulder diseases but in time also makes the disease more disabling.

Previous studies on occupations and shoulder diseases have predominantly reported the incidence or prevalence of shoulder diseases or shoulder pain for specific occupations. Rotator cuff syndrome is common among female nurses (Chung et al., 2013). Meat processing workers are at an increased risk of shoulder impingement syndrome than people not working in slaughtering and meat processing (Frost & Andersen, 1999), and painters have considerably more supraspinatus tears and shoulder pain than controls who do not use their hands above shoulder level (Loew et al., 2019). A German study reported that male construction workers were over-represented in rotator cuff operations (Rolf et al., 2006). Despite the different outcome however, the findings of this thesis study are in line with those of these previous studies. The highest IR of disability retirement was found among male construction workers, electricians and plumbers, and female building caretakers, cleaners, assistant nurses, and kitchen workers.

The most recent systematic review and meta-analysis of work-related risk factors for specific shoulder diseases concluded that evidence that psychosocial demands increase the incidence of subacromial pain is of low quality (van der Molen et al., 2017). However, this review also reported that there is also low-quality evidence that low social support, low decision latitude or low job control do not increase the incidence of shoulder diseases. In line with the review, high job demands were associated with SA and disability retirement due to a shoulder lesion in this thesis, but only among men. Low job control was, however, associated with disability retirement due to a shoulder lesion among both genders. Disability retirement due to a specific disease is, nevertheless, a different outcome than the disease itself. Psychosocial work-related factors can increase the biomechanical loading of the shoulder. The biomechanical load is partly defined by organisational factors such as speed of work and variation of tasks. A person with low job control typically cannot schedule their work tasks, and as a result is forced to work at a fixed pace and might lack breaks when they are needed. Time pressure may increase hurried movements with high accelerations or poor posture. All this might lead to musculoskeletal overstrain with impaired recovery. In addition, work-related psychosocial factors, such as high job demands, may increase work-related stress, which in turn increases muscle tone but is also associated with increased perception of musculoskeletal symptoms (Bongers, de Winter, Kompier, & Hildebrandt, 1993). Furthermore, a Norwegian study suggested that work-related psychosocial factors may increase musculoskeletal pain through impaired sleep (Vleeshouwers, Knardahl, & Christensen, 2019). Psychosocial factors can play a different role in the development of work disability than in the development of the disease. They understandably also affect job satisfaction, mood, and coping skills (Feuerstein, Shaw, Nicholas, & Huang, 2004).

6.2.4.2 Non-occupational risk factors

Daily smoking predicted SA due to a shoulder lesion among both genders. However, the evidence of the associations between smoking and shoulder diseases is inconsistent even though smoking is a known risk factor for several other musculoskeletal diseases including low back pain, lumbar disc herniation and lateral epicondylitis (Huang, Han, Liu, Yu, & Yu, 2016; Sayampanathan, Basha, & Mitra, 2020; Shiri, Karppinen, Leino-Arjas, Solovieva, & Viikari- Juntura, 2010). Nicotine is a recognised vasoconstrictor and carbon monoxide is known to disturb cellular metabolism (Leow & Maibach, 1998; Mosley & Fineseth, 1977). These metabolic changes may boost tendon degeneration and eventually lead to a symptomatic shoulder disease. Smoking has also been reported to predict SA due to musculoskeletal pain (Haukka et al., 2014). It might, however, also be related to other factors leading to SA.

Obesity was a risk factor for SA due to a shoulder lesion among men. Obesity has been reported to enhance tendon degeneration in a multifactorial way (Abate, Salini, & Andia, 2016). Obesity and overweight have also both been reported to be independent risk factors for shoulder impingement syndrome surgery (Dalboge, Frost, Andersen, & Svendsen, 2018). Overall, multiple studies have shown that obesity is a significant predictor of all-cause SA (Catalina-Romero et al., 2019; Ferrie et al., 2007; Reber, Konig, & Hajek, 2018). It has also been associated with SA due to musculoskeletal diseases among both genders (Svard et al., 2020). Interestingly, in the current thesis study, obesity was not attributed to SA due to a shoulder lesion among women, even though it has been reported to be a stronger predictor of all-cause and musculoskeletal-related SA among women than men (Reber et al., 2018; Svard et al., 2020). This might be because obese women are more often employed in physically less demanding jobs than obese men, in which the overall shoulder load is smaller. The work environments of obese women are also perhaps more versatile than those of men and enable easier work modifications. A cohort study showed that in RTW attempts after SA due to a mental or musculoskeletal disease, women more often had reduced working hours and reported more job satisfaction than men (De Rijk, Nijhuis, & Alexanderson, 2009).

Most people with a symptomatic rotator cuff disease have sleep disturbances and sleep quality correlates with pain (Khazzam, Mulligan, Brunette-Christiansen, & Shirley, 2018). Low-quality sleep in turn appears to enhance the likelihood of hyperalgesic pain and to predict chronic widespread pain (Lautenbacher, Kundermann, & Krieg, 2006; Lavigne, Nashed, Manzini, & Carra, 2011). In agreement with the studies mentioned above, insomnia-related symptoms at baseline were associated with SA due to a shoulder lesion (Study IV). However, psychosocial distress was not a risk factor for SA due to a shoulder lesion. Psychosocial distress cannot be considered only a risk factor as it can also be a consequence of a disease.

6.2.5 PREVENTATIVE POTENTIAL OF TARGETING OCCUPATIONAL AND NON-OCCUPATIONAL RISK FACTORS

Preventive potential refers to the probability of controlling or reducing a future problem if interventions in the problem under consideration are conducted. This thesis study assessed the attribution of the earlier determined risk factors to SA or disability retirement due to a shoulder lesion or in other words, the potential to prevent SA or disability retirement due to a shoulder lesion if these risk factors were eliminated.

Previous studies have reported that 23–28% of all-case long-term SA are attributed to work-related exposures (Christensen et al., 2007; Sterud, 2014). Even though these studies did not include cumulative exposures, their results are in line with the finding of this thesis. Being exposed for more than ten years to physically heavy work explained 26% and being exposed for more than ten years to at least two specific physical workload factors explained 18% of SA in the whole study population.

The attribution of non-occupational factors to SA due to a shoulder lesion was also evaluated. In the absence of daily smoking, 16% of SA due to a shoulder lesion could be prevented. This percentage is even higher than reported in a previous study on all-cause SA (13.5% for men and 6.9% for women) (Laaksonen, Piha, Martikainen, Rahkonen, & Lahelma, 2009). Obesity explained 30% of SA due to a shoulder lesion among men. This PAF value for obesity is also higher than that reported by previous studies. In a Finnish study of city employees, obesity explained 9.6% and 8.0% of all-cause SA among men and women, respectively (Laaksonen et al., 2009). Moreover, a multicohort study with data on participants from four cohorts from the UK, France, and Finland found 7.8% of SA due to musculoskeletal diseases to be attributed to obesity (Virtanen et al., 2018).

The overall PAF for the studied occupational and non-occupational risk factors, when observing SA due to a shoulder lesion, was lower for women than men. The reason for this probably lies in factors that this thesis was not able to consider. Among women, who bear the main responsibility for housework and family, work–family interference is associated with long-term SA (Lidwall, Marklund, & Voss, 2010).

A Danish study reported that 21% (men) and 34% (women) of all-cause disability pensions were attributed to physical work exposures (Labriola, Feveile, Christensen, Stroyer, & Lund, 2009). The contribution of physical work exposures was even higher for disability retirement due to a shoulder lesion. Physical work exposures explained 46% and 41% of disability retirement due to a shoulder lesion among men and women, respectively. Physically heavy work made the highest contribution to disability retirement among both genders. The association of high physical workload and disability benefits has also been observed before among Swedish construction workers (Robroek et al., 2017).

A total of 49% (men) and 35% (women) of disability retirement due to a shoulder lesion was attributed to psychosocial work-related factors (Study II).

Low job control explained 39% and 19% of disability retirement among men and women, respectively. This finding is in line with that of a German population-based study that reported early retirement due to musculoskeletal diseases to be notably attributed to low job control, especially among men.

When occupational differences in disability retirement were further explored, working with hands above the shoulder level made a notable contribution to disability retirement among construction workers, electricians, and plumbers, as well as metal and machinery workers. Both occupational groups are male dominated, and depending on work tasks, may spend significantly more time per day with their hands above shoulder level than the determined lower limit for this exposure. However, the contribution of work-related psychosocial factors to disability retirement due to a shoulder lesion was only modest when specific occupational groups were explored.

6.3 METHODOLOGICAL CONSIDERATIONS

All the studies included in the thesis were longitudinal with a relatively long follow-up time, and were based on nationally representative samples of working-age men and women. The longitudinal study design made it possible to explore the causal associations between occupational and non-occupational risk factors and work disability due to a shoulder lesion and to estimate the preventive potential of the studied modifiable factors. As the sample was large, the statistical power was sufficient to observe associations. Furthermore, all analyses for men and women could be carried out separately.

However, all the studies included in this thesis also had some limitations. First, the diagnosis of a shoulder lesion is mainly recorded in primary care. It is typically based on a clinical assessment only. This and the varied practices of different physicians could lead to some inaccuracy in diagnosis. None of the studies had information on the time of the onset of the shoulder lesion or the severity of the condition, type of treatment, or medical rehabilitation. In addition, no information was available on accidental injuries of the shoulder. Therefore, some residual confounding in the observed associations of the studied risk factors with work disability due to a shoulder lesion may still have remained.

Studies I–III utilised data from a large, register-based cohort of 30–59-year- olds. As the cohort was register-based, selection and attrition bias are unlikely. The cohort was linked to numerous national registers and thus covered a wide range of variables, including sociodemographic information, education, income, occupational and employment history (FLEED), SA, retirement, and vocational rehabilitation (KELA and FCP). The KELA and FCP registers included data on employment and unemployment periods and pensions, and had complete coverage and relatively high accuracy (Gissler & Haukka, 2004). Furthermore, the data derived from the registers are not

prone to recall bias and therefore could be seen as more reliable and accurate than those based on self-reports. The above-mentioned advantages of a register-based cohort, as well as the possibility to merge data from multiple registers using unique personal identification codes provided an excellent basis to study the impact of a disabling shoulder lesion on work participation, the duration of working life and lost working years. Moreover, the very large sample size of the cohort made it possible to identify occupational groups at a high risk of work disability due to a shoulder lesion.

Studies I–III had a few limitations that are typical for register-based epidemiological studies, and these should be taken into consideration when interpreting the results. The registers used in these studies did not include information on ill-health behaviour and lifestyle factors. However, taking the established association between education and health and lifestyle factors (Cutler & Lleras-Muney, 2010) and the availability of data on education from the FLEED register into consideration partially covered this shortcoming. Furthermore, in Studies I–III, information on occupation was based on annual register records made on the last day of the year and, therefore, the exact time spent in the occupation was unknown. Furthermore, occupation might have been missing for people who were unemployed at the end of the year, Moreover, as a person with shoulder problems might have changed jobs to one that is less physically demanding, the possibility of misclassification of occupational exposures cannot be excluded. Finally, the KELA register provided information on compensated SA episodes, capturing spells that extended over ten weekdays. Therefore, in Study I, the time expected to be spent at work might have been overestimated, while the time expected to be spent on time-restricted work disability might have been underestimated, especially for people with several SA episodes during the follow-up.

The use of JEM as a source of exposure information for register-based cohorts can be considered both a strength and a limitation. Exposures estimated using JEM are not liable to information bias. Nevertheless, this kind of method typically creates a non-differential misclassification bias. The variability of tasks, activities, and work processes within occupational classes in different workplaces is not taken account.

Study IV utilised the data of a national population health survey of a random sample of adult Finns (Health 2000 Study). The sampling in the Health 2000 Study was done within age groups and gender strata. The study population for Study IV was limited to those aged 30–62. The participation rate in this age group was high and comparable to the overall participation rate in the Health 2000 Study. Therefore, the population of Study IV was nationally representative. Due to its broad scope, the survey covered a wide range of variables, collected through interviews, health examinations and self-administrated questionnaires. Furthermore, the survey data were linked to several registers, the KELA SA register being one of them.

In the Health 2000 Study, information was collected via interviews on occupational history and physical work-related factors for each occupation

held for at least a year. This information was used to examine the contribution of cumulative physical workload factors on work disability due to a shoulder lesion and to explore dose-response associations. Self-assessment of physical workload may, however, lead to overestimation of exposure time (Viikari-Juntura et al., 1996). Information on smoking was also self-reported, which may have led to this risk factor being underestimated. In addition, due to the limited size of the study population, the association between smoking and SA due to a shoulder lesion was only studied among the daily smokers, excluding occasional and ex-smokers. However, the Health 2000 Study did include a physical examination during which trained nurses measured height and weight. The availability of information on both occupational and non-occupational risk factors meant it was possible to explore the relative importance of these factors in preventing work disability due to a shoulder lesion.

6.4 CLINICAL IMPICATIONS AND RECOMMENDATIONS

People with a disabling shoulder lesion are expected to spend only 35–55% of their potential working life years at work. The potential working life years will be mainly lost due to preterm old-age retirement and disability retirement. People with prolonged SA due to a shoulder lesion are at a threefold risk of disability retirement compared to the general population. The thesis study discovered a notable musculoskeletal co-morbidity: a third of those who received a disability pension had a shoulder lesion as their primary or secondary diagnosis, and low back diseases and osteoarthritis were also common reasons for retirement. Prolonged SA due to a shoulder lesion could, therefore, also be considered a warning sign of work disability due to other musculoskeletal conditions. Clinicians should consider interventions targeted at improving musculoskeletal functioning and necessary work modifications early enough, before the shoulder problem becomes chronic or the possible co-occurring musculoskeletal problems become disabling.

The results of this thesis study suggest that secondary preventive measures targeting both occupational and non-occupational factors have the potential to decrease disability caused by a shoulder lesion. Reducing prolonged exposure to physical work exposures and avoiding regular smoking among both genders and obesity among men have a high potential to prevent SA due to a shoulder lesion. This implies that clinicians should focus on both work modifications and health promotion in cases of patients with a shoulder lesion.

Targeting occupational exposures also has high potential in tertiary prevention to reduce disability caused by a shoulder lesion. Modifying working conditions, especially reducing the physical strenuousness of work may prevent disability retirement due to a shoulder lesion among both genders and across almost all occupations. Decreasing the physical strenuousness of work

and specific physical work exposures has even greater potential to reduce disability retirement in occupations with high physical demands. Disability retirement due to a shoulder lesion could also be prevented by increasing workers' job control.

6.5 FUTURE RESEARCH

This thesis is the first to study work participation among people with a disabling shoulder lesion and the potential risk factors for prolonged disability due to a shoulder lesion. Other studies are needed to confirm the findings of this study and cross-country comparisons would be beneficial. The material of this thesis made it possible to study only the potential of the risk factors to reduce prolonged work disability. The role of non-occupational risk factors in disability retirement was not assessed and will need to be studied in future research. Intervention studies are needed to assess the effectiveness of workplace modifications and lifestyle changes in the prevention of disability due to shoulder lesions.

7 CONCLUSIONS

The results of this thesis show that working life expectancy is notably reduced among people with prolonged SA due to a shoulder lesion. Medical rehabilitation and work modifications should be considered before a shoulder problem becomes chronic. Moreover, physicians should be critical of prescribing long SA spells without a clear RTW plan. Although disability retirement due to other musculoskeletal conditions is also common after a disabling shoulder disease, clinicians should also pay attention to other, possibly co-occurring, musculoskeletal problems.

The findings of this thesis suggest that prolonged exposure to several physical workload factors and regular smoking are risk factors for SA due to a shoulder lesion among both genders, and obesity is a risk factor among men. Therefore, secondary preventive measures targeting these risk factors could potentially reduce SA caused by a shoulder lesion.

Of physical work exposures, heavy physical work showed the strongest association with disability retirement among both genders. The contribution of heavy physical work to disability retirement was especially seen in highly exposed occupations, such as construction workers, electricians, and plumbers. In addition, working with hands above shoulder level was a risk factor for disability retirement among men and working in a forward bent posture among women. Targeting these physical work-related factors could potentially greatly reduce disability retirement due to a shoulder lesion.

Psychosocial work-related factors also showed a high contribution to disability retirement due to a shoulder lesion. Low job control among men explained a significant proportion of disability retirement. This indicates that increasing workers' own control over how work and necessary rest breaks are scheduled at floor level can reduce disability retirement due to a shoulder lesion.

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