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ISBN 978-951-29-7172-5 (PRINT)
ISBN 978-951-29-7173-2 (PDF)
ISSN 0355-9483 (Print)
ISSN 2343-3213 (Online)
Painosalama Oy – Turku, Finland 2018

To those spending high efforts at work

ABSTRACT

ANNE JUVANI: WORK-RELATED STRESS AND DISABILITY PENSION

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Joint Authority of Karkkila and Vihti for Public Health and Social Services, Occupational Health Care Unit of Vihti.

Annales Universitatis Turkuensis, Ser.D, Medica–Odontologica. Painosalama Oy, Turku, Finland, 2018.

Work stress has been linked to employee ill-health. However, work stress in relation to disability pension has rarely been studied. Thus, three major work-related stressors—job strain, effort-reward imbalance (ERI) and organizational injustice—were studied in relation to disability pensions in three prospective studies among 24,000–69,000 public sector employees in Finland. A fourth prospective study examined both single stressors and the combinations of them among 54,000 employees. Two leading causes of disability pensions, mental and musculoskeletal disorders, were chosen as study endpoints. In addition, disability pensions granted due to ischemic heart diseases were examined in two studies. Stress was measured by self-reports and, more objectively, by work-unit means. National records, employers' registers and survey responses were used to collect data on baseline covariates and disability pensions.

Adjusted for demographics, job strain was linked with a 1.4 to 2.4-fold increase in the risk of disability pensioning due to musculoskeletal disorders. ERI was associated with disability pensioning due to mental disorders, when fully adjusted, showing hazard ratios from 1.3 to 1.9. The combination of job strain + ERI showed hazard ratios from 1.5 to 2.1 for the same association. Organizational injustice was not independently associated with disability pensions. Work stress was not a risk factor for disability pension due to ischemic heart diseases. All these results were based on both self-reports and work-unit means.

Conclusions: Work-related stress is associated with an increased risk of disability pensioning. Reducing work-related stress may be beneficial in preventing disability pensions and improving work ability.

KEYWORDS: psychological demands, job control, procedural justice, relational justice, organizational justice, psychosocial work environment, occupational health care, work disability, work ability, early exit, early retirement due to disability, observational study, cohort study

TIIVISTELMÄ

ANNE JUVANI: **TYÖSTRESSIN YHTEYS TYÖKYVYTTÖMYYSELÄKKEISIIN**

Turun yliopisto, Lääketieteellinen tiedekunta, Kansanterveystiede, Turun kliininen tohtoriohjelma.

Perusturvakuntayhtymä Karviainen (Karkkila ja Vihti), Työterveyshuolto Vihti.

Annales Universitatis Turkuensis, Ser.D, Medica–Odontologica. Painosalama Oy, Turku, Suomi, 2018.

Työstressi on yhdistetty työntekijöiden sairastavuuteen, mutta työstressin yhteyttä työkyvyttömyyseläkkeisiin on tutkittu vähän. Siksi tässä tutkimuksessa selvitettiin kolmen merkittävän työstressimallin (job strain, effort-reward imbalance (ERI) ja organizational injustice) mukaisen työstressin yhteyttä työkyvyttömyyseläkkeisiin kolmella pitkittäisellä tutkimuksella 24 000–69 000 julkisen alan työntekijän joukossa Suomessa. Neljännessä pitkittäistutkimuksessa tutkittiin lisäksi sekä yksittäisiä stressitekijöitä että näiden yhdistelmiä 54 000 työntekijän joukossa. Tutkimuksen päätetapahtumina olivat kaksi yleisintä työkyvyttömyyseläkkeiden aiheuttajaa: mielialahäiriöt sekä tuki- ja liikuntaelinsairaudet. Lisäksi kahdessa tutkimuksessa selvitettiin iskeemisistä sydänsairauksista johtuvia työkyvyttömyyseläkkeitä. Työstressiä arvioitiin sekä henkilökohtaisten kyselyvastausten pohjalta että objektiivisemmin työpaikkakohtaisten keskiarvojen perusteella. Kansallisia rekistereitä, työnantajien rekistereitä sekä kyselyvastauksia hyödynnettiin kerätessä tietoa taustamuuttujista ja työkyvyttömyyseläkkeistä.

Job strain oli yhteydessä tuki- ja liikuntaelinsairausperäisiin työkyvyttömyyseläkkeisiin, ja riskin suurenema oli 1,4–2,4- kertainen demografisilla tiedoilla vakioiduissa analyyseissä. ERI oli yhteydessä mielialahäiriöistä johtuviin työkyvyttömyyseläkkeisiin. Riskitiheyssuhde vaihteli 1,3:n ja 1,9:n välillä täysin vakioiduissa malleissa. Job strainin ja ERIn yhdistelmä osoitti riskitiheyssuhteita 1,5:stä 2,1:een suhteessa mielialahäiriöperäisiin työkyvyttömyyseläkkeisiin. Nämä luvut perustuivat täysin vakioituihin malleihin. Organizational injustice ei ollut itsenäinen riskitekijä työkyvyttömyyseläkkeille, eikä työstressi yleisesti ole yhteydessä iskeemisistä sydänsairauksista johtuviin työkyvyttömyyseläkkeisiin. Kaikki edellä mainitut tulokset perustuvat henkilökohtaisesti raportoituun työstressiin ja työpaikkojen keskiarvoihin stressistä.

Johtopäätökset: Työstressi on yhteydessä suurentuneeseen työkyvyttömyyseläkeriskiin. Työstressin ehkäiseminen lienee kannattavaa, kun pyritään ehkäisemään työkyvyttömyyseläkkeitä ja parantamaan työntekijöiden työkykyä.

AVAINSANAT: psykologiset vaatimukset, vaikutusmahdollisuus työssä, päätöksenteon oikeudenmukaisuus, esimies-alaissuhde, oikeudenmukainen organisaatio, psykososiaalinen työympäristö, työterveyshuolto, työkyvyttömyys, työkyky, varhainen poistuminen työelämästä, henkilökohtainen varhaiseläke, havainnoiva tutkimus, kohorttitutkimus

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ABBREVIATIONS

ATC	Anatomical therapeutic chemical
CI	Confidence interval
DDD	Defined daily doses
ERI	Effort-reward imbalance
FPS	Finnish Public Sector (Study)
HR	Hazard ratio
ICD-10	The International Classification of Diseases, 10th Edition
JCQ	Job Content Questionnaire
OECD	The Organisation for Economic Co-operation and Development
RR	Risk ratio

LIST OF ORIGINAL PUBLICATIONS

I Mäntyniemi A, Oksanen T, Salo P, Virtanen M, Sjösten N, Pentti J, Kivimäki M and Vahtera J. Job strain and the risk of disability pension due to musculoskeletal disorders, depression or coronary heart disease: a prospective cohort study of 69 842 employees. Occup Environ Med. 2012;69(8):574–81.

II Juvani A, Oksanen T, Salo P, Virtanen M, Kivimäki M, Pentti J, Vahtera J. Effort-reward imbalance as a risk factor for disability pension: the Finnish Public Sector Study. Scand J Work Environ Health. 2014;40(3):266–77.

III Juvani A, Oksanen T, Virtanen M, Elovainio M, Salo P, Pentti J, Kivimäki M, Vahtera J. Organizational justice and disability pension from all-causes, depression and musculoskeletal diseases: A Finnish cohort study of public sector employees. Scand J Work Environ Health. 2016;42(5):395–404.

IV Juvani A, Oksanen T, Virtanen M, Salo P, Pentti J, Kivimäki M, Vahtera J. Combined effect of multiple workplace stressors on the risk of all-cause and cause-specific disability pension: A cohort study of job strain, effort-reward imbalance and organizational injustice (submitted manuscript).

1. INTRODUCTION

Stress refers to a situation in which we face adverse or challenging events that are extremely consuming or demanding in relation to our individual abilities to cope (Koskenvuo 2003). Instead of the traditional "fight or flight" stress, nowadays we generally face less life-threatening stress from various sources: time pressures at work and home, economic insecurity, loneliness, and inter-personal conflicts (OECD 2003, Leka et al. 2008, OECD 2010). When "stressed-out," we go through a pattern of cognitive, emotional, behavioral and physiological reactions. Such reactions include feeling anxious, frustrated and worried, having trouble concentrating or relaxing, eating more and/or unhealthily, not socializing, increasing alcohol intake and physical inactivity, as well as having digestive problems, increased heart rate and/or elevated blood pressure. (Koskenvuo 2003, Heikkilä et al. 2012, Heikkilä et al. 2013, Nyberg et al. 2013, EU-OSHA 2014). If prolonged, all these reactions to stress are harmful to our health (Koskenvuo 2003, Ströhle et al. 2003, Ahola et al. 2006, McEwen 2006, Jarczok et al. 2013, EU-OSHA 2014).

During the past few decades, job tasks have increasingly changed from productive and physically demanding manual work towards non-manual jobs that are characterized by the use of information and communication technologies and the need for inter-relationships. At the same time, globalization and a generally accelerated pace of life have created the need for a more intense work style, usage of unconventional working hours and work contacts, as well as the need for multitasking and constant learning of new skills. (Eurofound et al. 2014). As a result, work-related stress is commonly experienced in today's work environment. In fact, 25% of employees in Europe have been reported to perceive work-related stress during most of their work time (Eurofound et al. 2014). Moreover, as workplace physical and toxicological hazards are more controlled these days, the psychosocial work environment has become an important work-related factor affecting employees' well-being and health (OECD 2003, Kauppinen et al. 2010, EU-OSHA 2014, Eurofound et al. 2014). The World Health Organization and the European Union have highlighted work-related stress, one aspect of the psychosocial work environment, amongst the most common factors that cause work-related illnesses and have targeted preventive actions towards alleviating it (Leka et al. 2008).

Major theoretical concepts of work-related stress include job strain, effort-reward imbalance (ERI) and organizational injustice (Nieuwenhuijsen et al. 2010, Eurofound et al. 2014, Theorell et al. 2015). The job strain model claims that an employee may become emotionally exhausted and consequently unhealthy if the strains related to work amount

and time pressures at work are not balanced with job characteristics including decision authority, use of various skills, learning, and versatile job tasks (Karasek 1985, Karasek et al. 1990). The ERI model states that if the work-related effort is not balanced with the work-related reward (e.g. salary, recognition, promotion prospects, or job security) an employee's health is jeopardized due to stress reactions caused by this imbalance (Siegrist 1996). Finally, the organizational injustice model refers to stress-awakening situations where an employee perceives an organization's decision-making processes to be unfair and/or s/he feels mistreated by his/her supervisor (Moorman 1991).

Previous research suggests an association between work-related stress and depressive disorders or ischemic heart diseases (Kivimäki et al. 2012, Theorell et al. 2016, Harvey et al. 2017, Madsen et al. 2017) as well as increased risk of sickness absences (Kivimäki et al. 2007a, Lund et al. 2008, Alexanderson et al. 2012, Jansson et al. 2013, Eurofound et al. 2014). Furthermore, work-related stress may decrease work effectiveness and increase employee turnover (Leka et al. 2008, Eurofound et al. 2014). Thus, work-related stress is not only a factor that may jeopardize employees' health; it is also an important economic factor concerning governments and employers. The general costs of work-related stress in Europe have been estimated at 20 billion Euros (EU-OSHA 2014). Work-related stress has been linked to common mental disorders (Harvey et al. 2017), which are the leading causes of disability pensioning and major contributors to the overall global burden of diseases (OECD 2003, WHO 2008, The Finnish Centre for Pensions et al. 2016, WHO 2017). It has been suggested that job strain can be attributed to at least 5% (and possibly more than 30%) of mental disorders worldwide (Sultan-Taïeb 2011). Moreover, of the total global costs for mental disorders and coronary heart disease, job strain has been estimated to attribute between 1.8 and three billion Euros (Sultan-Taïeb 2013).

The large cohort of "baby boomers" (i.e. those born between 1945 and the early 1960s) is ageing. At the same time, life expectancy has increased and birth rates have decreased, which has led to an increased dependency ratio (i.e. the ratio of the people aged over 65 years in relation to those aged 15 to 64 years) in Finland and the other Organisation for Economic Co-operation and Development (OECD) countries (The Statistics Finland 2007, OECD 2014). This demographic change has induced a worldwide pension crisis. Consequently, most OECD countries have gone through pension reforms (OECD 2010, OECD 2013, OECD 2014, OECD 2016a). In order to fight the pension crisis, the eligibility age for the old age pension has been raised in Finland. Moreover, opportunities to apply for early retirement have been blocked (partial early old age pension) or suppressed (unemployment pension). (OECD 2013, OECD 2014, Keva 2016). However, in order to balance the dependency ratio, it is also important to aim preventive actions towards disability pensions.

During the past two decades, the question of how work-related stress affects employees' health and work ability has been highlighted (OECD 2003, Leka et al. 2008, OECD 2010, EU-OSHA 2014, Knardahl et al. 2017). Recent reviews and meta-analyses have linked job strain, ERI and organizational injustice with common mental disorders, depressive disorders and ischemic heart diseases (Kivimäki et al. 2006a, Bonde 2008, Siegrist 2008, Kivimäki et al. 2012, Ndjaboué et al. 2014, Pejtersen et al. 2015, Xu et al. 2015, Theorell et al. 2016, Harvey et al. 2017, Madsen et al. 2017), but results on the association between work-related stress and musculoskeletal disorders have been inconsistent (Bongers et al. 2006, Macfarlane et al. 2009, Hauke et al. 2011, Lang et al. 2012, Long et al. 2012, Kraatz et al. 2013, Koch et al. 2014, Bernal et al. 2015). However, the most recent reviews (which are of better quality compared to earlier studies) suggest a link between work-related stress and musculoskeletal disorders (Hauke et al. 2011, Long et al. 2012, Lang et al. 2012, Kraatz et al. 2013, Koch et al. 2014, Bernal et al. 2015). Furthermore, a recent review suggests an association between job strain, or job control, and disability pension (Knardahl et al. 2017).

However, most of these previous studies have been vulnerable to reverse causality and/or subjectivity bias since work-related stress has often been measured using self-reports only (Kasl 1998, Bonde 2008, Theorell T et al. 2016). Reverse causality means that stressed-out employees, who became ill or ended up on a disability pension, reported high work-related stress due to their (subclinical) illness and/or impaired work ability (and not vice versa). Subjectivity bias means that individual characteristics, such as negativity, may have biased the results of the previous studies due to the high tendency of the negative employees to both report high work-related stress and seek a disability pension (Kasl 1998, Hintsanen et al. 2011, Kolstad et al. 2011). This methodological limitation particularly concerns the studies on job demands and job control, as well as some of the studies on job strain. Moreover, the association between ERI, or organizational injustice, and disability pension has been rarely studied. In fact, to the best of my knowledge, there is only one previous study on this association (van den Berg et al. 2010). Furthermore, no previous studies on the associations of either organizational (in)justice and disability pension or multiple work-related stressors and disability pension exist. Consequently, there is an evident gap of knowledge as the associations between job strain, ERI and organizational injustice and disability pensioning remain understudied due to the methodological limitations of the previous studies on job strain, and lack of studies on ERI, organizational injustice and multiple work-related stressors.

The aim of this study was to examine the association of job strain, ERI and organizational injustice—three major work-related stressors—with disability pensioning. This study focused on all cause disability pensions, and specifically disability pensions granted due to depressive and musculoskeletal disorders, as depressive and musculoskeletal disorders are

the two main causes for disability pensioning in Finland (The Finnish Centre for Pensions et al. 2016). In addition, disability pensions due to ischemic heart diseases were studied as work-related stress has previously been associated with ischemic heart diseases in numerous studies and meta-analyses (Kivimäki et al. 2006a, Kivimäki et al. 2012, Pejtersen et al. 2015, Xu et al. 2015, Theorell et al. 2016). Moreover, to address the previous methodological gaps, work unit mean scores (i.e. work unit-based aggregates) of work-related stress were used in addition to self-reports to more objectively assess the exposure to work-related stress. This way, the effects of subjectivity bias and reverse causality could be avoided or cut down to a minimum.

2. LITERATURE REVIEW

2.1. CONCEPTUAL FRAMEWORK

2.1.1. Stress

Stress may be looked at from the angle of a stressor (i.e. a stress stimulus) or from the angle of the response of an individual under stress. Moreover, stress may be categorized, for example, by its severity or time course (i.e. acute, repeated, or chronic). A person is thought to experience stress (i.e. being stressed-out) when the external factors (i.e. stressors) an individual faces are so challenging that they exceed one's capacity to cope. (Lazarus et al. 1984). As severe stressors (such as natural disasters, war, the death of a closed one, divorce, job loss, personal injury or illness) usually occur only occasionally in one's lifetime, it has been suggested that less severe stressors (i.e. "daily hassles") may be even more important stress stimuli nowadays, as they often occur repeatedly. These kinds of stressors include, for example, work-family conflict, time pressures at work, situations when being evaluated, facing disapproval, feeling lonely, having an argument, getting irritated or facing a (minor) setback. (Lazarus et al. 1984). Even though stress is often referred to as a negative issue, it is important to bear in mind that stress may also have positive effects as stressful events (i.e. challenges) may lead to positive achievements and personal growth (i.e. outdoing oneself). (Lazarus et al. 1984).

When under stress, an individual's sympathetic activity increases and parasympathetic activity decreases. Moreover, the hypothalamic-pituitary-adrenal axis is activated. As a result, one's body releases chemical mediators that help to cope with the demanding situation in hand. This neuro-endocrine stress response is also referred as allostasis. (McEwen 2006). While allostasis is essential for survival, insufficient, prolonged or chronic allostasis (referred as "allostatic load") may jeopardize our health (McEwen 2006).

Moreover, being stressed-out causes various emotional reactions, such as feeling anxious, angry, frustrated and worried (Koskenvuo 2003, Leka et al. 2008). In addition to physiological and emotional effects, stress may have injurious effects on individuals' health behavior. These behavioral effects include adverse changes in smoking and drinking habits, eating and diet, leisure time physical activity and sleeping patterns (Koskenvuo 2003, Heikkilä et al. 2012, Heikkilä et al. 2013, Nyberg et al. 2013, EU-OSHA 2014). All health risk behavioral factors (i.e. smoking, high alcohol consumption, unhealthy diet/obesity, and leisure time physical inactivity) and poor quality of sleep are known to cause allostatic load (McEwen 2006).

Stress responses for the same stressor may differ between individuals (Lazarus et al. 1984). For example, genes, childhood experiences (e.g. uncaring guardian), and experiences in adult life (e.g. being in an unsatisfying relationship) have an effect on how burdensome we consider possible stressors, or how our bodies respond to them (McEwen 2006, Klaassens et al. 2009). Moreover, good self-esteem, sense of coherence, self-efficacy, positive thinking, lack of hostility, and social support have been associated with decreased levels of chemical stress mediators and increased activity of the parasympathetic neural system (Ahola et al. 2006, McEwen 2006, Kanitz et al. 2016). Figure 1 illustrates the factors related to perceived stress.

2.1.2. Work-related stress

Employees typically spend most of their waking hours at the workplace. Thus, work-related psychosocial factors (i.e. factors related to workplace psychosocial environment that affect employees' behavior and health) may become important stress stimuli along with private life stressors. In fact, work-related stress (i.e. an important work-related psychosocial factor) has been considered amongst the most common factors to cause work-related illnesses nowadays (Leka et al. 2008). Several factors at work can act as a source of work-related stress. Such factors include long working hours, poor control over working time, low workplace social capital, conflicts and bullying at work, and job insecurity (OECD 2003, Stansfeld et al. 2006, Kauppinen et al. 2010, OECD 2010, Theorell et al. 2015). This dissertation focuses on three major concepts of work-related stress: job strain, effort-reward imbalance and organizational injustice.

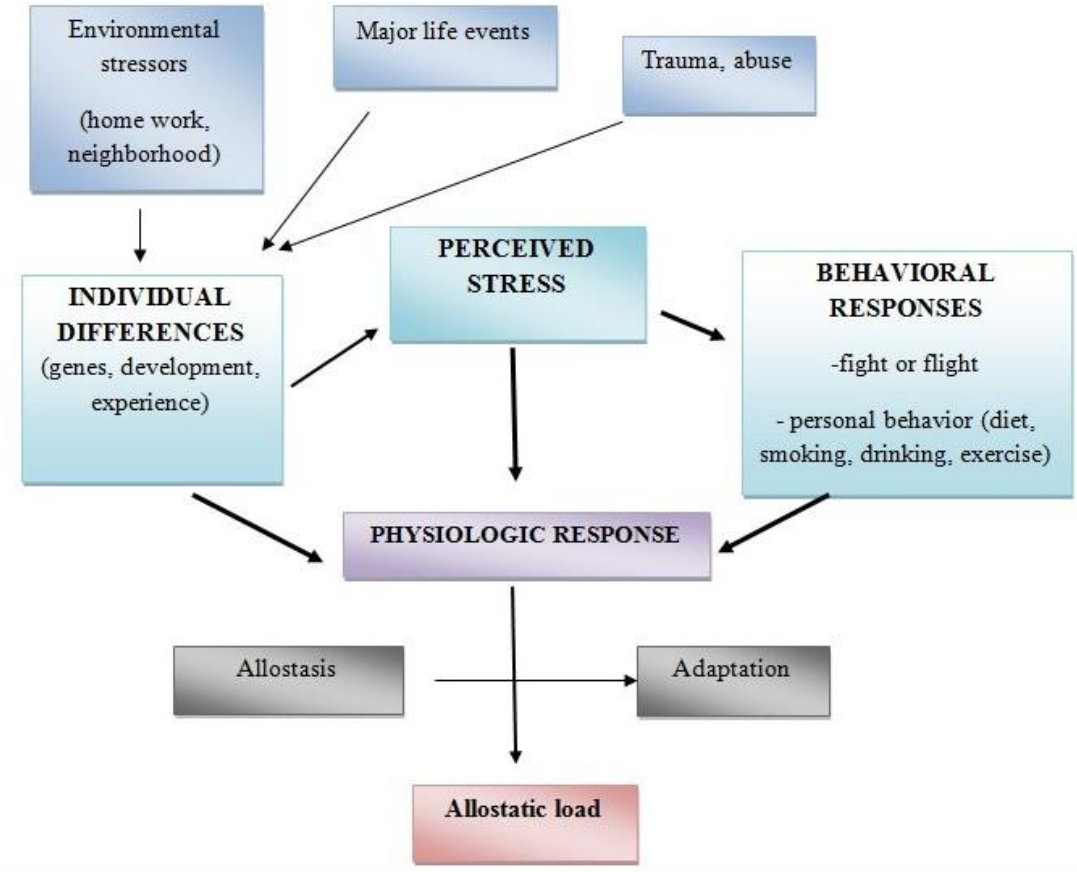

Figure 1. Factors related to perceived stress and stress responses.

Figure has been modified from McEwen BS (2006). Protective and damaging effects of stress mediators: Central role of the brain. Dialogues Clin Neurosci. 2006;8(4):369.

2.1.2.1. Job strain

The job strain model (or demand-control model) was developed by Karasek in the 1980s (Karasek 1985), and was further evolved by Karasek and Theorell (Karasek et al. 1990). This stress model postulates that high psychological demands at work, in combination with low control (combination being referred as high job strain), may cause stress reactions that are harmful to employees' health. High psychological demands mean that an employee must work intensively and/or rapidly and s/he may experience conflicting expectations, while low control means that an employee has low decision authority and low skill

discretion. Low decision authority indicates that an employee has no or little influence on what tasks s/he performs and/or how to carry out these tasks. Low skill discretion means that a job is characterized by a low variety of tasks and no need for creativity, using skills, learning or personal development. The job strain model divides jobs in four categories: high strain jobs (i.e. a combination of high demands and low control), low strain jobs (low demands, high control), active jobs (high demands, high control) and passive jobs (low demands and low control) (Figure 2). Social support from supervisors and co-workers was subsequently added to this model as it had been discovered that social support buffered the effects of job strain (Johnson 1989). This demand-control-support model is also called the iso-strain model.

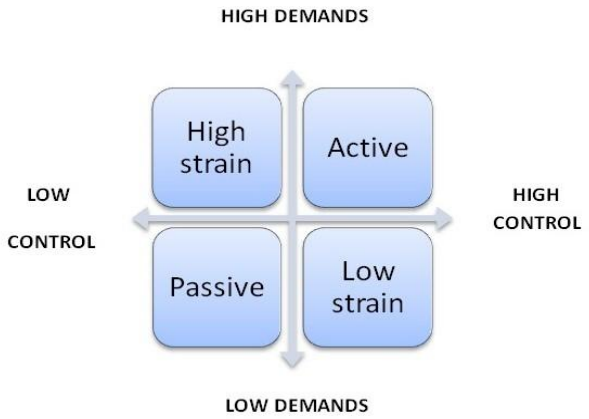

Figure 2. Four categories of job strain.

2.1.2.2. Effort-reward imbalance

The ERI model was developed by Siegrist (1996) to represent stressful situations that are characterized by the imbalance between "costs and gains" at work (Figure 3). The ERI model states that an imbalance between effort and reward at work may raise stress reactions that lead to health impairment. Effort contains issues dealing with time pressures and interruptions at work, as well as increasingly demanding work. Reward deals with work-related respect and prestige, job promotion opportunities and job security. Moreover, reward concerns adequate remuneration in relation to an employee's work effort and

achievements. Furthermore, reward also takes into account the possibility of an undesirable change in job situation. (Siegrist 1996). Overcommitted employees tend to work excessively, which may easily lead to imbalance between effort and reward. Thus, over-commitment was later added to the ERI model (Siegrist et al. 2004).

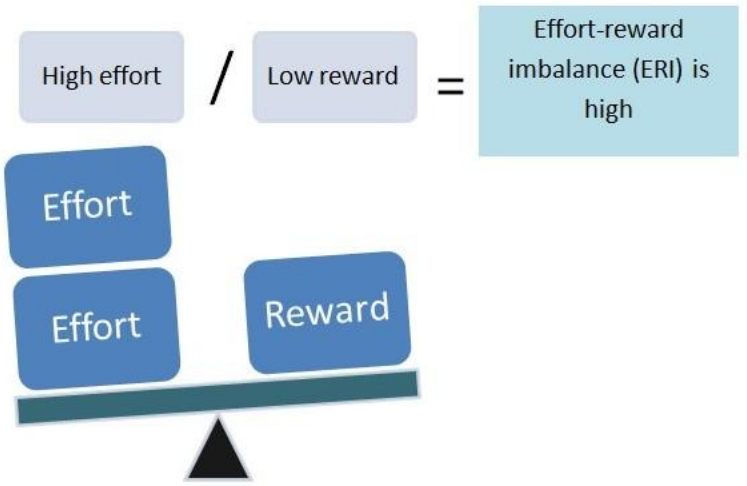

Figure 3. Effort-reward imbalance

2.1.2.3. Organizational injustice

According to Moorman, the concept of organizational justice consists of procedural justice and distributive justice (Moorman 1991). Procedural justice has two subcomponents: formal procedures and interactional justice. They measure the fairness of the procedures used in the decision making in the organizations (formal procedures), and the fairness of the interactions that enacted those procedures (interactional justice) (Moorman 1991). High procedural justice refers to situations in which decision-making is accurate, non-biased, ethical, amendable, and consistent, and those involved have a voice (Leventhal 1980). Moreover, high interactional justice indicates that employees are treated respectfully and considerately by their supervisors (Bies et al. 1986, Tyler et al. 1996). Distributive justice estimates whether an employee feels fairly rewarded in comparison to his/her

responsibilities, educational level, effort and performance (per se, and in relation to his/her colleagues) (Moorman 1991, Ndjaboué et al. 2012).

Elovainio et al. (2002), who were among the first to study the health consequences of organizational (in)justice, introduced the terms "procedural justice" (formal procedures) and "relational justice" (interactional justice). Since then, these terms have been widely used in studies on organizational justice. However, the original term, "interactional justice," has also been used often (Ndjaboué et al. 2012). Thus, the terminology is inconsistent. Moreover, interactional justice has sometimes been divided further into "relational justice" (degree of dignity and respect received from managerial authority) and "informational justice" (presence or absence of explanations about new procedures from the managerial authority) (Ndjaboué et al. 2012). In this dissertation, procedural and relational justice are used to indicate formal procedures and interactional justice, as proposed by Moorman, and to form an organizational justice variable (Figure 4). Distributive justice was not included in this study.

Figure 4. Organizational justice

2.1.2.4. Comparison of job strain, ERI and organizational injustice

Job strain, ERI and organizational injustice are individual models that measure different aspects of work-related stress. It has been suggested, however, that these stressors may overlap and be redundant to each other (Calnan et al. 2004, Kawachi 2006). On the conceptual level, the demand and effort components of the job strain and the ERI models

are largely similar, and these stressors differ from each other only in their control and reward components: job strain deals with a task-level imbalance between effort and "reward" (i.e. decision authority and skill discretion), while the reward in the ERI model cover wider socioeconomic aspects such as recognition and salary (Karasek et al. 1990, Siegrist 1996). Moreover, the reward and distributive justice components of the ERI and organizational justice models overlap as both assess reward in relation to work contributions.

2.1.3. Disability pension

The ill-health based disability pension provides a livelihood for those whose ability to work is impaired due to disablement, illness or injury. However, the disability pension may decrease the quality of life by reducing beneficiaries to poverty, as being employed enables an individual to receive a higher income. Moreover, being employed is important to one's self-identity, well-being and social relationships. (OECD 2010, OECD 2011, Hovbrandt et al. 2017). In most OECD countries, mental health problems are the biggest single cause for a disability benefit claim, closely followed by musculoskeletal disorders (OECD 2003, Krokstad et al. 2004, OECD 2010, The Finnish Centre for Pensions et al. 2016). Granting a disability pension can be thought of as the late and severe stage of a chronic illness that deteriorates an employee's ability to work. However, sometimes the pathway to a disability pension may be rather acute, as in the case of cancer or injury.

Recent pension reforms in Finland and most of the OECD countries have resulted in a higher eligibility age for the old age pension (OECD 2013, OECD 2014). This may cause increased pressure on applying for a disability pension by those ageing employees whose work ability and health does not meet the strict requirements of a working life (Knardahl et al. 2017). Generally, in the majority of the OECD countries, the number of disability benefit recipients has shown an increasing trend between 2007 and 2012 (OECD 2016b). However, the trend has been decreasing in countries such as Finland, Sweden and UK (OECD 2016b). In Finland in 2012, 17% of all pension recipients were on a disability pension, while 79% of them were on the old age pension (The Finnish Centre for Pensions et al. 2013). The same figures in 2015 were 14% and 82%, respectively (The Finnish Centre for Pensions et al.2016).

In Finland, a partial disability pension may be granted if, due to illness or injury, an employee's work ability is diminished by at least 40%. When work ability diminishes by at

least 60%, an employee is entitled to a full-time disability pension. Moreover, a disability pension may be granted permanently or for a fixed-term (i.e. as a rehabilitation subsidy). (The Finnish Centre for Pensions 2007). With regard to public sector employees, work disability is evaluated in relation to education, age and previous occupation (Finlex 2016). A disability pension application must be attached with a certificate from the treating physician(s), including a detailed description of the onset, treatment and rehabilitation received for the illness(es) causing the work disability. Moreover, diagnostic codes according to the International Classification of Diseases, 10th Edition (ICD-10) must be provided in that certificate. (The Finnish Centre for Pensions 2007).

Recent meta-analyses show that poor self-rated health, obesity, mental disorders and chronic diseases (particularly musculoskeletal diseases) all increase the risk of subsequent applications for a disability pension (Neovius et al. 2008, Robroek et al. 2013, van Rijn et al. 2014). Moreover, a recent study by Airaksinen et al. (2017) found that, from 84 possible predictors, eight (i.e. age, self-rated health, number of sickness absences in previous year, socioeconomic position, chronic illnesses, sleep problems, body mass index, and smoking) were the main predictors of disability pensioning and explained over 99% of the variance in the full model. Also, other previous studies have linked increasing age, low socioeconomic status (in terms of low occupational status, low income or low education), employee health, smoking and prevalence of short- and long-term sickness absences with disability pensioning (Krokstad et al. 2002, Krokstad et al. 2004, Gravseth et al. 2007, Kivimäki et al. 2007a, Lund et al. 2008, Pietikäinen et al. 2011, Alexanderson et al. 2012, Jansson et al. 2013, Ishtiak-Ahmed et al. 2014). Ishtiak-Ahmed et al. (2014) reported that an extended duration of the first sickness absence one to five years preceding receipt of the disability pension was associated with an increased risk of disability pensioning among employees with a history of stress-related sickness absence. To better understand the association of sickness absences and disability pensioning, Laaksonen et al. (2016) studied sickness absence trajectories during the ten years preceding receipt of a full-time disability pension. They found four main patterns—1) increasing, 2) stable high, 3) stable low, 4) early high and decreasing pattern—which all showed an evident increase in sickness absence days during the last year preceding receipt of a disability pension. However, these main patterns diverged from each other in the earlier years (Laaksonen et al. 2016). Previous studies have also linked individual and social factors, such as being neurotic or unsatisfied with life, having a retired partner, living alone or not being married, and generous disability pension reimbursements, with an increased rate of disability pensioning (Rice et al. 2011, Ropponen et al. 2012, Samuelsson et al. 2012, Ishtiak-Ahmed et al. 2014, Mullen et al. 2016). Moreover, it has been suggested that economic and legal factors, such as increased unemployment rates or governmental pension reforms, affect disability pensioning (Krokstad et al. 2004, Stattin 2005a, OECD 2016a, OECD 2017).

Disability pensioning is expensive. The average costs of all disability benefits across the OECD were around 10% of total public social spending and, on average, 1.7% of the Gross Domestic Product (OECD 2010, OECD 2017). Moreover, if a public sector employee with an average wage ends up on a disability pension at the age of 55 years (or 60 years), his/her employer would have to pay 105,000 Euros of extra pension contributions to the pension insurance company during the three years after this disability pension was granted (Eläketurvakeskus 2017, Keva 2017).

2.1.4. Work-related stress and disability pensions

A recent review and meta-analysis suggests moderate evidence of the association between low job control and disability pension as well as high job strain and disability pension. In fact, 18 of the 24 studies included in this review suggested a link between low control and disability pension, while a meta-analysis of 16 studies showed a pooled risk ratio (RR) of 1.40 and 95% confidence interval (CI) varying from 1.21 to 1.61 for the association between low job control and disability pension (Knardahl et al. 2017). Furthermore, Knardahl et al. (2017) found four studies that had linked high job strain with disability pension, and two studies that did not support this association. However, both the negative studies suggested an association between passive jobs and disability pensions. Five studies (including both the negative studies) were suitable for a meta-analysis and showed a pooled RR (95% CI) of 1.45 (0.96–2.19) for the association between job strain and disability pension. The authors concluded that this finding was borderline significant. Finally, no support for the association of job demands and disability pension was found, as only four of twenty studies suggested a link between these two factors. A meta-analysis of 13 studies showed a pooled RR (95% CI) of 1.12 (0.98–1.28) for the association between job demands and disability pension. Studies on job demands were heterogeneous, for example, due to use of non-validated questionnaires. (Knardahl et al. 2017).

Knardahl et al.'s (2017) review only included prospective cohort studies, longitudinal case-control studies and intervention studies. Moreover, it included clear, although wide and rather heterogeneous, inclusion criteria for the exposure. The outcome criterion was also clearly stated. However, in addition to register-based disability pension, self-reports of illness-based disability pensions were accepted as a study endpoint. The literature search included looking through the reference lists of already included studies. Systematic quality assessment was performed, and low-quality studies were excluded. Knardahl et al.'s literature search was comprehensive, as the literature review for this dissertation found only five studies (Stattin et al. 2005b, van den Berg et al. 2010, Robroek et al. 2013, Emberland et al. 2017, Markkula et al. 2017) that were not included in the final sample of

the review by Knardahl et al. Three of these studies (Stattin et al. 2005b, van den Berg et al. 2010, Robroek et al. 2017) were excluded due to their low-rated quality score (Knardahl et al. 2017), and the remaining two because they were published in the same year as the review. The excluded study by Stattin et al. (2005b) suggested that job strain and its components were associated with an increased risk of all cause disability pension entitlement among construction workers in Sweden, while Markkula et al. (2013) and Robroek et al. (2017) associated job control with disability pension entitlement.

Concerning ERI in relation to disability pension, Knardahl et al. (2017) found only one study (i.e. the sub-study II of this dissertation) examining the association between ERI and disability pensions. Thus, the authors concluded that the evidence between ERI and disability pension was insufficient due to the limited number of studies. There are at least two additional studies on the association of ERI and early exit from work due to disability (van den Berg et al. 2010, Robroek et al. 2017). These studies were excluded from the review by Knardahl et al. (2017) due to low-rated quality scores. The study by van den Berg et al. (2010) showed an odds ratio of 1.6 (95% CI from 1.06 to 2.48) for the association between low ERI and disablement, when using unadjusted models. The disablement in this study was self-reported and predominantly included those on a disability pension (van den Berg et al. 2010). The study by Robroek et al. (2017) showed no association between reward and self-reported permanent disablement/sickness.

Finally, there are no studies on the association between organizational injustice and disability pension as far as I am aware. However, organizational injustice has been linked with intentions to withdraw or retire (Heponiemi et al. 2008) and low organizational justice with an increased risk of non-disability early retirement (Breinegaard et al 2017). Moreover, Emberland et al. (2017) followed 12,438 employees during a mean of 5.8 years and found an association between fair leadership and decreased risk of register-based disability pension. The age, sex, skill level, and three-year sickness absence history (due to certain illnesses) adjusted the hazard ratio (HR) between fair leadership (that was perceived high) and disability pension in their study was 0.56 (95% CI 0.39–0.81). The same figures for medium fair perceived leadership were 0.61 (0.40–0.93). No association was found between empowering leadership and disability pension, or support from immediate supervisor and disability pension. (Emberland et al. 2017). However, Clausen et al. (2014) found no association between quality of leadership and disability pension in their study, which utilized pooled data from four papers to study the association between psychosocial working conditions (including the quality of leadership) and register-based disability pension. Their study included 40,554 participants, who were followed-up over 5.9 years (Clausen et al. 2014).

The majority of the previous studies on job demands, job control, ERI and fairness/quality of leadership have been based on self-reports of the exposure (Stattin et al. 2005b, van den Berg et al. 2010, Clausen et al. 2014, Emberland et al. 2017, Knardahl et al. 2017). However, some studies have used various aggregated measures to assess job strain more objectively (Laine et al. 2009, Ropponen et al. 2013, Samuelsson et al. 2013, Knardahl et al. 2017). These aggregated measures include using the mean scores of all self-reported (i.e. survey-based) job strain scores from a certain work unit for each participant in that work unit (Laine et al. 2009), and using the age, sex and occupation-specific job exposure matrix to assess (aggregated) job strain scores (Ropponen et al. 2013, Samuelsson et al. 2013). All these studies using aggregated measures were included in Knardahl et al.'s (2017) review.

2.1.4.1. Underlying mechanism linking work-related stress and disability pensions

In this study, the hypothesis on the underlying mechanism linking work-related stress and disability pensions included the key role of employee health as a principle mediator, since stress-induced allostatic load may lead to illnesses such as depressive disorders and ischemic heart diseases (Koskenvuo 2003, Ahola et al. 2006, Kivimäki et al. 2012, Theorell et al. 2016, Harvey et al. 2017, Madsen et al. 2017). Moreover, physiological stress responses may cause reduced blood flow to muscles and limbs, increased muscle tension and muscle activation, as well as decreased effectiveness of the immune system (Carayon et al. 1999). This may further lead to nerve and tissue damage due to poor metabolism and lack of necessary nutrients, and impaired tissue reparation due to reduced immune system function. Allostatic load may also cause overuse of muscles, joints and tendons due to increased motor activity. (Carayon et al. 1999). Furthermore, when "stressed-out", employees may disregard good work ergonomics and thus be exceptionally vulnerable to work-related musculoskeletal symptoms and physical injuries (Carayon et al. 1999).

Previous studies have shown an association between job strain, ERI and organizational injustice and various neuro-endocrine stress markers (Elovainio et al. 2010, Nakata 2012, Jarczok et al. 2013, Eddy et al. 2016). Moreover, job strain, ERI and organizational injustice have been linked with sleep disturbances and an unfavorable change in health risk behavior (Kouvonen et al. 2006, Siegrist et al. 2006, Kouvonen et al. 2008, Fransson et al. 2012a, Heikkilä et al. 2012, Heikkilä et al. 2013, Nyberg et al. 2013, Linton et al. 2015, Halonen et al. 2017, Lallukka et al. 2017). The evidence suggests that high work-related stress is associated with the existence of multiple health risk behavioral factors in particular (Kouvonen et al. 2006, Siegrist et al. 2006).

Although employee ill health is the key factor in relation to work disability and disability pensioning, work disability also has other important aspects. The concept of work ability has, for example, been illustrated by Juhani Ilmarinen's "work ability house" model (Figure 5). This model proposes that at the core of work ability are an employee's personal resources in relation to work-related factors (Ilmarinen et al. 2003, Ilmarinen 2006). The basement of the work ability house is formed by an employee's health and functioning capacities along with his/her (occupational) skills and competence. If the basement is not strong enough, it will fall down in a case of increasing requirements of the work-related factors. (Ilmarinen et al. 2003, Ilmarinen 2006). In addition to health and functioning capacities, employees' attitudes, values and motivation contribute to their work ability in this model. Values, attitudes and motivation affect how an employee sees the relationship between work-related factors and his/her personal resources. Moreover, the relationship between work and personal life is considered thorough one's values, attitudes and motivation. (Ilmarinen et al. 2003, Ilmarinen 2006). Work-related factors in the work ability house model include the content and requirements of the work, the working conditions, the work community and the work organization. Furthermore, management and leadership are important work-related factors affecting work ability. (Ilmarinen et al. 2003, Ilmarinen 2006). Finally, supervisors have an important role with regard to employees' work ability by enabling the development of their skills and competence through the provision of relevant work tasks. Moreover, remolding job tasks to meet declining work performance (for example, due to illness) may return the balance between work ability and work requirements. (Ilmarinen et al. 2003, Ilmarinen 2006).

When an employee's health resources, functioning, skills and motivation are balanced with the physical and mental requirements of the work, s/he has full work ability. As work ability depends on factors related to the employee and to the work, there are three possible scenarios leading to work disability. Work ability may be jeopardized either 1) due to ill-health and/or impaired functioning; 2) due to increased mental or physical requirements of the work environment; or 3) due to alterations in both of these factors. (Lahelma et al. 2012). If the imbalance between an employee's resources and work-related factors is prolonged, it may eventually lead to loss of work ability and disability pensioning (Lahelma et al. 2012).

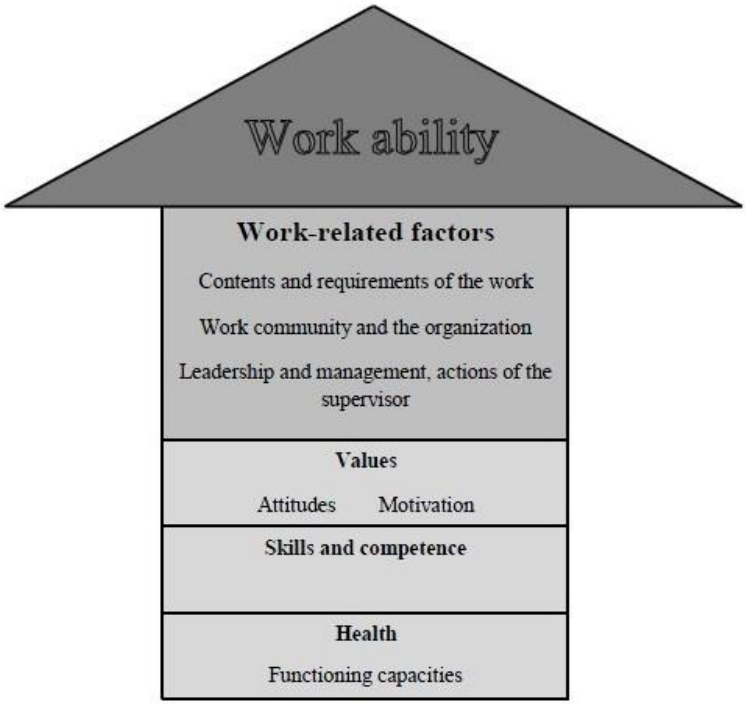

Figure 5. Ilmarinen's (2006) work ability house, which illustrates the factors associated with employees' work ability.

The figure has been modified from Ilmarinen J (2006). Pitkää työuraa!: Ikääntyminen ja työelämän laatu Euroopan unionissa. Helsinki: Työterveyslaitos and Sosiaali ja Terveysministeriö, page 80.

2.2. GAPS IN PREVIOUS RESEARCH

There is an evident gap in the previous research on the association between work-related stress and disability pensioning. To the best of my knowledge, there are only two studies on the association between ERI and disability pension, and no previous studies on the association between organizational (in)justice and disability pension. Moreover, no previous study has examined the associations between multiple work-related stressors and disability pensioning. The available studies on the association between work-related stress

and disability pension have been concentrated to study job strain and its components. These studies suggest moderate evidence on the associations between job strain, or job control, and disability pensioning (Knardahl et al. 2017). However, half the studies examining the association between job control and disability pension were limited to the use of non-validated questionnaires to assess job control (Knardahl et al. 2017). This limitation was also evident concerning job demands, as over half the studies used non-validated measures on job demands (Knardahl et al. 2017). Furthermore, most of the previous studies on job control, job demands or job strain in relation to disability pension concern all-cause disability pensions. However, few previous studies have addressed the associations of job strain, or its components, with diagnosis-specific disability pensioning due to musculoskeletal diseases or mental illnesses (Hagen et al. 2006, Lahelma et al. 2012, Ropponen et al. 2013, Samuelsson et al. 2013, Knardahl et al. 2017).

A major methodological limitation of the previous studies on the association of work-related stress and employee health, or work-related stress and disability pensions, is the possibility of reverse causality and subjectivity bias (Kasl 1998, Bonde 2008, Kolstad et al. 2011, Bonzini et al. 2015, Madsen et al. 2017). Reverse causality might explain the results of the previous research if adverse changes (clinical or subclinical) in an employee's health and work ability lead to reporting of high work-related stress (and not vice versa). Individual characteristics, such as pessimism, may be linked to both ill-health and reporting of high work-related stress, and thus act as mediators for the reverse causality (Kasl 1998). Using aggregated measures based on, for example, work unit mean values of work-related stress, is a suggested way to deal with reverse causality (Bonde 2008).

Common method bias refers to situations of measurement error due to self-reported exposure and outcome (Kasl 1998). Self-reports may be biased due, for example, to individuals' tendency to exaggerate (or underestimate) both the phenomena under investigation and the consequences of it. Moreover, individual differences, such as negative affectivity (i.e. tendency to experience negative emotions and to have poor self-concept), may have an impact on how employees actually perceive work-related stress (Kasl 1998, Hintsanen et al. 2011, Kolstad et al. 2011), and additionally affect their tendency to seek a disability pension. Subjectivity bias refers to bias caused by individual differences. Besides dealing with possible reverse causality, aggregated measures are also helpful when trying to avoid common method and subjectivity biases.

The majority of the studies on work-related stress and employee health have been vulnerable to common method bias, subjectivity bias and reverse causality due to the use of self-reports of the exposure and outcome. This methodological limitation also concerns previous studies that have examined the associations of job demands and job control with

disability pensions. However, the majority (3/5) of the previous studies on the association of job strain and disability pensions have used aggregated measures to assess job strain (Laine et al. 2009, Ropponen et al. 2013, Samuelsson et al. 2013, Knardahl et al. 2017). Nevertheless, the studies by Ropponen et al. (2013) and Samuelsson et al. (2013) used aggregated scores based on historical surveys and occupational titles. Thus, these studies were limited as they did not use aggregates derived from the study population concerned. Moreover, these two studies did not use self-reports, which may also be thought of as a limitation, since aggregated measures may poorly catch the true differences between individual employees.

3. AIMS OF THE STUDY

Previous studies suggest there is an association between high job strain, effort-reward imbalance (ERI) and organizational injustice and the subsequent ill-health of the exposed employees (Kivimäki et al. 2012, Theorell et al. 2016, Harvey et al. 2017, Madsen et al. 2017). This study was based on a hypothesis that a high level of work-related stress would also be associated with an increased risk of receiving a disability pension.

A prospective study design with a register-based study endpoint (including clinical diagnosis with specific ICD-10 codes) was chosen to enable conclusions of the temporal order between work-related stress and reliably assessed disability pensions. Importantly, in addition to self-reports, aggregated measures based on work unit mean scores were used to more objectively assess the exposure to work-related stressors. This method was used in order to have control over reverse causality and subjectivity bias. The study endpoint was all-cause disability pension, as well as disability pensions due to two major disease groups causing disability pensioning (i.e. depressive and musculoskeletal disorders) (The Finnish Centre for Pensions et al. 2016). Moreover, disability pensions due to ischemic heart diseases were studied as work-related stress (and job strain in particular) has previously been associated with ischemic heart diseases (Kivimäki et al. 2012, Xu et al. 2015, Theorell et al. 2016).

The primary aims of this study were:

1) To add to the limited number of studies on job strain and disability pensioning, this study aimed to further examine the associations of job strain with all-cause and diagnosis-

specific disability pensions by using self-reports as well as cohort-specific occupation- and work unit-based aggregates.

2) To fulfill the gap of knowledge on the associations of ERI and organizational (in)justice with disability pensioning (all-cause and diagnosis-specific). In order to control reverse causality and subjectivity bias, both self-reports and work unit-based aggregates were used to assess ERI and organizational (in)justice.

3) To be the first study to provide information on the associations between multiple work-related stressors (measured using self-reports and work unit-based aggregates) and disability pensions due to any cause as well as depressive or musculoskeletal disorders.

4. MATERIALS AND METHODS

4.1. PARTICIPANTS AND STUDY DESIGN

Study participants were recruited from an ongoing prospective cohort study, the Finnish Public Sector (FPS) Study, which studies various work-related factors and the health of municipal and local government employees in the service of ten towns (Turku, Espoo, Vantaa, Tampere, Oulu, Raisio, Naantali, Valkeakoski, Virrat and Nokia) and 21 public hospitals from six hospital districts (Varsinais-Suomi, Kanta-Häme, Vaasa, Pirkanmaa, Pohjois-Pohjanmaa and Helsinki-Uusimaa). The FPS-study is run by the Finnish Institute of Occupational Health. This cohort covers almost 30% of the municipal public sector employees in Finland. The Ethics Committees of the Finnish Institute of Occupational Health and the Hospital District of Helsinki and Uusimaa approved the FPS-study in 2012. The first FPS-study survey was carried out in 1997 (towns) and in 1998 (hospitals) in a sub-cohort, whilst the first survey concerning the whole cohort was executed in 2000–02. Since 2000–02, surveys have been repeated biannually.

Table 1 explains the study designs and the study samples of the four sub-studies included in this dissertation. In 2000–02, the eligible study population comprised 71,705 employees in 3,699 work units. The eligible employees had worked full-time (towns and hospitals) or part-time (hospitals) for at least six months in one of the target organizations with a fixed-term or permanent work contract. Of these eligible employees, 48,598 responded to the survey (68% response rate). In 2004, the survey cohort comprised 72,437 employees, 48,076 of whom responded (response rate 66%). These surveys included questions on workplace psychosocial factors (including job strain, ERI and organizational justice) and health risk behavior (e.g. smoking and physical activity).

Table 1. Description of the study designs and study samples across the four sub-studies.

	Study I	Study II	Study III	Study IV
Study design	Prospective cohort study	Prospective cohort study	Prospective cohort study	Prospective cohort study
Data source	FPS-study*	FPS-study*	FPS-study*	FPS-study*
Baseline survey (response rate)	2000–02 (68%)	2000–02 (68%)	2000–02 (68%) and 2004 (66%)	2000–02 (68%) or 2004 (66%)
Exposure	Job strain (occupation-based, work unit-based, and self-reported)	Effort-reward imbalance (work unit-based and self-reported)	Organizational justice (self-reported)**	Exposure to single and multiple stressors, measured with self-reports and work unit-based aggregates†
Outcome	Disability pensions due to any cause, depressive and musculoskeletal disorders, and ischemic heart diseases	Disability pensions due to any cause, depressive and musculoskeletal disorders, and ischemic heart diseases	Disability pensions due to any cause, depressive and musculoskeletal disorders	Disability pensions due to any cause, depressive and musculoskeletal disorders
Follow-up at most until	31st December 2005	31st December 2010	31st December 2011	31st December 2011
Study sample	Respondents and non-respondents	Respondents and non-respondents	Respondents	Respondents
N of participants	69,842	51,874	24,895	54,460
Baseline status	Non-retired, not on a long (>90 days) sickness absence	Non- retired, not on a long (>90 days) sickness absence	Non- retired, not on a long (>90 days) sickness absence	Non- retired, not on a long (>90 days) sickness absence

*The Finnish Public Sector study. ** Supplemental analyses with work unit-based measures †Included stressors were job strain, effort-reward imbalance and organizational injustice.

The study population for the sub-studies I and II were all eligible participants of the FPS survey in 2000–02 (n=71,705). The study population for the sub-study III comprised those employees who responded to both the 2000–02 and 2004 surveys (n=29,172). Finally, the sub-study IV comprised those participants who had responded to either the 2000–02 or 2004 survey (n=63,996). The sub-studies I and II included both the respondents and the non-respondents, while the sub-studies III and IV included only the respondents. Of the all included participants in each study, participants who had retired or died at the beginning of the follow-up, which started on 1st of January following the survey year, were excluded. Additionally, employees who were on extended (over 90 days) sick leave were excluded because long-term sickness absence may be considered an early stage of disability pension (Laaksonen et al. 2016). Moreover, participants with missing values on the exposure or any of the covariates were also excluded. Finally, employees who were working in work units (or occupations in the sub-study I) with less than three respondents were excluded from the sub-studies I and II (and from the analyses with work unit-based aggregates in the sub-studies III and IV), because aggregated measures should be based on responses of at least three respondents to ensure objectivity. As a consequence, the final analytical sample of the sub-study I comprised 69,842 employees, and the sub-study II comprised 51,874 employees. The sub-study II concerned ERI, which was not measured in two large hospital districts in Central and Northern Finland in 2000–02. This resulted in 10,185 excluded participants due to missing values on ERI. The final analytical sample for the sub-study III comprised 24,895employees. In the sub-study IV, 54,460 employees, concerning self-reported exposure, and 51,279 employees, concerning work unit-based (aggregated) exposure, belonged to the final analytical sample. A more detailed explanation of the exclusion process in each sub-study can be seen in the original publications.

All four sub-studies included in this dissertation were prospective cohort studies and profited from a great deal of data from official registers. The data for the exposures (i.e. job strain, ERI and organizational injustice) was derived from the FPS-study surveys in 2000–02 and 2004, as described earlier. The sub-study III used repeated measures over two time points to assess long-term exposure to organizational justice. Thus, the sub-study III was based on surveys in both 2000–02 and 2004. The other three sub-studies only used a single-point measure of exposure: sub-studies I and II measured the exposure in 2000–02, and the sub-study IV in either 2000–02 or in 2004. With regard to the sub-study IV, if responses to both surveys were available, only the first were used. Some of the covariates (i.e. factors related to baseline health risk behavior) in the sub-studies III and IV were also based on survey responses, while in the sub-studies I and II, all the baseline covariates were register-based. The study endpoint was disability pension, which was also derived from the reliable national register. The follow-up began on 1st of January following the survey year and ended at the first occurrence of any of the following occasions: 1) if the participant was granted a disability pension or an old age pension, 2) in the event of death,

3) at 31st of December 2005 (sub-study I)/ 2010 (sub-study II)/ 2011 (sub-studies III and IV).

4.2. WORK-RELATED STRESS

The FPS -study surveys include questions on work-related stress (i.e. job strain, ERI and organizational injustice). A five point Likert-type response format was used in all survey questions on work-related stress. The response options for job strain and organizational injustice were 1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, 5 = Strongly agree; and 1 = Not at all, 2 = A little, 3 = Somewhat, 4 = Much, 5 = A great deal for ERI.

4.2.1. Job strain

Job strain can be measured with a standardized and widely-used questionnaire, the Job Content Questionnaire (JCQ) (Karasek 1985, Karasek et al. 1998). The JCQ measures the demand and control components of job strain. The original concept has four job strain categories, as described earlier in "Conceptual background". However, there are multiple ways to form a job strain score from its components. To formulate a class variable of high job strain, below median (or lowest third/quartile) control may be combined with above median (or highest third/quartile) demands. Moreover, the subtraction model, or the ratio of demands and control, may also be used to formulate a continuous variable of job strain (Kivimäki et al. 2015, Courvoisier et al. 2010).

The FPS-study survey questions on job strain were derived from the JCQ and are shown in Table 2. Diverging from the original JCQ, job demands were assessed using three items only as the questions on work speed and conflicting demands were lacking from the surveys targeting hospital employees. Nevertheless, the validity of the short measure has been shown to be good (Fransson et al. 2012b). It was decided to use the subtraction model in this study to form a total job strain score from its components (Courvoisier et al. 2010). In this model, a self-reported job strain score was calculated for each respondent by subtracting the mean of nine self-reported job control scores from the mean of three self-reported job demand scores. A higher score indicated higher job strain.

Table 2. The FPS-study survey questions on job strain.

Demands scale (Cronbach α= 0.77)	**Control scale** (skill discretion/*decision authority*, Cronbach α = 0.82).
1. I have to work very hard.	*1. My job allows me to make a lot of decisions on my own*.
2. My job involves an excessive amount of work.	2. My job requires me to be creative.
3. I don't have enough time to get my work done.	3. My job requires that I learn new things.
	4. My job involves a lot of repetitive work.*
	5. *I have a lot of say about what happens in my job*.
	6. My job requires a high level of skill.
	7. I get to do a variety of different things in my job.
	8. I have an opportunity to develop my own special abilities.
	9. *In my job, I have very little freedom to decide how I do my work**.

* Items 4 and 9 reversed when computed.

4.2.2. Effort-reward imbalance

ERI can be measured with a specific scale that measures effort and reward (Siegrist 1996). Different versions of this scale have been used and validated (Siegrist et al. 2009). Similar to job strain, an ERI score can be formulated in various ways. For example, combining high effort levels (e.g. above median or highest thirds/quartiles) with low reward (e.g.

below median or lowest thirds/quartiles) leads to a classified ERI variable. Moreover, a ratio of effort and reward results in a continuous variable. This quotient may further be categorized by dividing it into thirds or quartiles. However, a median cut-point has also been widely used. (Koch et al. 2014).

The FPS-study included one survey question on effort and three on reward as proxy measures to assess ERI. Thus, the specific effort questions on time pressure, heavy workload, disturbances and interruptions, as well as increasing demands were not included in the FPS-study. Moreover, the FPS- study lacked the specific reward questions on job security, promotion prospects (overall and in relation to effort), and expectation of undesirable change. (Siegrist 1996). The survey questions used in the FPS-study are shown in Table 3. To form an ERI score, the ratio of the effort score and the mean of the reward scores was computed (ERI=effort score/mean score of reward). This ERI score was further divided into quartiles. The lowest ERI quartile acted as a reference group.

4.2.2.1. Validation of the ERI measure

The four-item ERI scale used in this study was tested for validity. Validity testing was done among those participants, who had responded the FPS-study surveys both in 2000–02 and 2010 (N=18,928). In 2000–02, ERI was measured using a 4-item scale, while the original 10-item scale was used in 2010. Using Pearson's correlation coefficients and the 2010 survey responses, a moderate correlation between the four and the ten-item ERI scales was found ($R=0.57$, $P<0.001$). This suggests that the short measure is valid. Similarly, Siegrist et al. (2009) found support for the validity of the short ERI scales.

4.2.3. Organizational justice

Organizational justice (specifically its relational and procedural components) can be measured with a standardized Moorman's scale (Moorman 1991). High organizational (in)justice may be formulated by combining high procedural and high relational justice to indicate high organizational justice, or low procedural and low relational justice to indicate high organizational injustice. As with job strain and ERI, the cut-point for the components of justice can be median, thirds or quartiles.

Table 3. The FPS-study survey questions on effort-reward imbalance.

Effort scale:	**Reward scale (Cronbach α = 0.64)**
1. How much do you feel you invest in your job in terms of skill and energy?	1. How much do you feel you get in return for work in terms of income and job benefits? 2. How much do you feel you get in return for work in terms of personal satisfaction? 3. How much do you feel you get in return for work in terms of recognition and prestige?

The original Moorman's scale was used in the FPS -study to assess organizational justice (Moorman 1991). Relational justice was calculated as a mean of the six items, and procedural justice as a mean of the seven items. The survey questions are presented in Table 4. The total organizational justice score was calculated as a mean of the two components. Long-term exposure to organizational justice (i.e. repeated measure of organizational justice and its components over two time points) was based on survey responses in both 2000–02 (Time1) and 2004 (Time2). Long-term organizational, relational and procedural justice scores were calculated as an average of the corresponding Time1 and Time2 scores.

4.2.4. Multiple work-related stressors

In the sub-study IV, different combinations of job strain, ERI and organizational injustice were used as explanatory variables. First, the mean scores for the components of each work-related stressor (i.e. means of demand, control, effort, reward, relational and procedural justice) were calculated and divided into quartiles. Then the highest quartile of demand was combined with the lowest quartile of control to indicate exposure to high job strain. Similarly, the highest quartile of effort in combination with the lowest quartile of reward indicated

Table 4. The FPS-study survey questions on organizational justice.

Relational justice (**Cronbach α=0.92**)	**Procedural justice** (**Cronbach α=0.91**)
1. Your supervisor considers your viewpoint	1. Procedures are designed to collect the accurate information necessary for making decisions.
2. Your supervisor is able to suppress personal biases.	2. Procedures are designed to provide opportunities to appeal or challenge the decision.
3. Do you receive consistent information from line management (your supervisor)?	3. Procedures are designed to hear the concerns of all those affected by the decision.
4. Your supervisor treats you with kindness and consideration.	4. Procedures are designed to generate standards so that decisions can be made with consistency.
5. Your supervisor shows concern for your rights.	5. The opinion of employees is taken into account.
6. Your supervisor takes steps to deal with you in an honest manner	6. Procedures are designed to provide useful feedback
	7. Procedures are designed to provide clarification regarding the decision.

exposure to high ERI. The lowest quartiles of relational and procedural justice were combined to indicate high organizational injustice. The remaining groups were set as non-exposed. Finally, an eight-category exposure variable was formed to present all the possible combinations of job strain, ERI and injustice. The exclusive (i.e. each participant belonged to one category only) categories were: 1) non-exposed, exposure to 2) job strain only, 3) ERI only, 4) organizational injustice only, 5) job strain + ERI, 6) job strain + organizational injustice, 7) ERI + organizational injustice, 8) job strain + ERI + organizational injustice. The non-exposed acted as a reference group.

4.2.5. Aggregated measures

Cohort-specific aggregated measures of the exposure were used in the main analyses of the sub-studies I, II and IV in order to avoid subjectivity bias and reverse causality. In the sub-study III, aggregated measures were used only in the supplemental analyses.

4.2.5.1. Work unit-based aggregates

To form a work unit-based score for each work-related stressor, all the work units at the lowest organizational level with at least three survey respondents were detected using employers' administrative records. In all, 3,699 functional work units (mean size 12.0 person-years, range 3–397) were detected. These functional units were typically at a single location (e.g. a school or a hospital ward). To form a work unit-based aggregate, a mean score of all the survey responses within the same work-unit was calculated for the components of each work-related stressor (i.e. demands and control, effort and reward, procedural and relational justice). Thus, a work unit-based aggregate was based on the mean score of all survey responses within the same work unit concerning the work units with at least three respondents. Consequently, each participant in the same work unit was given the same work unit-based aggregate score regardless of their own survey responses. Total work unit-based scores for each stressor were formulated identically to the self-reported scores: the aggregated demands were subtracted from the aggregated control to form an aggregated job strain. The ratio of the aggregated effort and reward was calculated to form an aggregated ERI. The mean of Time1 and Time 2 aggregated relational (procedural) justice indicated a long-term work unit-based relational (procedural) justice. An aggregated long-term organizational justice was an average of the sum of the aggregated long-term relational and procedural justices. Finally, in the sub-study IV, the aggregated components of each stressor were divided into quartiles. Then, aggregated job strain, ERI and organizational injustice were formulated equivalent to the self-reported measures in the sub-study IV. Intraclass correlation (Merlo et al. 2005) for work unit-based job strain was 18%, indicating that job strain varied remarkably between different work units. The corresponding figure for ERI was 5% (indicating moderate variance), and for organizational justice 20% (indicating remarkable variance).

4.2.5.2. Occupation-based aggregate

A job exposure matrix model was used to assess cohort-specific occupation-based (aggregated) job strain scores in the sub-study I (Goldberg et al. 1993). Participants' occupational titles (based on the International Standard Classification of Occupations) were obtained from the employers' administrative records and used to determine an occupation for each study participant. The job-axis of the job exposure matrix was same for each participant in the same workplace (town or hospital) with the same occupational title. A total of 1,259 occupations with at least three respondents were identified (mean group size 40.8, range 3–1178). The exposure-axis was calculated as a mean of all self-reported job strain scores within the same job axis. In other words, each participant in the same workplace with the same occupational title was given the same occupation-based job strain value. This was done regardless of their own survey responses, and whether they had, or had not, responded the survey. Intraclass correlation was 14%, indicating that job strain varied remarkably between the occupations.

4.3. DISABILITY PENSIONS

Study endpoints were all-cause disability pensions (all ICD-10 codes), disability pensions due to depressive disorders (ICD-10 codes F32–F34), disability pensions due to musculoskeletal disorders (ICD-10 codes M00–M99), and disability pensions due to ischemic heart diseases (ICD-10 codes I20–I25). The Finnish Centre for Pensions produces official statistics (*The Pension Register)* on all private and public sector (earnings-related) pensions. For example, this register holds data on the start dates and the diagnosis that leads to disability pensioning. This study used information on the start dates and the diagnoses, as well as information on the type (permanent or fixed-term, and partial or full-time) of disability pension. These data were derived from The Pension Register and linked to the participants by their personal identification codes. Data was available for all permanent citizens of Finland and for the persons who permanently work in Finland (The Finnish Centre for Pensions 2017). Thus, the linkage to registers was available for virtually all of the participants.

4.4. COVARIATES

All the sub-studies included age, sex, occupational status, and baseline health (baseline physical illnesses and mental disorders) as baseline covariates. Other covariates were work-related factors, socioeconomic factors and baseline health risk behaviors. These covariates were used inconsistently between the sub-studies (for details, see Tables 5 and 6). To utilize vast amount of data from various registers, the participants were linked to the employers' records and comprehensive national registers using their personal identification codes. The data from the national registers have been shown to be high in specificity, reliability, accuracy and comprehensiveness (Rapola et al. 1997, Pajunen et al. 2005, Mähönen et al. 2013).

4.4.1. Registers used to collect covariates

The baseline covariates were collected from the registers of the Social Insurance Institution of Finland, the National Research and Development Centre for Welfare and Health, the Institute for Statistical and Epidemiological Cancer Research, the Statistics Finland and the Population Register Centre.

The Social Insurance Institution of Finland provided data on 1) sickness absence periods (from The Sickness Absence Register), 2) outpatient medication purchases (from The Drug Prescription Register), 3) entitlement to special reimbursement of pharmacological treatment for chronic physical or mental diseases (from The Drug Reimbursement Register), and 4) entitlement to psychotherapy (from The Rehabilitation Register). *The Sickness Absence Register* holds data (i.e. duration and diagnosis according to ICD-10 codes) on all private or public sector sickness absence spells with duration of at least nine days. *The Drug Prescription Register* holds data on the purchases of prescribed drugs: 1) date of a purchase, 2) anatomical therapeutic chemical (ATC) classification code for the drug according to the World Health Organization, and 3) amount of the purchased drug measured as defined daily doses (DDDs). DDDs are determined as the assumed daily maintenance dose for a drug's main indication in adults (WHO 2004). *The Drug Reimbursement Register* holds information on all Finnish citizens entitled to the special reimbursement for the costs of medication for specific chronic or severe diseases. Such diseases include hypertension, diabetes mellitus types I and II, ischemic heart disease, psoriasis or cancer. The special reimbursement (which is 65% or 100% of the medication costs), is granted on the grounds of a detailed medical certificate with information on the onset, symptoms, diagnosis (including ICD-10 codes) and treatment for the disease. The criterion for special reimbursement is stricter than the general treatment guidelines. *The*

Table 5. Baseline covariates and their distribution across the study population in sub-studies I-IV.

	Study I	**Study II**	**Study III**	**Study IV**
Covariate	**N (%) of participants**	**N (%) of participants**	**N (%) of participants**	**N (%) of participants**
All participants	69842 (100)	51,874 (100.0)	24,895 (100.0)	54,460 (100.0)
Sex				
Male	16613 (23.8)	12,785 (24.6)	4,624 (18.6)	11,220 (20.6)
Female	53229 (76.2)	39,089 (75.4)	20,271 (81.4)	43,240 (79.4)
Age (years)				
< 40	21,771 (31.2)	15,989 (30.8)	4,126 (16.6)	18,269 (33.6)
40 – <50	24,198 (34.6)	17,900 (34.5)	9,002 (36.2)	18,506 (34.0)
50 – <60	22,062 (31.6)	16,735 (32.3)	10,590 (42.5)	16,424 (30.2)
≥ 60	1,881 (2.6)	1,250 (2.4)	1,177 (4.7)	1,261 (2.3)
Occupational status				
Upper non-manual	20,942 (30.2)	16,750 (32.3)	7,503 (30.1)	16,512 (30.3)
Lower non-manual	34,157 (49.3)	23,903 (46.1)	13,420 (53.9)	28,273 (51.9)
Manual	14,216 (20.5)	11,221 (21.6)	3,972 (16.0)	9,675 (17.8)
Education				
Primary	not used	7,084 (13.7)	2,106 (8.5)	5,207 (9.6)
Secondary		18,572 (35.8)	8,513 (34.2)	18,381 (33.8)
Tertiary		26.218 (50.5)	14,276 (57.3)	30,872 (56.7)
Size of residence				
Small	not used	15,299 (29.5)	5,985 (24.0)	15,563 (28.6)

Medium		19,764 (38.1)	9,440 (37.9)	20,250 (37.2)
Large		16,881 (32.5)	9,470 (38.0)	18,647 (34.2)
Physical illnesses				
Yes	7,873 (11.3)	5,757 (11.1)	5,991 (24.1)	10,826 (19.9)
No	61,969 (88.7)	46,117 (88.9)	18,904 (75.9)	43,634 (80.1)
Mental disorders				
Yes	3,941 (5.6)	2,999 (5.8)	1,739 (7.0)	3,457 (6.4)
No	65,901 (94.4)	48,875 (94.2)	23,156 (93.0)	51,003 (93.7)
Smoking status				
Smoker	not used	not used	3,842 (15.4)	9,996 (18.4)
Non-smoker			21,053 (84.6)	44,464 (81.7)
High alcohol consumption				
Yes	not used	not used	2,226 (8.9)	4,622 (8.5)
No			22,669 (91.1)	49,838 (91.5)
Obesity (Body mass index>30kg/m^2)				
Yes	not used	not used	3,267(13.1)	6,362 (11.7)
No			21,628 (86.9)	48,098 (88.3)
Leisure-time physical inactivity				
Yes	not used	not used	5,862 (23.6)	13,092 (24.0)
No			19,033 (76.5)	41,368 (76.0)

Rehabilitation Register holds data on all granted entitlements for reimbursement of psychotherapy or entitlement to other medical rehabilitation (e.g. medical rehabilitation due to back pain).

The Care Register for Health Care (formerly The Hospital Discharge Register) is kept by the National Research and Development Centre for Welfare and Health. It includes countrywide data (e.g. diagnoses according to the ICD-10 codes, the start and the end dates for the hospitalization) on all the patients who have been treated in public hospitals (Sund 2012, The National Research and Development Centre for Welfare and Health 2017). The *Finnish Cancer Register* is kept by the Institute for Statistical and Epidemiological Cancer Research. This register holds nationwide data on all cancer cases in Finland since 1953 (The Institute for Statistical and Epidemiological Cancer Research 2015).

The Statistics Finland (2016) produces hundreds of official national statistics, including individual-level data for *Statistics on students and qualifications of educational institutions. The Building Information Register* of The Population Register Centre (2017) holds data on the address, owner, size (floor area) and facilities (e.g. pool, sauna, balcony, lift) of buildings in Finland.

4.4.2. Demographic factors

Employers' registers were used to determine age, sex, and occupational title for each participant. Age was used as a continuous variable in the sub-studies III and IV, and categorised as below 40, 40 to below 50, 50 to below 60, and over 60 years in the sub-studies I and II. Classification of occupations by The Statistics Finland (1987) was used to categorize participants' occupational status (higher non-manual, lower non-manual and manual). Additionally, level of education (primary, secondary or tertiary) and size of residence were used to assess participants' socio-economic position. Size of residence was used as a proxy of income (Halonen et al. 2012). Data on education and residence size were obtained from the registers of The Statistics Finland (2016) and The Population Register Centre (2017).

4.4.3. Baseline health and health risk behavior

Baseline physical illnesses and mental disorders were used as dichotomous (yes/no) covariates. A participant was coded to have a prevalent physical illness (yes) in the case of fulfilling any of the following criteria: 1) History of cancer diagnosis (until the end of year preceding the beginning of the follow-up); 2) Entitlement to special reimbursement for the costs of medication (for diabetes, asthma or chronic obstructive pulmonary disease, hypertension, cardiac insufficiency, or coronary heart disease) effective at the beginning of the follow-up; 3) Purchases of painkillers (i.e. drugs coded as N02, M01A in the ATC-classification) equal to at least 100 DDDs during the five years preceding the beginning of the follow-up. Prevalent mental disorders were coded "yes" if any of the following criteria were fulfilled during the five years before the beginning of the follow-up: 1) Long- term (over 90 days) sickness absence due to mental disorders (ICD-codes F00-F99); 2) Hospitalization due to mental disorders (ICD-10 codes F00-F99); 3) Reimbursement for psychotherapy; 4) Purchases of over 100 DDDs of prescribed antidepressant medication (ATC-code N06A); 5) Entitlement to special reimbursement for antipsychotic medication effective in 2004 (entitlement is possible for psychotic diseases only).

Baseline health risk behaviors were used only in the sub-studies III and IV, which also exploited self-reported exposure (in addition to work unit-based exposure) in the main analyses. Baseline health risk behaviors included current smoking status (smoker or non-smoker), high alcohol consumption (average weekly consumption of at least 210g of absolute alcohol or under 210g of absolute alcohol), obesity (body mass index at least 30kg/m^2, or under 30kg/m^2), and leisure time physical inactivity (under 2.0 metabolic equivalent task hours per day, or at least 2.0 metabolic equivalent task hours per day). These covariates were derived from the surveys, and thus were based on self-reports.

4.4.4. Work-related covariates

Work-related covariates were the geographical location of the work place, the type of employer, the type of work contract, the size of the work unit, the mean age of the employees in the work unit, and the proportion of fixed-term employees in the work-unit. Work unit-level job strain was additionally used in the sub-study II. The detailed use of the work-related covariates is shown in Table 6.

Table 6. Work-related covariates used in sub-studies I –IV.

Covariate	Study I N (%) of participants	Study II N (%) of participants	Study III N (%) of participants	Study IV N (%) of participants
Location of workplace				
Southern Finland	not used	30,499 (58.8)	11,377 (45.7)	27,675 (50.8)
Central Finland		16,412 (31.6)	9,675 (38.9)	18,861 (34.6)
Northern Finland		4,963(9.6)	3,843 (15.4)	7,924 (14.6)
Type of employer				
Municipal	not used	41,370 (79.8)	not used	not used
Hospital		10,504 (20.2)		
Type of job contract				
Permanent	13,069 (19.2)	42,627 (82.2)	not used	not used
Fixed-term	55,103 (80.8)	9,247 (17.8)		
Size of the work unit (person-years)				
3–19	28,656 (41.8)	20,141 (38.8)	not used	not used
20–39	20,847 (30.4)	16,393 (31.6)		
≥40	19,066 (27.8)	15,340 (29.6)		
Proportion (%) of temporary employees at work unit	17,345 (25.3)	13,145 (24.3)	not used	not used
0–14	25,647 (37.4)	20,473 (39.5)		
14–28	25,577 (37.3)	18,256 (35.2)		
29–100				
Mean age of employees at work unit				
15–40	12,169 (17.7)	8,918 (17.2)	not used	not used
41–45	31,841 (46.4)	24,400 (47.0)		
46–64	24,559 (35.8)	18,556 (35.8)		
Work unit-level job strain				
Low	-	12,968 (25.0)	not used	-
Medium		12,957 (25.0)		
High		12,947 (25.0)		
Highest		13 002 (25.1)		

- indicates that using the covariate was not appropriate in the sub-study.

4.5. STATISTICAL METHODS

4.5.1. Main analyses

Cox proportional hazard models were used in all sub-studies to assess hazard ratios (HRs) and their 95% confidence intervals (CIs) for the associations between work-related stress and disability pensions. All statistical analyses were performed using SAS statistical software, versions 9.1.3, 9.2, and 9.3 (SAS Institute Inc, Cary, NC, USA). Multivariate adjusted HRs were calculated using the PHREG procedure.

Analyses of the sub-study I were stratified by sex and occupational status and, with regard to the main analyses examining the risk of all-cause disability pension, adjusted stepwise: 1) crude model (only reported in the original publication); 2) adjusted for age, sex (when appropriate), and type of job contract; 3) additionally adjusted for work-related covariates (i.e. the work unit's size, the proportion of temporary employees at the work unit, and the mean age of all employees at the work unit); 4) additionally adjusted for baseline health; and 5) additionally adjusted for occupational status (if appropriate). Analyses of the diagnosis-specific disability pensions were adjusted only for age, sex (when appropriate), and type of job contract.

All the main analyses of the sub-study II were adjusted for: 1) the age, sex and location of the workplace; 2) additionally for occupational status, education, size of residence, baseline health, and work-related covariates (i.e. type of employer and job contract, the work unit's size, the proportion of temporary employees at the work unit, the mean age of all the employees at the work unit, and work unit-based job strain). No interaction between sex and ERI was found ($p=0.1–0.8$, depending on the endpoint). Thus, the analyses were not stratified by sex. Additional analyses included: 1) Kaplan-Meier estimator in order to assess cumulative incidence of disability pensions due to depression by the four categories of ERI (i.e. quartiles from the lowest to the highest) over a ten-year time span; 2) Associations of effort and reward separately with diagnosis-specific disability pensions.

A three-phase adjustment model was used for the sub-study III. First, the models were adjusted for age, sex and the location of the workplace. Second, models were additionally adjusted for occupational status, education and size of residence. Thirdly, models were, in addition to all aforementioned covariates, adjusted for baseline physical and mental health, and baseline health risk behaviors. Interaction between sex and organizational justice ($p<0.001$) was found in the analyses exploring the risk of all-cause disability pension.

Thus, analyses were run among all participants, and men and women separated. Two supplemental analyses were included in the sub-study III. First, additional adjustment for long-term job strain and ERI was performed to explore whether organizational justice was independent from the other work-related stressors. Secondly, associations between long-term work unit-based organizational justice and disability pension were studied.

In the sub-study IV, analyses were first adjusted for the demographics and location of the workplace, and then additionally for socio-economic factors (i.e. occupational status, education, and size of residence), baseline physical and mental health, and baseline health risk behaviors. Analyses were not stratified by sex, as no sex interaction was found (p=0.06–0.9, depending on the outcome) for the exposure. Moreover, the Kaplan-Meier procedure was used to study the cumulative incidence of all-cause disability pensions, and diagnosis-specific disability pensions due to depressive and musculoskeletal disorders using the eight self-reported exposure categories. Results were presented over age (from 30 to 63 years).

4.5.2. Sensitivity analyses

In the sub-study I, two sensitivity analyses were performed. First, associations of self-reported job strain with disability pension among 45,579 survey respondents were studied. Secondly, sensitivity analyses among the 22,139 non-respondents were run. Sensitivity analyses were stratified by sex and occupational status, and adjusted for age, sex (when appropriate), and type of work contract.

In the sub-study III, two sets of sensitivity analyses were run. First, associations of organizational justice with disability pension were studied among initially healthy participants (i.e. disability pensions due to depressive disorder was studied among participants with no baseline mental illnesses (n=23,156), and disability pensions due to musculoskeletal diseases was studied among those with no baseline physical illnesses (n=18,904), while all-cause disability pension was studied among those without baseline physical and mental illnesses (n=17,810)). These analyses were adjusted (equivalent to the main analyses) for demographic factors, socioeconomic status, baseline health (as relevant) and health risk behavior. Secondly, associations between organizational justice and all-cause disability pension were studied among participants without long (over nine days) sickness absence spells during the year preceding the study baseline. These analyses were adjusted for age, sex and the location of the work place.

The sensitivity analyses for the sub-study IV were run amongst 51,003 participants with no history of mental illnesses (disability pension due to depressive disorders) and 43,634 participants without history of physical illnesses (disability pension due to musculoskeletal disorders). As with the main analyses, sensitivity analyses were adjusted in two phases. Cox proportional hazard models, performed with SAS statistical software, were used in all sensitivity analyses to provide HRs and their 95% CIs for the estimated associations.

5. RESULTS

Table 7 shows that the mean follow-up time in all four sub-studies ranged from 4.6 years (the sub-study I) to 8.9 years (the sub-study II). From 4% to 9% of all participants across the sub-studies were granted a disability pension. Of the disability pensions granted, 17% to 19% were due to depressive disorders, and 40% to 46% due to musculoskeletal disorders. With regard to baseline covariates, especially increasing age, baseline physical and mental illnesses, lower occupational status and lower education were associated with an increased risk of all-cause disability pensions in all the studies (see Tables 1 in the original publications of the sub-studies I, III and IV).

5.1. ALL-CAUSE DISABILITY PENSIONS

This study showed HRs from 1.1 to 1.4 for the associations of aggregated (work unit-based or occupation-based) job strain and all-cause disability pension among men, women and manual workers when fully adjusted (Table 8). All of these associations were statistically significant, except for the association between work unit-based job strain and all-cause disability pension among women. No association was found between aggregated job strain (exclusive of the other stressors) and all causes disability pensions among all participants (Table 9).

Table 7. The follow-up time, number of participants and the cases across the sub-studies I–IV.

			Disability pensions due to			
			Any cause	**Depressive disorders**	**Musculo-skeletal disorders**	**Ischemic heart diseases**
	Mean follow-up time (years)	**Number of participants**	**Number (%) of cases**	**Number (%) of cases**	**Number (%) of cases**	**Number (%) of cases**
Study I	4.6	69,842	2,572 (3.7)	493 (0.7)	1,020 (1.5)	53 (0.08)
Study II	8.9	51,874	4,642 (8.9)	890 (1.7)	2,001 (3.9)	87 (0.2)
Study III	6.4	24,895	1,658 (6.7)	282 (1.1)	816 (3.3)	-
Study IV	8.6	54,460	4,220 (7.7)	778 (1.4)	1,926 (3.5)	-

Table 8. Aggregated job strain, based on mean scores of occupations and work units, and all-cause disability pension among men, women and manual employees.

			Adjustment*			
			Model 1	**Model 2**	**Model 3**	**Model 4**
Job strain	**N of participants**	**N of cases**	**HR (95% CI)**	**HR (95% CI)**	**HR (95% CI)**	**HR (95% CI)**
Men						
Occupation-based	16,315	583	**2.05 (1.70-2.46)**	**1.91 (1.58-2.32)**	**1.92 (1.58-2.33)**	**1.40 (1.15-1.71)**
Work unit-based	14,934	531	**1.53 (1.29-1.82)**	**1.47 (1.23-1.76)**	**1.51 (1.26-1.81)**	**1.28 (1.07-1.53)**
Women						
Occupation-based	52,792	1,948	**1.67 (1.52-1.84)**	**1.64 (1.49-1.81)**	**1.63 (1.48-1.80)**	**1.17 (1.04-1.31)**
Work unit-based	48,453	1,802	**1.28 (1.19-1.39)**	**1.26 (1.17-1.37)**	**1.24 (1.14-1.35)**	1.07 (0.98-1.17)
Manual employees						
Occupation-based	14,069	959	**1.39 (1.19-1.62)**	**1.35 (1.16-1.58)**	**1.39 (1.18-1.62)**	
Work unit-based	12,742	865	**1.24 (1.10-1.40)**	**1.22 (1.07-1.38)**	**1.19 (1.04-1.35)**	

*Model 1 adjusted for age, sex (when appropriate) and type of job contract; Model 2 additionally adjusted for work-related covariates; Model 3 additionally adjusted for baseline health; Model 4 additionally adjusted for occupational status.

Table 9. Single and multiple work-related stressors, measured with self-reports and work unit aggregates, and the risk of all-cause disability pensioning.

Measurement Combination of stressors	Number of participants (cases)	Demographics adjusted* HR (95% CI)	Fully adjusted** HR (95% CI)
Self-reported	54,460 (4,220)		
None	29,367 (1,786)	1.00	1.00
Strain	5,060 (549)	**1.60 (1.45-1.76)**	**1.33 (1.21-1.46)**
ERI	4,243 (332)	**1.35 (1.20-1.52)**	**1.21 (1.07-1.36)**
Injustice	5,414 (365)	1.09 (0.98-1.22)	1.07 (0.95-1.20)
Strain + ERI	2,772 (341)	**1.94 (1.73-2.18)**	**1.52 (1.35-1.70)**
Strain + Injustice	2,402 (272)	**1.82 (1.60-2.06)**	**1.51 (1.33-1.72)**
ERI + Injustice	2,214 (189)	**1.40 (1.20-1.62)**	**1.22 (1.05-1.42)**
Strain + ERI + Injustice	2,988 (386)	**2.02 (1.81-2.25)**	**1.57 (1.41-1.76)**
Aggregated	51,279 (3,948)		
None	26,474 (1,778)	1.00	1.00
Strain	4,223 (435)	**1.37 (1.24-1.53)**	1.07 (0.96-1.19)
ERI	4,533 (358)	**1.17 (1.05-1.31)**	1.04 (0.92-1.16)
Injustice	5,075 (307)	0.93 (0.82-1.05)	0.96 (0.84-1.08)
Strain + ERI	3,223 (385)	**1.60 (1.44-1.79)**	**1.17 (1.05-1.31)**
Strain + Injustice	2,685 (187)	1.08 (0.93-1.26)	1.06 (0.91-1.24)
ERI + Injustice	2,379 (221)	**1.29 (1.12-1.48)**	1.04 (0.90-1.20)
Strain + ERI + Injustice	2,687 (277)	**1.50 (1.32-1.70)**	**1.24 (1.09-1.40)**

* Adjusted for socio-demographic factors (i.e. age, sex and location of the workplace). ** Additionally adjusted for socio-economic factors, baseline physical and mental illnesses and baseline health risk behaviours (i.e. occupational status, education, size of residence, baseline physical illnesses and mental disorder, smoking status, alcohol abuse, obesity, and leisure time physical inactivity).

The associations of work unit-based ERI with all-cause disability pension became statistically non-significant when fully adjusted, while the demographics adjusted models suggested an association between high work unit-based ERI and all-cause disability pension (Tables 9 and 10). However, high self-reported ERI showed a 1.1- to 1.3-fold increased risk of all-cause disability pension in the fully adjusted models, compared to low ERI.

This study showed no support for the independent association between organizational injustice and all-cause disability pension. The main analyses of the sub-study III suggested that self-reported organizational justice was associated with a decreased risk of disability pensioning (see Table 2 of the sub-study III). However, these associations became statistically non-significant after additional adjustment for job strain and ERI. Moreover, work unit-based organizational justice was not associated with all-cause disability pension in the sub-study III. Furthermore, no statistically significant associations were found between self-reported or work unit-based organizational injustice (exclusive of other stressors) and all-cause disability pension in the sub-study IV (Table 9).

5.2. DISABILITY PENSIONS DUE TO DEPRESSIVE DISORDERS

With regard to the most adjusted model available, self-reported job strain was consistently associated with disability pensions due to depressive disorders among all participants, men, women and all occupational groups (Table 11, and Table 4 of the sub-study I). The HRs for these associations varied from 1.3 to 1.7 across this study. However, with regard to aggregated measures, only high work unit-based job strain among men and higher non-manual employees was associated with an increased risk of disability pensions due to depressive disorders, while the remaining analyses showed no statistically significant associations (Tables 11 and 12).

In the fully adjusted model, the highest quartile of work unit-based ERI was associated with a 1.6-fold increased risk of disability pensioning due to depressive disorders, when compared to the lowest ERI (Table 10). The same figure for the work unit-based ERI (exclusive of the other stressors) was 1.3-fold, when compared to the non-exposed (Table 11). The highest quartile of self-reported ERI, compared to the lowest ERI, showed a HR of 1.9 for the association between ERI and disability pensions due to depressive disorders

Table 10. Work unit-based and self-reported effort-reward imbalance (ERI) and disability pensions due to any cause, depressive and musculoskeletal disorders. Hazard ratios (HR) and their 95% confidence intervals (95% CI) were derived from Cox proportional hazard models.

		Work-unit level ERI			Self-reported ERI			
Subgroup of ERI (quartile)	**N participants**	**N cases**	**HR (95%CI)***	**HR (95%CI)****	**N participants**	**N cases**	**HR (95%CI)***	**HR (95%CI)****
				All-cause disability pensions				
All	51,874	4,642			35,260	2,982		
1st (lowest)	12,971	983	1.00	1.00	9,681	718	1.00	1.00
2nd	12,959	1,052	1.07 (0.98-1.17)	1.02 (0.93-1.12)	6,975	497	0.96 (0.86-1.08)	0.99 (0.88-1.11)
3rd	12,970	1,200	**1.20 (1.11-1.31)**	1.02 (0.93-1.12)	10,217	852	**1.13 (1.02-1.25)**	**1.11 (1.01-1.23)**
4th (highest)	12,974	1,407	**1.42 (1.31-1.55)**	1.07 (0.97-1.18)	8,387	915	**1.51 (1.36-1.66)**	**1.33 (1.20-1.47)**
				Disability pensions due to depressive disorders				
All	51,874	890			35,260	551		
1st (lowest)	12,971	173	1.00	1.00	9,681	114	1.00	1.00

2nd	12,959	208	1.19 (0.98-1.46)	1.21 (0.98-1.49)	6,975	80	0.96 (0.72-1.27)	0.97 (0.73-1.29)
3rd	12,970	218	**1.23 (1.01-1.51)**	1.20 (0.97-1.49)	10,217	148	1.20 (0.94-1.54)	1.18 (0.92-1.51)
4th (highest)	12,974	291	**1.68 (1.39-2.03)**	**1.63 (1.31-2.04)**	8,387	209	**2.08 (1.65-2.61)**	**1.90 (1.51-2.40)**
				Disability pensions due to musculoskeletal disorders				
All	51,874	2,001			35,260	1,338		
1st (lowest)	12,971	404	1.00	1.00	9,681	314	1.00	1.00
2nd	12,959	436	1.07 (0.94-1.23)	0.99 (0.86-1.14)	6,975	235	1.04 (0.88-1.23)	1.10 (0.92-1.30)
3rd	12,970	520	**1.25 (1.10-1.42)**	0.98 (0.85-1.13)	10,217	384	1.15 (0.99-1.34)	**1.17 (1.01-1.37)**
4th (highest)	12,974	641	**1.55 (1.36-1.75)**	1.02 (0.88-1.19)	8,387	405	**1.49 (1.29-1.73)**	**1.32 (1.13-1.53)**

*__Model 1__ adjusted for demographics (*age, sex and location of the workplace)* ** **Fully adjusted:** additionally adjusted for socio-economic status (*occupational status, education and income*), work-related characteristics *(type of employer*, *type of work contract*, *size of the work unit, mean age of the employees in work unit, proportion of fixed term workers at the work unit and work unit-level job strain)* and baseline health.

Table 11. Single and multiple work-related stressors, measured with self-reports and work unit aggregates, and the risk of disability pensioning due to depressive disorders.

Measurement **Combination of stressors**	**Number of participants (cases)**	**Demographics adjusted*** **HR (95% CI)**	**Fully adjusted**** **HR (95% CI)**
Self-reported	54,460 (778)		
None	29,367 (307)	1.00	1.00
Strain	5,060 (89)	**1.46 (1.15-1.85)**	**1.35 (1.06-1.72)**
ERI	4,243 (58)	**1.34 (1.01-1.77)**	1.20 (0.90-1.59)
Injustice	5,414 (61)	1.06 (0.80-1.39)	0.97 (0.73-1.27)
Strain + ERI	2,772 (86)	**2.69 (2.11-3.42)**	**2.23 (1.74-2.84)**
Strain + Injustice	2,402 (45)	**1.66 (1.21-2.27)**	**1.45 (1.06-1.98)**
ERI + Injustice	2,214 (44)	**1.89 (1.38-2.60)**	**1.60 (1.17-2.20)**
Strain + ERI + Injustice	2,988 (88)	**2.56 (2.02-3.25)**	**2.07 (1.63-2.63)**
Aggregated	51,279 (728)		
None	26,474 (334)	1.00	1.00
Strain	4,223 (70)	1.15 (0.89-1.49)	1.09 (0.84-1.42)
ERI	4,533 (81)	**1.40 (1.09-1.78)**	**1.30 (1.02-1.66)**
Injustice	5,075 (57)	0.93 (0.70-1.23)	0.90 (0.67-1.19)
Strain + ERI	3,223 (64)	**1.38 (1.06-1.81)**	**1.32 (1.01-1.74)**
Strain + Injustice	2,685 (28)	0.82 (0.56-1.21)	0.87 (0.59-1.28)
ERI + Injustice	2,379 (36)	1.21 (0.85-1.71)	1.08 (0.76-1.53)
Strain + ERI + Injustice	2,687 (58)	**1.65 (1.25-2.18)**	**1.46 (1.10-1.93)**

* Adjusted for socio-demographic factors (i.e. age, sex and location of workplace). ** Additionally adjusted for socio-economic factors, baseline physical and mental illnesses and baseline health risk behaviours (i.e. occupational status, education, size of residence, baseline physical illnesses and mental disorder, smoking status, alcohol abuse, obesity, leisure time physical inactivity).

in the fully adjusted model. The same figure for the self-reported ERI (exclusive of the other stressors) was 1.2, but it was statistically non-significant in the fully adjusted model.

This study revealed that organizational injustice was not independently associated with disability pensions due to depressive disorders, although long-term self-reported organizational justice was associated with a decreased risk of disability pensioning due to depressive disorders among all participants, women, and particularly men in the sub-study III (see Table 3 of the original publication). However, after further adjustment for job strain and ERI, these associations became statistically non-significant. Moreover, the sub-study IV showed no association between organizational injustice and disability pension due to depressive disorders (Table 11).

5.3. DISABILITY PENSIONS DUE TO MUSCULOSKELETAL DISORDERS

This study showed a consistent association between aggregated job strain and disability pensions due to musculoskeletal disorders in the analyses adjusted for age, sex (if appropriate) and type of work contract or place of work unit among all participants, men, women and manual employees (Tables 12 and 13). These analyses showed a 1.3- to 2.4-fold increase in risk of disability pensioning due to musculoskeletal disorders depending on the measure (work unit-based or occupation-based) and the sub-group of participants (all, men, women, or manual employees). However, the association between work unit-based job strain (exclusive of the other stressors) and disability pension due to musculoskeletal disorders became statistically non-significant, when fully adjusted. Self-reported job strain was also consistently associated with disability pensions due to musculoskeletal diseases in all the analyses studied, regardless of the adjustment or the stratification (Table 4 of the sub-study I, and Table 13).

Work unit-based ERI was not associated with the disability pensions due to musculoskeletal disorders although the age, sex and location of the workplace adjusted analyses of the sub-study II suggested an association between these factors (Tables 10 and

13). However, that association became statistically non-significant when fully adjusted. Moreover, the sub-study IV showed no association between work unit-based ERI

(exclusive of the other stressors) and disability pensions due to musculoskeletal diseases. Nevertheless, self-reported ERI was consistently associated with disability pensions due to musculoskeletal diseases in both sub-studies, showing fully adjusted HRs from 1.2 to 1.3.

This study showed no association between organizational injustice and disability pensions due to musculoskeletal disorders as the few statistically significant associations found in the Study III became statistically non-significant after further adjustment for job strain and ERI (Table 4 of the sub-study III and Table 13).

5.4. DISABILITY PENSIONS DUE TO ISCHEMIC HEART DISEASES

This study showed no association between work-related stress and disability pension due to ischemic heart diseases. An association between occupation- and work unit-based job strain and disability pension due to ischemic heart diseases was found among men (Table 12). However, this finding was not repeated using self-reported job strain (see Table 4 of the sub-study I). In addition, no association between work unit-based or self-reported ERI and disability pensions due to ischemic heart diseases was found (Tables 3 and 4 of the sub-study II).

5.5. MULTIPLE WORK-RELATED STRESSORS AND DISABILITY PENSIONS

With regard to work unit-based measures, all the combinations of multiple work-related stressors, except for that of job strain and organizational injustice, were associated with all-cause disability pension when adjusted for age, sex and location of the workplace (Table 9). However, only the associations between work unit-based job strain+ERI and all three work-related stressors combined (measured with work unit-based aggregates) remained statistically significant when fully adjusted. The HR for both of these associations was 1.2. Moreover, all the combinations of multiple work-related stressors (measured with self-reports) were associated with all-cause disability pensions in

Table 12. Aggregated job strain, based on mean scores of occupations and work-units, and cause-specific disability pensions, stratified by sex and occupational status.

		Depressive disorders		Musculoskeletal disorders		Ischemic heart diseases	
Job strain	**N of partici-pants**	**N of cases**	**HR (95% CI)***	**N of cases**	**HR (95% CI)***	**N of cases**	**HR (95% CI)***
Sex							
Men							
Occupation-based	16,173	86	1.30 (0.78-2.16)	224	**2.41 (1.81-3.21)**	32	**2.37 (1.10-5.10)**
Work unit-based	14,793	81	**1.59 (1.03-2.47)**	198	**1.66 (1.26-2.20)**	27	**2.14 (1.01-4.50)**
Women							
Occupation-based	51,780	407	1.24 (1.00-1.53)	796	**2.21 (1.91-2.57)**	21	0.98 (0.39-2.47)
Work unit-based	48,012	380	1.15 (0.97-1.37)	721	**1.48 (1.31-1.67)**	21	1.18 (0.57-2.45)
Occupational status							
Higher non-manual							
Occupation-based	20,609	123	1.67 (0.92-3.05)	84	**2.12 (1.03-4.35)**	6	3.72 (0.26-53.4)
Work unit-based	19,237	116	**1.56 (1.09-2.21)**	77	1.25 (0.81-1.94)	5	1.38 (0.23-8.29)
Lower non-manual							
Occupation-based	33,297	245	1.12 (0.83-1.51)	445	1.10 (0.88-1.37)	15	1.14 (0.34-3.83)
Work unit-based	30,822	229	1.00 (0.80-1.26)	409	1.05 (0.89-1.25)	15	1.74 (0.69-4.38)
Manual							
Occupation-based	14,047	125	1.18 (0.76-1.81)	491	**1.38 (1.11-1.71)**	32	0.75 (0.34-1.68)
Work unit-based	12,726	116	1.29 (0.93-1.79)	433	**1.28 (1.08-1.52)**	28	0.99 (0.49-2.00)

*Hazard ratios (95% confidence interval) are adjusted for age, sex (when appropriate) and type of job contract.

Table 13. Single and multiple work-related stressors, measured by self-reports and work unit aggregates, and risk of disability pensioning due to musculoskeletal disorders.

Measurement **Combination of stressors**	**Number of participants (cases)**	**Demographics adjusted***	**Fully adjusted****
		HR (95% CI)	**HR (95% CI)**
Self-reported	54,460 (1,926)		
None	29,367 (804)	1.00	1.00
Strain	5,060 (265)	**1.62 (1.40-1.86)**	**1.22 (1.06-1.40)**
ERI	4,243 (151)	**1.36 (1.14-1.61)**	**1.20 (1.01-1.43)**
Injustice	5,414 (160)	1.07 (0.91-1.27)	1.11 (0.93-1.31)
Strain + ERI	2,772 (155)	**1.85 (1.56-2.20)**	**1.35 (1.13-1.60)**
Strain + Injustice	2,402 (137)	**1.97 (1.65-2.37)**	**1.59 (1.32-1.91)**
ERI + Injustice	2,214 (76)	1.24 (0.98-1.57)	1.12 (0.88-1.41)
Strain + ERI + Injustice	2,988 (178)	**1.98 (1.69-2.33)**	**1.51 (1.28-1.77)**
Aggregated	51,279 (1,793)		
None	26,474 (783)	1.00	1.00
Strain	4,223 (203)	**1.38 (1.18-1.61)**	0.94 (0.81-1.11)
ERI	4,533 (159)	1.19 (1.00-1.41)	1.02 (0.86-1.21)
Injustice	5,075 (127)	0.88 (0.73-1.06)	0.97 (0.80-1.17)
Strain +ERI	3,223 (202)	**1.82 (1.56-2.13)**	1.15 (0.98-1.35)
Strain +Injustice	2,685 (93)	1.22 (0.98-1.51)	1.12 (0.90-1.39)
ERI + Injustice	2,379 (102)	**1.37 (1.12-1.69)**	1.06 (0.86-1.31)
Strain +ERI +Injustice	2,687 (124)	**1.49 (1.24-1.81)**	1.15 (0.95-1.40)

* adjusted for socio-demographic factors (i.e. age, sex and location of the workplace).
**additionally adjusted for socio-economic factors, baseline physical and mental illnesses and baseline health risk behaviours (i.e. occupational status, education, size of residence, baseline physical illnesses and mental disorders, smoking status, alcohol abuse, obesity, leisure time physical inactivity).

the fully adjusted models. The HRs for these associations varied from 1.2 (ERI+injustice) to 1.6 (all three work-related stressors combined). Both the combination of job strain+ERI and job strain+injustice (based on self-reports) showed HRs of 1.5 for their association with all-cause disability pensions, when compared to the non-exposed and fully adjusted.

This study showed a consistent association between the combination of job strain and ERI, with or without organizational injustice, and disability pensions due to depressive disorders (Table 11). The increase in risk was 1.4- to 2.7-fold (depending on the measure) in the analyses adjusted for age, sex and location of the workplace. With regard to both self-reported and work unit-based measures, these associations also remained statistically significant when fully adjusted. The HRs for the fully adjusted models varied from1.3 to 2.2.

This study suggests an association between the combinations of job strain+ERI, job strain+ERI+injustice as well as ERI+injustice and disability pensions due to musculoskeletal diseases (Table 13). When using self-reports of the exposure, these combinations showed a 1.4- to 1.6-fold increased risk of disability pensioning due to musculoskeletal diseases, in the fully adjusted models and compared to the non-exposed. Moreover, analyses using work unit-based measures of the exposure showed a 1.4- to 1.8-fold increase in the risk of disability pensioning due to musculoskeletal diseases among those exposed to the combinations of work unit-based job strain+ERI, job strain+ERI+injustice, or ERI+injustice, compared to the non-exposed and adjusted for age, sex and location of the workplace. However, the analyses using aggregated measures became statistically non-significant when fully adjusted.

6. DISCUSSION

6.1. MAIN RESULTS

This study showed that high work-related stress, measured with job strain and effort-reward imbalance (ERI), was associated with an increased risk of disability pensioning. The association was found between work-related stress and all-cause disability pensions, as well as diagnosis-specific disability pensions due to depressive and musculoskeletal disorders (i.e. the two most common disease groups behind disability pensions). The increase in risk varied from 1.1-fold to 2.7-fold, depending on the measure of the exposure, the level of the adjustment and the disease group behind the disability pension. Although

previous studies have linked job strain and ERI with ischemic heart diseases, no association was found between either of these work-related stressors and work disability due to ischemic heart diseases in this study. Moreover, this study revealed that organizational injustice, another major work-related stressor, was not independently associated with disability pensioning.

This was, as far as I am aware, the first prospective study on the associations of all three major work-related stressors, alone and in combinations, with disability pensioning. The main associations found in this study remained robust after controlling for numerous confounders, such as age, occupational status and education, baseline physical and mental health, and health risk behavior. The strength of this study was the use of both self-reports and aggregated measures of the exposure. This was done to minimize the possibility of reverse causality and subjectivity bias. Reverse causality occurs if the illness/work disability behind the disability pension was linked to reporting of high work-related stress (and not vice versa). The tendency to perceive negative emotions (i.e. negativity) may be linked to both employee ill health (and tendency to seek a disability pension) and reporting high work-related stress, which may produce subjectivity bias.

6.2. RESULTS OF THE STUDY AND COMPARISON TO PREVIOUS RESEARCH

6.2.1. Job strain

No previous study has examined job strain and disability pension uptake due to any cause, depressive and musculoskeletal disorders using both self-reports and aggregated measures (i.e. occupation-based and work unit-based means scores) of job strain. This study revealed that high job strain was associated with an increased risk of all-cause disability pension uptake, and disability pensions due to musculoskeletal disorders particularly. The association between high job strain and disability pensions due to depressive disorders was less evident, as it was based on self-reported job strain only. Thus, the association between job strain and disability pensions due to depression needs to be studied further. Most of the previous studies on this subject have focused on studying job demands or job control separately rather than the combination (i.e. job strain) of these two (Knardahl et al. 2017). However, the few available studies are in line with this study, and suggest an association between job strain and all-cause disability pension (Stattin et al. 2005b, Laine et al. 2009, Ahola et al. 2011, Canivet et al. 2013, Knardahl et al. 2017).

Two previous studies have linked low job control with an increased risk of disability pension uptake due to musculoskeletal diseases, and an additional study linked low decision authority with disability pensions due to back pain. These studies showed HRs that varied from 1.1 to 1.5. (Hagen et al. 2006, Lahelma et al. 2012, Ropponen et al. 2013). The study by Ropponen et al. (2013) found no support for the association between high job strain and disability pensions due to musculoskeletal disorders (HR 0.93, 95% CI 0.73–1.19). Their study, however, suggested an association between passive jobs (HR 1.25, 95% CI 1.07–1.46) or the combination of high job strain and low social support (HR 1.27, 95% CI 1.04–1.57) and disability pensions due to musculoskeletal disorders (Ropponen et al. 2013). The explanation for the differences between this study and the study by Ropponen et al. (2013) may be the unimportance of high demands in relation to disability pensions due to musculoskeletal diseases: a passive job is a combination of low demands and low control, while high strain is a combination of high demands and low control. In fact, previous studies have associated low control with the risk of all-cause disability pensioning, while the evidence does not show support for the association of high demands and all-cause disability pensions (Knardahl et al. 2017). Moreover, the exposure in Ropponen et al.'s (2013) study was an aggregated measure based on a historical job exposure matrix, which may have led to some misclassification and/or dilution of the associations under investigation. However, the exposure in this study was cohort-specific as well as work unit-specific, and based on survey responses at the study baseline.

There are few previous studies on the association between job strain and disability pensions due to mental causes. Studies by Lahelma et al. (2012) and Samuelsson et al. (2013) found an association between low job control and disability pension due to mental causes. These studies reported that low control, when compared to high control, was associated with a 1.1-fold (Samuelsson et al. 2013) and 1.7-fold (Lahelma et al. 2012) increase in the risk of disability pension uptake due to mental causes. However, in line with the present study, the study by Samuelsson et al. (2013) found no association between high aggregated job strain and disability pensions due to mental causes (HR 0.96, 95% CI 0.75–1.22). Thus, the possibility of a link between job strain and disability pension due to depressive disorders needs to be confirmed in future studies.

6.2.2. Effort-reward imbalance and organizational injustice

This was the first study on the association of ERI and register-based all-cause and diagnosis-specific disability pensions. This study suggests a consistent (i.e. regardless of the measure of the exposure or model of adjustment) association between high ERI and disability pension uptake due to depressive disorders. High ERI was associated with a 1.3-

to 1.9-fold increase in risk of disability pensioning due to depressive disorders, when compared to low ERI or the non-exposed and adjusted for age, sex, socio-economic status, location of the workplace, baseline health and health risk behavior. High self-reported ERI was also associated with an increased risk of disability pension uptake due to any cause or musculoskeletal disorders, but this association was not repeated with the aggregated measures when fully adjusted. This is probably explained by both the subjectivity bias inherent in self-reported exposure and the tendency of aggregated measures to dilute the associations under study (Kolstad 2011). Thus, this study also suggests a possible association between ERI and all-cause disability pensions and disability pensions due to musculoskeletal diseases, but this remains to be confirmed in future studies. Equally, at least one previous study suggests an association between ERI and early exit from work due to disablement (van den Berg et al. 2010), while another found no support for such association (Robroek et al. 2017).

This study found no support for the independent (from job strain and ERI) association of organizational justice with disability pensions. However, organizational justice wasn't totally redundant in relation to job strain and ERI: when combined with self-reported job strain, self-reported organizational injustice was associated with increased risk of disability pension uptake due to musculoskeletal disorders. This risk was higher than the risk associated with job strain alone. Furthermore, with regard to disability pensioning due to depression, the combination of self-reported ERI and organizational injustice was associated with higher risk than self-reported ERI alone. These results suggest that organizational justice is a minor contributor to the risk of disability pensioning. To the best of my knowledge, no study has examined the associations of organizational injustice with disability pension before. However, fair leadership has been associated with decreased risk of disability pension uptake, while quality of leadership showed no association with the same risk (Clausen et al. 2014, Emberland et al. 2017). Consequently, in the light of available evidence, there is a lack of support for the association of organizational fairness with disability pensioning.

6.2.3. Multiple work-related stressors

This study suggests that the combination of high job strain and ERI is especially hazardous to employees' health and work ability, as this combination was associated with roughly a two-fold increase in the risk of disability pension uptake due to any cause and to musculoskeletal disorders, and over a two-fold increase in the risk of disability pensioning due to depressive disorders, when compared to non-exposed and adjusted for demographics. This means that the most hazardous combination of work-related stress, in

relation to disability pensions, is a stressful situation characterized by factors such as a large amount of work with frequent time pressures combined with very few possibilities to influence how to do one's job, no need for learning or using skills, in addition to low rewards in terms of salary, recognition and personal satisfaction.

This was, most likely, the first study to examine multiple work-related stressors in relation to disability pensioning. However, there are some studies that have examined multiple work-related stressors in relation to employee health. These previous studies have shown inconsistent evidence on the associations of multiple work-related stressors and employee health: some studies suggest that exposure to the combination of at least two different stressors is linked to higher risk of ill-health than exposure to single stressors (de Jonge et al. 2000, Ota et al. 2005, Kivimäki et al. 2007b, Trudel et al. 2013, Herr et al. 2015, Dragano et al. 2017), while other studies suggest that exposure to single or multiple stressors is linked to an equal (or almost equal) sized risk of ill-health (Calnan et al. 2004, Rydstedt et al. 2007, Dragano et al. 2008). These previous studies have addressed both mental illnesses (Ota et al. 2005, Kivimäki et al. 2007b, Rydstedt et al. 2007, Dragano et al. 2008) and musculoskeletal diseases (Herr et al. 2015). This dissertation suggests that the associations of the combination of job strain and ERI with disability pensioning were additive, as the combination of job strain and ERI led to higher risk of disability pension uptake than either of these stressors alone. In light of these results, it may be hypothesized that the previous studies, which have addressed only single stressors, may have shown underestimated HRs for the associations of work-related stress and disability pensioning. This dissertation suggests that this limitation may apply particularly in the case of disability pensions due to depressive disorders.

6.2.4. Work stress and disability pension due to ischemic heart diseases

No association between work-related stress and disability pension due to ischemic heart diseases was found in this study, even though work-related stress, and high job strain in particular, has been associated with ischemic heart diseases in earlier studies (Kivimäki et al. 2012, Pejtersen et al. 2015, Xu et al. 2015). This is probably explained by the fact that high job strain adds to the risk of ischemic heart diseases by approximately 20% (Kivimäki et al. 2012, Pejtersen et al. 2015, Xu et al. 2015). Thus, the contribution of job strain on ischemic heart diseases is minor when compared to the traditional risk factors (Kivimäki et al. 2012). Moreover, the prevalence of ischemic heart diseases is low among the working-aged or those under 60 years (Koskenvuo 2003). Current treatment (e.g. medication and percutaneous coronary intervention) for ischemic heart diseases has improved the prognosis for this illness. Thus, work disability due to ischemic heart diseases is

uncommon nowadays (Koskenvuo 2003). In fact, only 0.08% (32 men and 21 women) of all the participants in the sub-study I ended up on a disability pension due to ischemic heart diseases. The same figure in the sub-study II was 0.2% (87 participants). Furthermore, a recent study showed that 80% of the employees that had gone through coronary artery bypass grafting had returned to work one year after the procedure, while 4% were on paid sick leave and another 4% had been granted a disability pension (Butt et al. 2017).

6.2.5. Additional remarks based on the results of the study

6.2.5.1. Differences in work-related stressors in relation to disability pensioning

Besides attempting to address the gaps in previous research evidence and answering its own study questions, this study provided some additional observations on the associations between work-related stress and disability pension. An important contribution of this study is the detailed knowledge on the associations of three work-related stressors, alone and in combinations, on disability pensioning. As previous research on work-related stress and disability pensioning have focused on the associations of job strain and its components, the possible differences between work-related stressors in relation to disability pensions remained, before this study, unknown.

This study suggests that job strain and ERI are equally important in relation to all-cause disability pension. These work-related stressors individually contribute to work disability and are complementary to each other. However, the results imply that ERI is more important in relation to work disability due to depressive disorders, while job strain might be more important in relation to work disability due to musculoskeletal disorders. In other words, these results suggest that poor income, prestige, recognition and personal satisfaction (i.e. low rewards) in relation to high work effort are linked with increased risk of work disability due to depressive disorders. It is also possible that low rewards at work (together with high effort) may induce or sustain depression-related symptoms such as low self-esteem, lack of enjoyment, hopelessness and sadness. Depression may also decrease the motivation to expend effort at work, and thus decrease the likelihood of a return to work. On the other hand, low decision authority, which is a sub-dimension of job control, might even make a return to work after a depression-based sickness absence easier, as decision making is usually impaired when suffering from depression.

This study suggests that job strain, rather than ERI, might be more important in relation to work disability due to musculoskeletal disorders. The assumption that, in relation to high effort, high job control (i.e. an employee's opportunity to decide how to perform his/her job tasks and to use various skills while doing them), rather than high rewards, might be more important regarding work disability due to musculoskeletal disorders is plausible: high job control enables an employee to remold (e.g. by rotating job tasks) his/her job to meet the declined work ability. However, a previous study that has addressed both job strain and ERI in relation to musculoskeletal pain does not support this assumption, as it showed that particularly ERI predicted musculoskeletal pain (Herr et al. 2015). The explanation to the inconsistency between this study and the study by Herr et al. might be the fact that Herr et al.'s (2015) analyses were adjusted for physical workload, while the analyses in this study were not. The first statement in the JCQ ("I have to work very hard") might act as a proxy for physical workload, in addition to measuring psychological strains with the remaining statements (i.e. excessive amount of work, and insufficient time to have work done). The ERI-questionnaire, in turn, asks if work demands have increased, whether there are possible time pressures in relation to workload, and whether there are interruptions at work. Thus, job strain may be more prone to adjustment for physical workload. On the other hand, this study also showed some support for the association of ERI and disability pensions due to musculoskeletal diseases.

Finally, the results of this study gave some support to the previous assumption that organizational injustice might belong to a higher hierarchical level than job strain and ERI (Kivimäki et al. 2007b). It has been hypothesized that the effects of organizational injustice on employee health might be mediated through job strain and ERI. In other words, unfair management, in terms of unequal decision making processes or the poor quality of the employee-supervisor relationship, may lead to a mismatch between work effort, control and/or reward. However, more studies are required to understand the possible differences in job strain, ERI and organizational injustice in relation to employee ill-health and work disability.

6.2.5.2. Aggregated measures

Using group aggregated scores to assess exposure to workplace psychosocial factors, such as work-related stress, has been suggested as a method to control subjectivity bias and reverse causality (Kasl 1998, Bonde 2008, Kolstad et al. 2011). In addition to minimizing the effects of reverse causality and subjectivity bias, aggregated measures take into account the fact that work units are social networks that have their own culture (Ahola et al. 2006).

This organizational culture may affect the opinion and behavior of the employees within it (Elovainio et al. 2004, Ahola et al. 2006). For example, employees within the same work unit may share similar opinion towards the amount of work or possibilities to develop one's skills while working, in addition to shared opinions towards disability pensioning. On the other hand, using aggregated measures usually tends to dilute the individually perceived exposure, and thus distorts the results towards null (Kolstad 2011). In other words, self-reported exposure better captures the true variance between individuals within the group of aggregation. In addition, this study revealed that the HRs based on the analyses using work unit aggregates were generally smaller than the HRs of the analyses using self-reports. However, the results based on either of these two measures were consistent and pointed in the same direction. To conclude, this study suggests that using both measures, instead of only self-reports or aggregates, is recommended.

The intraclass correlation of work unit-based job strain and organizational injustice in this study was 18% and 20%, respectively. This indicates that job strain and organizational injustice varied greatly between the work units, and in addition to individual-level variance. However, the intraclass correlation of the work unit-based ERI was only 5%. This indicates only moderate variance between work units, suggesting that the major variance in ERI was at the individual level. This might suggest that work unit aggregates might capture the task-level demands and control better than the socio-economically wider concept of effort and reward. Moreover, high intraclass correlation of organizational injustice was expected, as organizational justice is thought to represent organization-specific procedures for decision making.

Although previous studies on the association of work-related stressors and disability pensions have generally used self-reports of the exposure (Knardahl et al. 2017), most studies on the association of job strain and disability pensioning were based on aggregated scores of the exposure: Laine et al. (2009) used both work unit-based and self-reported job strain, while the studies by Ropponen et al. (2013) and Samuelsson et al. (2013) utilized a job exposure matrix to assess job strain and its components. However, the studies by Ropponen et al. (2013) and Samuelsson et al. (2013) did not provide results based on self-reports, which may have diluted the associations under investigation towards null, as discussed above. Moreover, exposures in both studies were based on historical surveys (conducted between 1989 and 1997) on job strain, and did not include cohort-specific or time-specific measures (Ropponen et al. 2013, Samuelsson et al. 2013). Nevertheless, in line with this study, previous studies encourage the use of aggregated measures when studying work-related stress and disability pensions.

6.3. LIMITATIONS OF THIS STUDY

This study has several limitations concerning the measurement of work-related stress. First, short versions of the original questionnaires were used to measure job strain and ERI. Hence, it is possible that these stressors were not estimated completely correctly. However, a previous study by Fransson et al. (2012b) suggests good validity for the short measure of job strain. Moreover, in the present study, the short ERI measure was shown to correlate with the original 10-item measure. Accordingly, the validity of the ERI, based on the short measure, was proved by Siegrist et al. (2009). Thus, the proxy measures of job strain and ERI are unlikely to cause major bias in the present study.

Second, all studies on work-related stress are limited in the use of the study specific means/thirds/quartiles to separate high work-related stress from low stress/non-exposed, as no threshold value for high work-related stress exists (Kivimäki et al. 2013). Thus, it is possible that participants in this study might be misclassified as exposed or non-exposed. However, in the previous studies, median cut point or dividing into thirds have commonly been used to separate the high stress group(s) from the low stress group(s) (Kivimäki et al. 2013, Fransson et al. 2012b). Thus, it is unlikely that, compared to previous studies, participants in the present study were excessively misclassified as exposed due to fact that the highest quartiles were chosen to indicate exposure to work-related stress (or continuous variables were used). In fact, in light of the previous studies that have used a median cut point, it is actually possible that I have misclassified some participants as non-exposed. This kind of misclassification might weaken, rather than exaggerate, the associations found in this study. However, this assumption must be taken with caution as scores of work-related stressors have so far been study-specific.

Third, the original concept of job strain categorizes jobs into four groups: low strain, passive, active and high strain jobs. However, in the sub-study IV, only high strain was included. Moreover, the subtraction model was used in the sub-study I, resulting in a continuous variable. Although the subtraction model has been shown to be a good means of forming a job strain score (Courvoisier et al. 2010), it does not repeat the original concept of four job strain categories.

Fourth, extended models of job strain and ERI (i.e. models including social support and over-commitment) were not used, which may also be counted as a limitation of this study. Last, except for the sub-study III, work-related stress was only measured once. This may have led to misclassification as survey responses may be based on momentary, rather than predominant, perceptions of the prevailing work environment. These momentary responses

may, or may not, differ from the constant work environment. Moreover, health consequences (and effects on work ability) of the work-related stress are likely evoked by long-term, rather than momentary, stress. Thus, using single-point measures may have led to measurement error. However, a previous study suggests that this kind of error might underestimate (rather than exaggerate) the associations found (Kivimäki et al. 2006b).

Further limitations of this study include the fact that almost 80% of the study population was women. Hence, the results of the sub-studies that were not stratified by sex (Studies II and IV) may not be generalized to men. Furthermore, the study population only included employees from the public sector in Finland. Thus, these results might not be generalized to the private sector in Finland and/or to countries other than Finland. Moreover, it is possible that residual confounding, such as self-rated health and sleep problems, may have affected the results of this study. However, major bias due to residual confounding is unlikely as the most important confounders (i.e. age, health status, health risk factors and socio-economic position) were included in this study (Airaksinen J. et al. 2017). Previous studies have shown that physical workload is a risk factor for disability pensioning (Hagen et al. 2002, Karpansalo et al. 2002, Lahelma et al. 2012, Kjellberg et al. 2016). This risk has shown to be independent from psychosocial factors at work, and it has been linked especially to disability pensions due to any cause and musculoskeletal disorders (Lahelma et al. 2012, Kjellberg et al. 2016). Thus, one limitation of this study was the fact that the analyses were not adjusted for physical workload. However, all the analyses of this study were adjusted for occupational status, and because manual jobs typically include physically demanding tasks, occupational status correlates with physical workload and acts as a proxy for it.

The response rate in this study was reasonable: 68% in 2000–02 and 66% in 2004. The non-respondents were included in the sub-studies I and II. Thus, the influence of the non-response bias was minimized in these sub-studies. Nevertheless, it is still possible that the non-response bias has exaggerated the results of this study, and the sub-studies III and IV in particular, if those perceiving work-related stress were more likely to respond than those who did not perceive work-related stress. This is unlikely though, as in the sub-study I, the sensitivity analyses among the non-respondents were in line with the main analyses run among both the respondents and the non-respondents. Moreover, no differences were detected between the respondents and the non-respondents in relation to mean age (43.1 vs. 43.8 years), sex (76% vs. 80% women) and socio-economic status (20% vs. 18% manual workers) in the present study. Furthermore, a previous study suggests that those with lower job strain are more likely survey respondents than those with higher strain (Cifuentes et al. 2008). Consequently, if anything, the non-response has diluted rather than exaggerated these results.

6.4. STRENGHTS OF THIS STUDY

The obvious strengths of this study include the use of both self-reports and work unit-based aggregates to measure work-related stress. Importantly, this study also exploited other strategies to control possible biases inherent in observational studies. Such strategies included using prospective study design and controlling for multiple confounders. Moreover, sensitivity analyses among initially healthy participants (sub-studies III and IV), or among participants without long sickness absence spells (the sub-study III), were run to further control reverse causality. Thus, reverse causality and subjectivity bias are unlikely to explain the results of this study. The results of this study can be generalized to municipal workers in Finland, as the FPS-study cohort covers almost 30% of this employee group. Moreover, the study cohort covers most of the biggest cities in Finland, and the smaller neighboring towns of Tampere and Turku. However, the employees from the northernmost and eastern towns of Finland remain unstudied.

Other strengths of this study include the large cohort size and minimal loss of follow-up: follow-up was not possible for less than 1% of the participants (who had moved abroad). Moreover, the mean follow-up time was long, varying from 4.6 to 8.9 years. The follow-up time is conceivably appropriate, as a previous study found that the major trend among those who ended up on a disability pension was an increasing rate of sickness absence days beginning five to six years before the year of retirement (Laaksonen et al. 2016). In addition, the use of multiple work-related stressors may be counted as strength of this study as employees in real life are more likely to be exposed to multiple work-related stressors than single stressors.

Lastly, the personal information and identity of each individual participant in this study was protected as personal identification codes were only used to connect a participant with the relevant register-based data, and these codes were removed from the data used in the analyses. Moreover, the data used in this study did not include any information other than that needed for the analyses.

6.5. PRACTICAL RELEVANCE

This study showed an increased risk of work disability among those participants who were exposed to high job strain and/or ERI. The increase in risk was detected especially in

relation to disability pensioning due to mental and musculoskeletal disorders, which are the two main causes for disability pensions worldwide (OECD 2003, OECD 2010, The Finnish Centre for Pensions et al. 2016). Disability pensions are extremely costly for societies due to lost years spent economically active. Work disability due to mental disorders is especially noxious as it typically causes early exit from the labor force among those of a younger age (OECD 2003, OECD 2010). Disability pensioning is also expensive for the employers: the full-time disability pension for a median waged public sector employee aged 60 years would cost about 105,000 Euros for his/her employer(s) during the three consecutive years after retirement (Kuntatyönantajat 2017, Eläketurvakeskus 2017, Keva 2017). Most importantly, disability pensioning also places the concerned employee at risk of financial losses, as disability compensation is always smaller than the regular wage. Thus, it is important to aim preventive actions towards disability pensions not only in order to improve the work ability and health of employees, but also the financial situation of the employees, employers and the governments.

This study suggests that balancing the mismatch between employees' job control and reward in relation to their job contribution is beneficial when targeting avoidance of disability pensions. As working life nowadays is often characterized by time pressures and an excessive amount of work (Eurofound et al. 2014), it is important to improve aspects such as employees' freedom to decide how to perform their jobs (i.e. aim to high decision authority), providing job tasks that enable learning as well as using and developing various skills (i.e. high skill discretion). Moreover, receiving the recognition and prestige justified by one's work contributions, as well as decent and adequate income and job benefits, is a way to balance the significant requirements of working life. Some previous review studies have examined whether the interventions aimed to change (improve or worsen) psychosocial work environments have an effect on employees' perceptions of the work environment, or if these interventions affect employees' health (Egan et al. 2007, Bambra et al. 2007, Joyce et al. 2010). Although the results of these review studies were inconsistent, they provide some support for the beneficial effects of workplace interventions. Moreover, a recent study suggests that stress management interventions aimed to reduce ERI were associated with lower anxiety and depression (Barreh et al. 2017). Finally, another recent study showed that autonomy at work and mastery are factors that might prevent early retirement among those of older age and with chronic diseases, while these factors were not relevant among healthy employees (Sewdas et al. 2017).

In order to restore impaired work ability, it is important to provide adequate, timely, and sufficient treatment and rehabilitation for the illness(es) contributing to the work disability. For example, previous studies have shown that disability pension applicants are generally under-treated in terms of psychotherapy (Overland et al. 2007, Apfel et al. 2008). A previous review suggests that combining traditional treatment for an illness with cognitive

therapy is beneficial in order to reduce work disability and absenteeism. The same study suggests that the combination of clinical treatment with work-directed interventions may be useful in order to restore work ability. (Nieuwenhuijsen et al. 2014). These work-directed interventions include attempts to change the work to match the impaired functional capacities of the employee (i.e. provide facilitated or fixed job tasks or vocational rehabilitation) (van Oostrom et al. 2009, van Vilsteren et al. 2015). Another recent review study suggested, based on moderate quality evidence, some support for workplace interventions (i.e. interventions aimed to improve, for example, employees' health risk behavior, work routines or work hours) in relation to improved work ability (Oakman 2017). Moreover, increasing the skills and competence of an employee may increase perceived job control. Additionally, increased skills and competence may decrease job-related strains (caused by inexperience) or enable more suitable job tasks in relation to one's physical or mental health and performance. It is possible that adequate economic compensation, job benefits and work-related recognition not only balance the ratio in relation to requirements of the work, but also affect employees' work-related attitudes and motivation, which are also suggested to contribute to work ability (Ilmarinen et al. 2003, Ilmarinen 2006). Considering the remarkable costs of disability pensioning, the actions listed here are worth financial charge.

Work disability associated with high work-related stress might be avoided by reducing work stress or by formulating the job requirements to meet the decreased work ability of an employee. Moreover, the effects of work-related stress on employee health may also be handled by increasing employees' tolerance to work-related stress (Li et al. 2017). This may be done, for example, by teaching new coping strategies or by trying to affect individual characteristics, such as self-esteem and tendency to ruminate (e.g. via cognitive therapy) (Koskenvuo 2003, Geurts et al. 2006). Moreover, adequate recovery is also important to overcome work-related stress and to increase tolerance to stress. Recovery within a work-day is referred to as internal recovery, while recovery outside work is referred as external recovery. Examples of internal recovery include taking a coffee break or undertaking less demanding job tasks, while external recovery includes empowering activities (such as physical exercise, social life, and cultural activities) one performs on free-time, holidays or days off. (Geurts et al. 2006). It is possible that high control and/or low demands enable internal recovery better than high strain jobs.

To conclude, increasing decision authority and enabling the use of various skills (i.e. increasing job control) as well as providing work-related recognition, job security and job benefits (i.e. high rewards) may be beneficial when targeting prevention of disability pensions. Moreover, reconstructive interventions aimed at work-related time pressures, need for intensive work and frequent interruptions while working might be beneficial. Furthermore, providing adequate treatment of the illnesses behind work disability

simultaneously with workplace interventions is important. Finally, providing psychotherapy aimed at increasing tolerance towards work-related stress and/or treatment of the illness behind work disability may be also needed.

6.6. SUGGESTIONS FOR FUTURE STUDIES

This study focused on three major work-related stressors and provided new and detailed information on their contribution to disability pensioning. The study examined both single stressors and different combinations of them, and suggested additive associations between the combinations of work-related stressors and disability pensions. Similarly, future studies should, instead of single stressors, study the associations of the combinations of stressors on employee health and work ability. Although this study included three major stress models, it covered only a small part of the psychosocial work environment, which is a vast and complex concept including beneficial and hazardous psychosocial factors such as workplace bullying, harassment, social support from colleagues and supervisors, and social capital. Thus, future studies should focus on other workplace psychosocial factors than those included in the present study. This is important in order to reveal the factors that account most for the employees' work disability, and to be able to aim preventive interventions to relevant psychosocial factors at work. Future studies should also examine the possible differences of various work-related stressors in relation to diagnosis-specific disability pensioning. Detailed information on the associations of work-related stress and diagnosis-specific work disability would help those specialized in occupational health care to create, in liaison with the employers, specific tools to improve the work ability of the employees.

Lastly, the results of this study should be verified by future studies conducted among private sector employees in Finland, and private and public sector employees in countries other than Finland. In particular, studies outside the Nordic countries are needed, since the majority of studies on work-related stress, and other psychosocial workplace factors, have been done among residents of the Nordic countries (Knardahl et al. 2017). This study suggested that job strain might be more relevant in relation to disability pensioning due to musculoskeletal diseases while ERI, in turn, might be more relevant in relation to depressive disorders-based disability pensioning. This should be verified or rebutted by future studies.

7. SUMMARY AND CONCLUSIONS

This study provided a great deal of important additional knowledge about the association of work-related stress with disability pensions. Only few previous studies on work-related stress in relation to disability pensions exist, and there is lack of studies on work-related stress and diagnosis-specific disability pensioning. This study was the first to examine effort-reward imbalance, organizational injustice or multiple work-related stressors in relation to register-based disability pensioning. Furthermore, this study aimed to fulfill the methodological gap (i.e. possibility of reverse causality and subjectivity bias) inherent in some of the previous studies addressing the associations of job strain and ERI with disability pensioning.

This study revealed that work-related stress, in terms of job strain and ERI, is associated with disability pensioning. The simultaneous effect of these two was additive. Regarding work disability, the most hazardous situation is demanding work with frequent time pressures in combination with low decision authority, no need for learning or creativity, low variation of work tasks, and low rewards in terms of salary, recognition and personal satisfaction. Employees exposed to this kind of work environment have approximately a 1.5-fold increased risk of ending up on a disability pension due to any cause, depressive or musculoskeletal disorders compared to those without work-related stress. This finding is reliable as it is not explained by subjectivity bias or reverse causality. Moreover, this study suggested that, to restore the work ability of an employee with a mental disorder, it might be beneficial to perform interventions aiming at increased recognition, job benefits and personal satisfaction. However, employees with a work disability due to musculoskeletal disorders might benefit from increased skill discretion (e.g. use of various skills) and decision authority. This study found no support for the independent (from job strain and ERI) association of organizational justice with disability pensions. Thus, these results suggest that, with regard to disability pensioning, fair and equal decision making in the organization, as well as fair treatment by the supervisor, should be targeted to improve the balance between work effort and control and/or reward.

It is important that specialists in occupational medicine, as well as policy makers and managers at different organizations, are aware of these results, since disability pensioning is extremely costly for societies and organizations. Most importantly, work disability is, to the individual concerned, a detrimental event including severe health deterioration and economic losses. Thus, all possible means should be considered to prevent disability pensioning.

8. ACKNOWLEDGEMENTS

This study was carried out at the Department of Public Health, University of Turku; in the Finnish Institute of Occupational Health; and in the Occupational Health Care Unit of Vihti, Joint Authority of Karkkila and Vihti for Public Health and Social Services from 2011 to 2017. It was supported by the National Graduate School of Clinical Investigation in liaison with the University of Turku, the Occupational Health Care Unit of Vihti in liaison with The Research Committee of Hospital District of Helsinki and Uusimaa, The Finnish Medical Foundation and The Finnish Work Environment Fund. The financial support was essential to ensure the finalization of this study as the work was mostly undertaken during limited hours of the night time and the weekends. Thus, I am extremely grateful to these institutions for their financial support of this study and for allowing me to occasionally take research leave to comprehensively focus on the research.

My deepest thanks go to my supervisors, Professor Jussi Vahtera and Docent Tuula Oksanen, who have fully supported me from the beginning of this work. My research interest was on depressive disorders and their association with disability pensions, and I was the most fortunate to be accepted into the extremely successful and experienced research group of the Finnish Public Sector Study. Jussi and Tuula, you have guided me—held my hand if needed—through this long and demanding "climb" from the first steps of my doctoral studies to the summit. I am very privileged to have such experienced supervisors. Moreover, you have allowed me to take all the time needed to complete my studies, which was essential due to my private life. In other words, you allowed high control during the whole process, which balanced the high demands required.

I am also deeply grateful to the co-authors who collaborated with me while working on the original studies for this thesis. You provided your experience to the point where I am proud of each sub-study included in this thesis. This would not be true without your contribution. My special thanks go to our statistician, Jaana Pentti, whose expertise made it possible to provide aggregated measures in this study—a method that raised the value of this research to a higher level. My sincere gratitude goes to the reviewers of this manuscript. First, I want to thank Professor Clas-Håkan Nygård for his experienced and precise comments that helped to fine-tune this manuscript. Docent Mikko Laaksonen put in a lot of effort while providing his expert comments, which helped me to complete the final revision of this manuscript. Finally, I want to thank Professor Tuula Putus and MD Pekka Virtanen for taking care of me during this process and giving your time as the members of the follow-up committee.

This work has taken its toll on me by forcing me to sit still for hour after hour. Fortunately, I had Joona Noutere as my coach at the CrossFit Central Nummela. Joona ensured that my sitting stiff body retained good posture and provided me with physical challenges. The endorphin boosts gained from "the box" kept me going in between the infinite and often unrewarded hours of research work. Without the physical challenges of the WODs, I wouldn't have been able to finalize this dissertation. So, I want to thank Joona and all the co-WODders at the Nummela box: you inspire me! Without facing the physical challenges, it would not have been possible to deal with this challenge.

Next, I owe my thanks to my co-workers at the Occupational Health Care unit of Vihti: you have always been more than just people I work with. I have been supported and taken care of, even though my research leaves have added more burden on your shoulders. My special thanks go to Sirpa and Katja, who were the pull factors for me joining this amazing team.

This study was done remotely from the other members of my research group. Hence, the fellowship of my private life friends has been extremely important to me. I especially want to thank Jonna, Eeva, Tanja, Maria and Anna, who have regularly offered me breakaways from the science. Elina, the quality coffee you made for me and the non-science conversations we had have been highly appreciated. Saija, you always made efforts to keep in contact with me. Finally, I am able to throw a party on you (and the opponent, of course)! Milla, Kaisa, Noora and Eeva, you are strong, intelligent and successful women who have always inspired me. No matter the distance, we are always there for each other. Finally, this achievement would not have been possible without having the confidence achieved by feeling appreciated and approved of by all my wonderful friends. Love you all!

I owe a special thanks to my mother, Sirpa, and father, Harri, for raising me as an independent, forward focused and unyielding person. Without those characteristics, this work would have been impossible. Moreover, even though independent, I was always able to count on you to "have my back." Also, my stepmother, Eija, deserves thanks for all the care and woolen socks that kept me warm while writing; while my mother-in-law, Kaisu, deserves thanks for all her efforts and love for me and my family. Special thanks go to my father for reading the early and immensely lengthy version of this manuscript. I am sorry to put you through that, but I'm forever thankful. I am privileged to be your daughter. Moreover, I want to deeply thank my wonderful mom for sharing her love by taking care of me, my children and our back yard, while I was working. You were the one who

realized that it's the journey, not the destination that matters. You have shown your pride, support and love during the whole journey. And look where it took us! Thank you. You mean everything to me.

My little brother Juha. You have always devoted yourself to helping me to succeed. When needed, you are our nanny, cleaning "lady", chef and personal shopper for the groceries. You were here when I faced unexpected events and extreme time pressures. You have been a knight in shining armor, risking yourself—more than twice—to childhood diseases to be there for us and this work. You were there when the irony of life gave us noro-virus during the last weeks of drafting this dissertation. I am sorry for the horrible 18 hours you spent with stomach cramps in our bathroom. Love you! I owe you millions of thanks.

My beloved husband Jussi. This study has been "the third person" in our relationship: for several years I have crept to my study to be in touch with my research at the weekends. Meanwhile, you have put aside some of your dreams for me to achieve mine. Your efforts with the kids and the house during the last kilometers of this study are highly appreciated. Love and appreciate you. Can't wait to be fully yours again!

Justus and Julia. I wanted this work to make a difference, I wanted it to matter. However, the pathway of a scientist to make a difference is a long road, and these were the first steps so far. Fortunately, by finalizing my work, I truly am able to make a difference. The finalization of this process will matter to you. Mommy doesn't "have to work" anymore. Justus and Julia, I want to do everything in my power to improve the world for you. For now on, I can, and will, always be there for you. I love you.

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Annales Universitatis Turkuensis

Turun yliopisto
University of Turku

Painosalama Oy, Turku, Finland 2018

ISBN 978-951-29-7172-5 (PRINT)
ISBN 978-951-29-7173-2 (PDF)
ISSN 0355-9483 (PRINT) | ISSN 2343-3213 (PDF)