The Role of Work Ability and Health on Sustaining Employability

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The Role of Work Ability and Health on Sustaining Employability

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Chapter 1

General introduction

1.1 Ageing workforce

Many Western countries face the challenge of an ageing population, due to increasing life expectancy and falling birth rates [1]. The ageing of the population leads to a socioeconomic pressure to sustain working life. However, in recent years the increase in life expectancy has not resulted in an increase of work participation of older workers, but rather in a decrease of the years spent in paid employment during lifetime. This rather paradoxical finding can partly be explained by an increase in years of education among younger individuals. However, the main explanation for the decrease in total life years in paid employment is the high rate of early exit from the labour market at older ages and likewise an average age of exit from paid employment well below the statutory pension age [2].

In order to balance the ratio of employed over dependent persons, the increase in work participation of older workers and the increase of age at full retirement has high priority in governmental policies [1]. The Lisboa goals state a participation of 70% in 2010 in general and 50% for workers aged over 55 years old. In 2008 the participation of workers aged 55-64 in the Netherlands was 53%, and in EU27 countries 45.6% [3].

1.2 Ill health and work participation of older workers

Besides socioeconomic motives to increase work participation, older workers are highly valuable for employers as they are the most skilled and productive employees and therefore of interest to keep at work. Nevertheless, an older worker differs from a younger colleague regarding physical and mental changes that accompany ageing [4], which may have negative consequences for their safety and vulnerability at work [5]. Work demands that are not sufficiently attuned to physical and mental capacities of ageing workers may increasingly cause health problems and subsequently displacement from the workforce [2]. Hence, the success of policies to sustain working life will depend on a better understanding of the particular role of health and work characteristics in continuing work in order to prevent exit from the labour market among older workers. Therefore, the role of (functional) health in working life is of interest.

There is ample evidence that ill health may cause selection out of the labour force [6-12]. It is well-established that poor health may lead to unemployment for example in construction workers, whereby several health problems predicted the risk of long-term unemployment [7]. More recently, there is an increasing awareness that among older workers ill health does not only affect unemployment and disability, but may also drive selection out of the workforce due to early retirement and staying

home to take care of the family [8, 9, 12]. On the European level it was shown that ill health was a risk factor for transitions between paid employment and various forms of non-employment, including retirement, unemployment, and taking care of the household [6, 11]. Additional to current knowledge, it is important to investigate which aspects of ill health, such as perceived poor health, presence of chronic diseases or experienced functional limitations, are primarily involved in displacement from the labour market through different pathways of exit. Besides, it is of interest to evaluate which factors explain the relation between ill health and labour exit.

1.3 Work ability

In order to increase work participation and prolong the working life among older workers the concept of work ability has been developed in the early 1980s in Finland, and was later adopted in various other European and Asian countries. According to Ilmarinen [13], work ability is built on the balance between a person's resources and work demands. The basis for work ability is health, and functional capacity, but work ability is also determined by professional knowledge and competence (skills), values, attitudes, and motivation, and work itself.

There is an overall decrease in work ability with age, but there are substantial inter-individual differences [4, 14]. Within this framework, the concept of work ability has been developed into an important tool to identify workers at risk for imbalance between health, capabilities and demands at work.

Work ability has been measured in different ways. For example, by a single question asking respondents to range their current work ability on a 5 or 10-point scale [15]. Moreover, work ability has been defined as not being on long-term sick leave [16], or in total days on sick leave during the last 12 months [17]. The work ability index (WAI) [18] is by far the most used, and well-accepted instrument to measure work ability, as is demonstrated by its availability in 21 languages. In the early 1980s the work ability index was developed in Finland in a follow-up study that involved ageing municipal workers in different types of occupations. The WAI [18, 19] is a measure for the degree to which a worker, given his health, is physically and mentally able to cope with the demands at work. The WAI consists of an assessment of the physical and mental demands of an individual in relation to his work at this moment, previously diagnosed diseases, and experienced limitations in work due to disease, occurrence of sick leave over the past 12 months, work ability prognosis within 2 years, and psychological resources recently. The WAI is constituted of seven dimensions and the index is derived as the sum score of the ratings on each dimensions. The range of the

summative index is 7-49, which is classified into poor (7-27), moderate (28-36), good (37-43), and excellent (44-49) work ability [18]. Reduced work ability is often defined as a score lower than 37 (poor and moderate). The work ability index has been promoted in recent years as a valuable tool in occupational health programs dedicated to decrease early exit from the work place [20].

1.4 Determinants of work ability

Previous research, predominantly in physical demanding jobs, showed that the WAI is negatively influenced by older age, high physical work demands, high psychosocial work demands (e.g. lack of possibilities to control one's own work), unhealthy lifestyle (lack of physical activity), and a poor physical fitness [5, 20-22]. Few studies have addressed determinants of work ability in occupational populations with predominantly mental demands at work. Among office workers Sjögren-Rönkä (2002) [23] showed that low stress at work and a better self-confidence were directly related to a higher work ability. Seniority in the job and job satisfaction were also associated with a better work ability among office workers [24]. However, the knowledge of determinants of work ability in mental demanding occupations is scarce and hence, it remains unclear whether in these jobs the relative importance of personal and work-related factors is similar to their well-known contribution in physically demanding jobs. Although several studies in different occupational settings have been conducted, there is a need for a systematic evaluation of the relative importance of work-related and individual determinants of work ability, measured with the WAI. This knowledge of determinants of work ability is important to tailor interventions aimed at increasing work participation among elderly workers, and at maintenance or improvement of the performance at work.

1.5 Consequences of decreased work ability for work participation and work performance

Earlier studies have shown that a low work ability score predicts work displacement from the labour market during follow-up most profound through work disability [25, 26]. Evidence for an increased risk for early-retirement are somewhat weaker but show positive associations [27, 28]. Besides consequences of decreased work ability for exit from paid employment, decreased work ability may have consequences for workers who remain in paid employment through a reduced productivity. There are two measures of lost productivity: (1) time away from the job due to illness and associated disability (sickness absence) [29], and (2) productivity losses at work due to a reduced health. The phenomenon that workers turn up at work, despite health problems that

may prompt absence from work, is sometimes referred to as sickness presenteeism [30]. Since sickness presenteeism may convey the wrong impression that health problems at work should promote absence from work, in this thesis the term productivity loss at work will be used.

Sickness absence is an expression of the complex relation between health and work characteristics [31] and is thought to have a multifactorial etiology [32]. A range of factors can influence the occurrence and duration of sickness absence such as individual characteristics, health behaviour, and work related factors [32-35]. There is limited information on the predictive value of work ability index score for future sickness absence. A study by Kujala et al. [36] showed that a decreased work ability among young employees had a predictive value for long-term sickness absence.

Various publications have addressed the negative consequences of impaired health, illness and disease for productivity loss at work. In a systematic review Schultz et al. [37] showed that different health conditions, such as impaired mental health, allergies, and arthritis, are associated with productivity loss at work. Likewise, individual studies have shown that the prevalence of productivity loss at work has a broad range varying between 7% and 60% among workers with impaired health [38-42], whereas the average productivity loss at work ranges between some 12% and 34%, which accounts for 1.0 to 2.7 hours per day assuming an 8 hour work day [39-42].
Despite the consistent results on the consequences of impaired health and, less pronounced, reduced work ability for productivity loss at work, it remains unclear which work related factors may explain the association between decreased work ability and productivity loss at work.

2. Objectives of this thesis

Extending working life and remaining active on the labour market at older age is one of the main goals for European governments. In this respect, the increase in life expectancy over the last 30 years is frequently used to support the possibility to increase the length of working life, but until now this has not yet resulted in extended work lives. Therefore, the aim of this study was to gain insight in the role of work ability and health on sustaining employability. In this thesis employability was restricted to remaining in paid employment, lack of sickness absence and productivity loss at work.

The primary objectives of this thesis were:

1) What is the relation between ill health and exit from paid employment among older workers?
2) Which individual characteristics, lifestyle factors and work-related risk factors are associated with work ability?
3) What are the consequences of a decreased work ability for sickness absence and productivity loss at work and are these consequences influenced by work related characteristics?

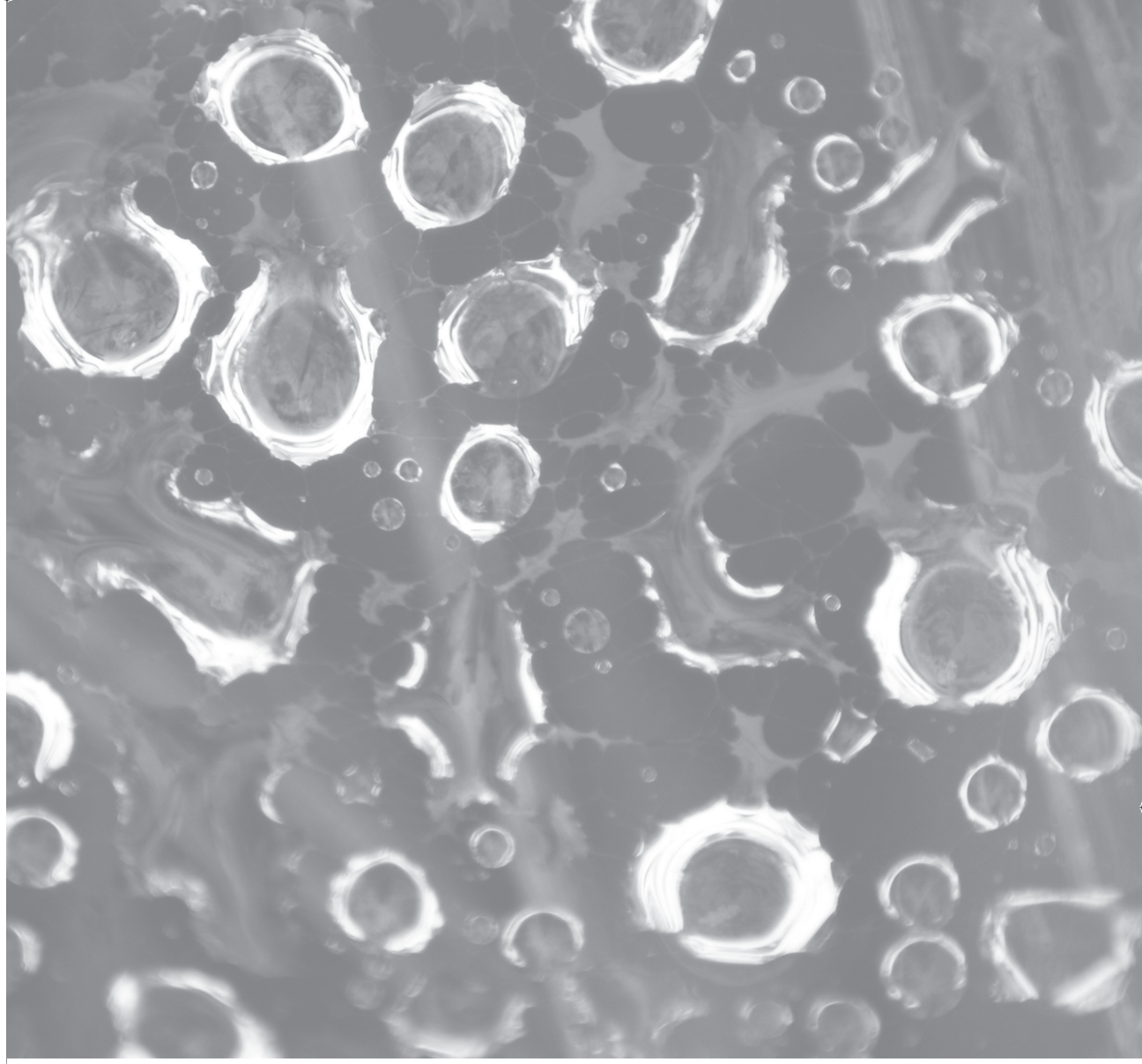
3. Outline of this thesis

Following this general introduction, objective 1 will be addressed in chapter 2 and 3. Chapter 2 will address the impact of ill health on exit from paid employment in Europe among older workers. Data derived from the first two waves of the Survey on Health and Ageing in Europe (SHARE) were analysed to determine the relation between poor health and work characteristics on becoming retired, unemployed, a homemaker, or disabled compared to remaining in paid employment in the following two years among 50 to 63 year olds in Europe. Chapter 3 presents a synthesis of findings derived from a systematic review of longitudinal studies on the influence of health and work on early retirement and of results obtained from focus group interviews about retirement decisions with workers aged over 40 years of age with poor and excellent work ability in the printing industry.
Objective 2 is addressed in chapter 4 and 5. An overview of the literature regarding the effects of individual and work-related factors on the Work ability index is given in chapter 4. Chapter 5 presents the results of an exploration of the associations of psychosocial factors at work, life style, and stressful life events on health and work ability among white-collar workers.
Objective 3 is addressed in chapter 6 and 7. The topic in chapter 6 is a prospective longitudinal study which describes the relative contribution of individual characteristics, lifestyle factors, work-related risk factors, and work ability on the occurrence of short (<2 weeks), moderate (2-12 weeks), and long (>12 weeks) duration of sickness absence during 1 year follow-up. Chapter 7 evaluates the possibility of interaction between work-related factors and reduced work ability in the association with productivity loss at work. Finally, chapter 8 comprises a summary of the results and general discussion.

References

[1] Ilmarinen JE. Aging workers. *Occup Environ Med*. 2001;58:546-52.
[2] Stattin M. Retirement on grounds of ill health. *Occup Environ Med*. 2005;62:135-40.
[3] Voortgangrapport Nederland 2009. In het kader van de Lissabonstrategie. Den Haag: Ministerie van Economische zaken; 2009.
[4] Silverstein M. Meeting the challenges of an aging workforce. *Am J Ind Med*. 2008;51:269-80.
[5] Ilmarinen J. Aging and work--coping with strengths and weaknesses. *Scand J Work Environ Health*. 1997;23 Suppl 1:3-5.
[6] Alavinia SM, Burdorf A. Unemployment and retirement and ill-health: a cross-sectional analysis across European countries. *Int Arch Occup Environ Health*. 2008;82:39-45.
[7] Bartley M. Unemployment and ill health: understanding the relationship. *J Epidemiol Community Health*. 1994;48:333-7.
[8] Cai L, Kalb G. Health status and labour force participation: evidence from Australia. *Health Econ*. 2006;15:241-61.
[9] Karpansalo M, Manninen P, Kauhanen J, Lakka TA, Salonen JT. Perceived health as a predictor of early retirement. *Scand J Work Environ Health*. 2004;30:287-92.
[10] Leino-Arjas P, Liira J, Mutanen P, Malmivaara A, Matikainen E. Predictors and consequences of unemployment among construction workers: prospective cohort study. *BMJ*. 1999;319:600-5.
[11] Schuring M, Burdorf L, Kunst A, Mackenbach J. The effects of ill health on entering and maintaining paid employment: evidence in European countries. *J Epidemiol Community Health*. 2007;61:597-604.
[12] Thomas C, Benzeval M, Stansfeld SA. Employment transitions and mental health: an analysis from the British household panel survey. *J Epidemiol Community Health*. 2005;59:243-9.
[13] Ilmarinen J. Towards a longer worklife. Helsinki: FIOH Bookstore 2005.
[14] van den Berg TI, Elders LA, de Zwart BC, Burdorf A. The effects of work-related and individual factors on the Work Ability Index: a systematic review. *Occup Environ Med*. 2009;66:211-20.
[15] Bobko NA, Barishpolets AT. Work ability, age and its perception, and other related concerns of Ukraine health care workers. *Exp Aging Res*. 2002;28:59-71.
[16] Lindberg P, Vingard E, Josephson M, Alfredsson L. Retaining the ability to work-associated factors at work. *Eur J Public Health*. 2006;16:470-5.
[17] Lindberg P, Josephson M, Alfredsson L, Vingard E. Promoting excellent work ability and preventing poor work ability: the same determinants? Results from the Swedish HAKuL study. *Occup Environ Med*. 2006;63:113-20.
[18] Tuomi K, Ilmarinen J, Jahkola A, Katajarinne L, Tulkki A. Work ability index. Helsinki: Finnish Institute of Occupational Health; 1998.
[19] Ilmarinen J. Work ability-a comprehensive concept for occupational health research and prevention. Scand J Work Environ Health. 2009;35:1-5.
[20] Tuomi K, Huuhtanen P, Nykyri E, Ilmarinen J. Promotion of work ability, the quality of work and retirement. *Occup Med (Lond)*. 2001;51:318-24.
[21] Alavinia SM, van Duivenbooden C, Burdorf A. Influence of work-related factors and individual characteristics on work ability among Dutch construction workers. *Scand J Work Environ Health*. 2007;33:351-7.
[22] Pohjonen T. Age-related physical fitness and the predictive values of fitness tests for work ability in home care work. *J Occup Environ Med*. 2001;43:723-30.
[23] Sjogren-Ronka T, Ojanen MT, Leskinen EK, Mustalampi ST, Malkia EA. Physical and psychosocial prerequisites of functioning in relation to work ability and general subjective well-being among office workers. *Scand J Work Environ Health*. 2002;28:184-90.

[24] Martinez MC, Latorre MRDO. Health and work ability among office workers. *Rev Saude Publica*. 2006;40:851-8.
[25] Liira J, Matikainen E, Leino-Arjas P, Malmivaara A, Mutanen P, Rytkönen H, et al. Work ability of middle-aged Finnish construction workers - a follow-up study in 1991-1995. *Int J Ind Erg*. 2000;25:477-81.
[26] Tuomi K, Toikkanen J, Eskelinen L, Backman AL, Ilmarinen J, Jarvinen E, et al. Mortality, disability and changes in occupation among aging municipal employees. *Scand J Work Environ Health*. 1991;17 Suppl 1:58-66.
[27] Hopsu L, Leppännen A, Ranta R, Louhevaara V. Perceived work ability and individual characteristics as predictors of early exit from working life in professional cleaners. *Int Congr Ser*. 2005;1280:84-8.
[28] Salonen P, Arola H, Nygard CH, Huhtala H, Koivisto AM. Factors associated with premature departure from working life among ageing food industry employees. *Occup Med (Lond)*. 2003;53:65-8.
[29] Gold M, Siegel J, Russell L. Cost-effectiveness in health and medicine. New York: Oxford University Press 1996.
[30] Aronsson G, Gustafsson K. Sickness presenteeism: prevalence, attendance-pressure factors, and an outline of a model for research. *J Occup Environ Med*. 2005;47:958-66.
[31] Benavides FG. Ill health, social protection, labour relations, and sickness absence. *Occup Environ Med*. 2006;63:228-9.
[32] Niedhammer I, Bugel I, Goldberg M, Leclerc A, Gueguen A. Psychosocial factors at work and sickness absence in the Gazel cohort: a prospective study. *Occup Environ Med*. 1998;55:735-41.
[33] Duijts SF, Kant I, Swaen GM, van den Brandt PA, Zeegers MP. A meta-analysis of observational studies identifies predictors of sickness absence. *J Clin Epidemiol*. 2007;60:1105-15.
[34] Kristensen TS. Sickness absence and work strain among Danish slaughterhouse workers: an analysis of absence from work regarded as coping behaviour. *Soc Sci Med*. 1991;32:15-27.
[35] Voss M, Floderus B, Diderichsen F. Physical, psychosocial, and organisational factors relative to sickness absence: a study based on Sweden Post. *Occup Environ Med*. 2001;58:178-84.
[36] Kujala V, Tammelin T, Remes J, Vammavaara E, Ek E, Laitinen J. Work ability index of young employees and their sickness absence during the following year. *Scand J Work Environ Health*. 2006;32:75-84.
[37] Schultz AB, Edington DW. Employee health and presenteeism: a systematic review. *J Occup Rehabil*. 2007;17:547-79.
[38] Geuskens GA, Hazes JM, Barendregt PJ, Burdorf A. Predictors of sick leave and reduced productivity at work among persons with early inflammatory joint conditions. *Scand J Work Environ Health*. 2008;34:420-9.
[39] Goetzel RZ, Long SR, Ozminkowski RJ, Hawkins K, Wang S, Lynch W. Health, absence, disability, and presenteeism cost estimates of certain physical and mental health conditions affecting U.S. employers. *J Occup Environ Med*. 2004;46:398-412.
[40] Lotters F, Meerding WJ, Burdorf A. Reduced productivity after sickness absence due to musculoskeletal disorders and its relation to health outcomes. *Scand J Work Environ Health*. 2005;31:367-74.
[41] Martimo KP, Shiri R, Miranda H, Ketola R, Varonen H, Viikari-Juntura E. Self-reported productivity loss among workers with upper extremity disorders. *Scand J Work Environ Health*. 2009;35:301-8.
[42] Meerding WJ, W IJzelenberg, Koopmanschap MA, Severens JL, Burdorf A. Health problems lead to considerable productivity loss at work among workers with high physical load jobs. *J Clin Epidemiol*. 2005;58:517-23.



Part 1

The relation between ill health and exit from paid employment

Chapter 2

The impact of ill health on exit from paid employment in Europe among older workers

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Abstract

Objective To determine the impact of ill health on exit from paid employment in Europe among older workers.

Methods Participants of the Survey on Health and Ageing in Europe (SHARE) in 11 European countries in 2004 and 2006 were selected when between 50 and 63 years old and in paid employment at baseline (n=4611). Data were collected on self-rated health, chronic diseases, mobility limitations, behavioural factors (obesity, smoking, alcohol use, and physical activity), and work characteristics. Participants were followed for two years and classified into employed, retired, unemployed, and disabled at end of follow-up. Multinomial logistic regression was used to estimate the effect of different measures of ill health on exit from paid employment.

Results During the two-year follow-up period, 17% of employed workers quitted paid employment, primarily due to early retirement. Controlling for individual and work related characteristics, poor self-perceived health was strongly associated with exit from paid employment due to retirement, unemployment, or disability (ORs from 1.32 to 4.24).

Adjustment by working conditions and lifestyle reduced the significant associations between ill health and exit from paid employment by 0 to 18.7%.

Low education, obesity, low job control, and effort-reward imbalance were associated with measures of ill health, but also risk factors for exit from paid employment after adjustment for ill health.

Conclusion Poor self-perceived health was strongest associated with exit from paid employment among European workers aged 50-63 years, compared to three other measures of ill health. This study suggests that the effects of ill health on exit from paid employment can be diminished by a variety of preventive measures towards obesity, problematic alcohol use, job control, and effort-reward balance.

Introduction

In many industrialized countries the population is ageing, due to increasing life expectancy and falling birth rates [1]. A rather paradoxical development is that, despite increases in life expectancy, the average time people spend in paid work has decreased in most European countries. Although part of this decrease is explained by prolonged education among younger cohorts, a more important contributor is the higher rate of exit from the labour market at older ages [2]. As a consequence, many countries are developing policies to encourage older workers to remain longer in the labour market and delay retirement [3]. Clearly, the success of these policies will depend on a better understanding of ageing in the workforce and the particular role of health and work characteristics in continuing work or exit from the labour market. Recent evidence suggests that work can be good for health, reversing the harmful effects of long-term unemployment and prolonged sickness absence [4]. However, the current assumption seems that illness is incompatible with being in work [4].

It is obvious that ill health plays a role in exit through work disability. Although less consistent, there is also evidence that ill health may cause exit from the labour force through unemployment and early retirement [3, 5-10]. In several European countries it was shown that ill health was a risk factor for transitions between paid employment and various forms of non-employment, including retirement, unemployment, and taking care of the household [5, 9]. The strength of the current study is the exploration of the three pathways simultaneously. Second, four different measures of health were used to study the role of ill health in exit from paid employment.

In order to minimize the negative effect of ill health on work participation, it is of interest to study factors that explain the relation between ill health and exit from paid employment and may therefore be important targets for primary preventive interventions in occupational populations. Research on occupational health has shown the negative influence of poor working conditions on workers' health [11-13]. Lifestyle factors, such as lack of physical activity, smoking, alcohol and overweight, are well-established determinants of poor health, and thus, may be important factors to intervene upon in order to decrease health-related exit from paid employment.

The following research questions were formulated. First, which measures of health are predictive for exit from paid employment? Second, how much of the observed associations between ill health and future exit can be explained by work related factors and lifestyle?

Methods

Study population

The study population consisted of participants of the Survey on Health and Ageing in Europe (SHARE study). SHARE is a longitudinal survey that aims to collect medical, social, and economic data on the population aged over 50 years in 11 European Union countries (Sweden, Denmark, The Netherlands, Belgium, Germany, Austria, Switzerland, France, Italy, Spain, and Greece) [14, 15]. In the participating SHARE countries the institutional conditions with respect to sampling were so different that a uniform sampling design for the entire project was not feasible. Different registries of national or local level were used that permitted stratification by age. The sampling designs varied from simple random selection of households to complicated multistage designs.

The first wave of data was collected by interviews between April and October 2004. The overall household response across the 11 SHARE countries in which data collection took place in 2004 was 57.4%, although substantial differences among countries were observed [15]. The available dataset from the first wave of data collection (SHARE Release 2.0) contains 28,517 participants, with 12,965 subjects (45%) aged between 50 and 63 years. Individuals aged 63 years and older were excluded from the current study, since it was assumed that workers normally retired when they became 65 years old at the end of follow-up. While this assumption certainly has limitations, given the complexity to define retirement at the individual level and the small proportion of workers above the age of 63 years in the study population (about 2%), it was considered to be the definition that was most comparable across countries. For 93 persons employment status was unknown, resulting in a study population of 12,872 subjects, of which 7119 (55%) subjects with paid employment. After two years 8,729 subjects participated again in the questionnaire survey (SHARE Release 1.0), resulting in a response of 67%. Complete information on employment status in 2006 was available for 8,568 subjects. For the longitudinal analysis of the influence of ill health on exit of the labour market, a cohort was available of 4,611 subjects with paid employment in 2004 and complete information on individual and work related characteristics at baseline and work status at follow-up in 2006.

Labour force participation

The outcome of this study is work status, which was based on self-reported current economic status that best described respondent's situation based on four mutually exclusive categories: paid work, retired, unemployed, disabled. The definition of being

employed in SHARE encompasses all individuals who declared to have done any kind of formal paid work in the last four weeks, including self-employed work for family business. Unemployed were those who were laid off from their last job before being able to benefit from normal pension benefits, and therefore were forced to spend some time in unemployment before effectively being retired. Sickness or disability insurance applied to people who exited the labour force for reasons of recognized health problems [14]. The category of disabled participants predominantly includes persons whose health problems at work were an eligibility criterion for receiving a disability pension. Total exit from the workforce was defined as exit either through early retirement, unemployment or disability.

Health measurements

The European version of self-perceived health, a 5-point scale question ranging between very good to (very) bad, was used to define poor health (less than good). This frequently used question has been shown to be a good indicator of general physical and mental health [16, 17]. A second health measure was having at least one of the following chronic diseases diagnosed by a doctor during lifetime; heart disease, stroke, diabetes, lung disease, asthma, arthritis or rheuma, and osteoporosis. Functional limitations, reflecting the ability of individuals to perform normally in society, were characterized with two dichotomous measures of health. The first measure of interest, mobility problems, reflects limitations with mobility, arm or fine motor functions. Mobility problems were defined as one or more affirmative answers on a list of 10 mobility problems, such as walking 100 meters and reaching or extending arms above shoulder level. The second measure, instrumental limitations, was positive for subjects with one or more of the 13 instrumental activities of daily life, such as preparing meals and making phone calls.

Individual characteristics

The highest education successfully completed was coded according to the 1997 International Standard Classification of Education (ISCED-97) and categorized into low (pre-primary, primary and lower secondary education), intermediate (upper secondary education) and high (post secondary education). Body mass index (BMI) was calculated by dividing body weight in kilogram by the square of body height in meters. BMI was recoded into normal (<25 kg/m^2), overweight (≧25 and <30 kg/m^2), or obese (≧30 kg/m^2). Marital status was used to categorize individuals into those who were living with a spouse or a partner in the same household (reference category) and those living alone. Smokers were subjects who were currently smoking; all others were

categorized as non-smokers. Problematic alcohol use was defined by an alcohol consumption of two or more glasses of alcoholic beverage at least 5 days a week in the last six months. Physical activity was measured with single questions on regular participation in moderate activities and vigorous activities, both on a 4-point scale ranging from 'more than once a week' to 'hardly ever, or never'. Those who reported less than once a week moderate or vigorous activity were considered to lack in leisure-time physical activity [15].

Work related characteristics

Work related characteristics were assessed by a short battery of items derived from (i) the Job Content Questionnaire measuring the demand-control model [18] and (ii) the effort-reward imbalance model questionnaire [12]. All items were on a four point scale ranging from 1 'strongly agree' to 4 'strongly disagree'. Single item measured high time pressure ("I'm under constant time pressure due to a heavy work load.") Lack of job control was measured by the sum score of two items ("I have very little freedom to decide how I do my work"; "I have an opportunity to develop new skills"). Country-specific median values were used to define the presence of high time pressure, and lack of job control.

Effort-reward imbalance was measured by 2 items on 'effort' ('physically demanding' and 'time pressure') and 5 items on 'reward' ('receive adequate support', 'receive recognition', 'adequate salary', 'job promotion prospects', 'job security'). 'Effort-reward imbalance' was defined by the ratio of the sum score of the 'effort' items and the sum score of the 'reward' items, adjusted for the number of items [19]. Effort-reward imbalance was defined as a score within the upper tertile of this ratio per country [19].

A high physical work demand was measured with one item ("My job is physically demanding"). Country-specific median value was used to define the presence of high physical work demand.

Statistical analysis

Logistic regression was used to evaluate cross-sectional associations at baseline between four measures of ill health as dependent variables and individual and work characteristics as independent variables, adjusting for country.

Risk factors for exit from paid employment during the two year follow-up were evaluated by means of a multinomial logistic regression analysis. The study population consisted of subjects with paid employment at baseline and odds ratios were calculated for the likelihood of transition to every state of non-participation, i.e. early

retirement, unemployment, and disability during the 2 year follow-up. The results for homemakers were not shown as this group was highly dominated by female gender, but subjects who exited paid employment through becoming a home worker remained in the sample. The first step in the analysis was to establish univariate associations between the dependent variable work status, and health measures, sociodemographic factors, lifestyle factors, and work characteristics as independent factors, including country as fixed effect. In the second step multivariate analyses were conducted to model employment status at the end of follow-up as a function of four measures of health. For the initial selection of potential covariates for the multivariate model, univariate associations with a significant level of $p<0.05$ were considered. For each independent variable measure of health, we calculated odds ratios for dependent variable exit for work adjusted for age, gender and education (reference model) and further adjusted for lifestyle factors and work related characteristics separately, and in combination. For each regression model the percentage change in odds ratio of each pathway of exit was calculated ($100x[OR_{reference\ model} - OR_{+explanatory\ factors}]/[OR_{reference\ model}-1]$ [20]. One of the main advantages of this method is that it can be used to estimate direct and indirect contributions of explanatory factors. One limitation is that the percentage change can be similar for different absolute changes in odds ratios. However, all contributions were calculated relatively to the same odds ratios, which were also presented. Therefore, we believe that this limitation has a limited effect on our results.

Population Attributable Fractions were calculated for significant determinants of exit from paid employment, using the formula PAF= Pe (OR-1)/(1+PE(OR-1))[21], whereby Pe represents the prevalence of exposure in the study population.

All statistical models were based on the number of persons with complete data available. The statistical analyses were carried out with SPSS version 15.0 [22].

Results

About 17% of the employed workers reported less than good health (Table 1). Interrelations of the four health measures were moderate, with Spearman correlations varying from 0.06 to 0.33. In total, 55% of the subjects with a poor health had a chronic disease, 57% mobility problems, and 9% instrumental limitations. Chronic diseases with highest prevalence were depression (17.7% n=814), arthritis/osteoporosis (12.3% n=565), and respiratory diseases (5.7% n=265) (data not shown). About 61% of subjects with a chronic disease perceived their health as good.

Table 1 Individual characteristics, lifestyle factors, health status, and work characteristics among 4611 employed persons aged 50-63 years old in 11 European countries during the first wave of the Survey on Health and Ageing in Europe (SHARE).

	Employed (n=4611)
Individual characteristics	
Female	45% (2088)
Age 50-54 yr	48% (2224)
55-59 yr	40% (1826)
60-63 yr	12% (561)
Education Low	31% (1443)
Intermediate	33% (1513)
High	36% (1655)
Without partner	20% (937)
Lifestyle factors	
BMI <25 kg/m^2	44% (2011)
25-30 kg/m^2	41% (1910)
≥30 kg/m^2	15% (690)
Current smoker	27% (1252)
Problematic alcohol use	14% (664)
Lack of leisure-time physical activity	56% (2561)
Work-related factors	
High time pressure at work (1/0)	56% (2567)
High physical work demands (1/0)	46% (2138)
Lack of job control (1/0)	57% (2622)
Effort-reward imbalance at work (1/0)	33% (1531)
Perceived health	
Very good	32% (1475)
Good	51% (2343)
Fair	15% (708)
(Very) bad	2% (85)
Chronic disease (1/0)	25% (1130)
Mobility problems (1/0)	28% (1287)
Instrumental limitations in daily activities (1/0)	4% (170)

Table 2 shows important determinants at baseline for all four health measures were lack of physical activity in leisure time (ORs 1.24-1.87) and effort-reward imbalance at work (ORs 1.25-1.64). A high body mass index was also associated with most measures of health.

Table 2 Cross-sectional multivariate associations between individual characteristics, lifestyle and work characteristics, and different health outcomes among 4611 employed persons aged 50-63 years old in 11 European countries, during the first wave of the Survey on Health and Ageing in Europe (SHARE).

	Less than good perceived health (N=793)	Chronic disease (N=1130)	Mobility problems (N=1287)	Instrumental limitations in daily activities (N=170)
	OR 95%CI	OR 95%CI	OR 95% CI	OR 95% CI
Age 50-54 yr	1	1	1	1
55-59 yr	**1.24*** (1.04-1.47)	**1.55*** (1.33-1.79)	**1.21*** (1.05-1.40)	1.33 (0.95-1.85)
60-63 yr	**1.35*** (1.06-1.73)	**1.72*** (1.39-2.13)	**1.43*** (1.16-1.77)	1.40 (0.86-2.29)
Education High	1	1	1	1
Intermediate	**1.55*** (1.26-1.90)	**1.21*** (1.02-1.44)	**1.22*** (1.03-1.44)	1.34 (0.90-2.03)
Low	**2.00*** (1.62-2.47)	**1.30*** (1.08-1.58)	**1.27*** (1.06-1.51)	**1.61*** (1.07-2.43)
Female	1.18 (1.00-1.39)	**1.34*** (1.16-1.54)	**2.05*** (1.78-2.37)	**2.44*** (1.74-3.43)
Without partner	0.99 (0.81-1.21)	**1.24*** (1.05-1.46)	1.05 (0.89-1.24)	1.17 (0.81-1.68)
BMI <25 kg/m^2	1	1	1	1
25-30 kg/m^2	1.03 (0.86-1.24)	**1.18*** (1.01-1.39)	**1.49*** (1.28-1.74)	1.13 (0.79-1.61)
≥30 kg/m^2	**2.01*** (1.62-2.50)	**1.88*** (1.55-2.29)	**2.74*** (2.25-3.32)	1.53 (0.99-2.35)
Current smoker	1.18 (0.98-1.40)	0.93 (0.80-1.09)	1.15 (0.99-1.34)	**1.55*** (1.11-2.16)
Problematic alcohol use	0.98 (0.78-1.24)	1.12 (0.92-1.37)	0.87 (0.71-1.07)	0.98 (0.60-1.60)
Lack of leisure-time physical activity	**1.46*** (1.23-1.72)	**1.24*** (1.08-1.43)	**1.57*** (1.37-1.81)	**1.87*** (1.33-2.63)
High time pressure at work	1.04 (0.87-1.24)	0.98 (0.84-1.15)	1.06 (0.91-1.24)	1.09 (0.76-1.56)
High physical work demands	1.14 (0.94-1.38)	1.09 (0.92-1.28)	**1.26*** (1.08-1.48)	1.07 (0.73-1.56)
Lack of job control	**1.26*** (1.06-1.49)	**1.15*** (1.00-1.33)	1.04 (0.90-1.19)	1.23 (0.88-1.71)
Effort-reward imbalance at work	**1.64*** (1.33-2.01)	**1.25*** (1.04-1.50)	**1.39*** (1.17-1.66)	**1.55*** (1.03-2.33)

* p<0.05, OR=odds ratio, CI= confidence interval

Table 3 Exit from paid employment among 4611 participants aged 50-63 years old in 11 European countries during two years follow-up during the first two waves of the Survey on Health and Ageing in Europe (SHARE).

Employed in 2004		**Labour market position 2006**				
Country	N	Employed	Retired	Unemployed	Disabled	Homemaker
Sweden	720	88.5% (637)	5.8% (42)	1.7% (12)	3.3% (24)	0.7% (5)
Denmark	409	81.2% (332)	13,0% (53)	3.9% (16)	1.7% (7)	0.2% (1)
The Netherlands	484	79.8% (386)	12.6% (61)	2.1% (10)	2.3% (11)	3.3% (16)
Belgium	617	84.8% (523)	8.8% (54)	0.8% (5)	3.4% (21)	2.3% (14)
Germany	411	76.6% (315)	12.9% (53)	7.1% (29)	1.0% (4)	2.4% (10)
Austria	209	71.8% (150)	23.0% (48)	2.9% (6)	1.4% (3)	1.0% (2)
Switzerland	238	88.2% (210)	5.5% (13)	2.5% (6)	0.4% (1)	3.4% (8)
France	490	80.4% (394)	12.7% (62)	3.9% (19)	2.2% (11)	0.8% (4)
Italy	276	72.1% (199)	19.2% (53)	4.3% (12)	0.4% (1)	4.0% (11)
Spain	228	80.7% (184)	7.0% (16)	4.8% (11)	2.6% (6)	4.8% (11)
Greece	529	92.1% (487)	5.1% (27)	0.2% (1)	0.2% (1)	2.5% (13)
Total	**4611**	**82.8% (3817)**	**10.5% (482)**	**2.8% (127)**	**2.0% (90)**	**2.1% (95)**

During the two year follow-up period 17% (n=794) of employed workers exited the workforce, primarily due to retirement (11%) (Table 3). Considerable differences in prevalence of exit from paid employment and pathways of exit were found among countries. Table 4 shows that self-perceived poor health was the measure of health most predictive for transition to unemployment (OR 2.49), retirement (OR 1.50), and work disability (OR 5.04). All four health measures were associated with any exit from work (ORs 1.56-2.08). The role of ill health on exit from paid employment was comparable for workers with a full-time or part-time contract (data not shown). All lifestyle factors except smoking were associated with exit from paid employment through retirement (ORs 1.23-1.40). Among work-related factors lack of job control showed the highest increased risks for all three pathways of exit (ORs 1.23-2.68). Table 5 shows that the observed associations between different measures of ill health and transitions to non-participation, after adjustment for lifestyle factors and work characteristics.

Table 4 Univariate associations between health, individual characteristics, lifestyle, and work characteristics, and transitions into unemployment, retirement, and disability among 4611 initially employed subjects aged 50-63 years old during two years follow-up in the Survey on Health and Ageing in Europe (SHARE) (staying in paid employment as reference category).

	Unemployed (n=127)	**Retired (n=482)**	**Disabled (n=90)**	**Total exit (n=699)**
	OR 95%CI	OR 95%CI	OR 95% CI	OR 95% CI
Less than good perceived health (1/0)	**2.49*** (1.70-3.66)	**1.50*** (1.19-1.90)	**5.04*** (3.28-7.74)	**2.08*** (1.72-2.51)
Chronic disease (1/0)	**1.62*** (1.10-2.37)	**1.74*** (1.42-2.14)	**3.00*** (1.96-4.59)	**2.00*** (1.68-2.37)
Mobility problems (1/0)	1.29 (0.88-1.90)	**1.37*** (1.11-1.68)	**3.44*** (2.26-5.26)	**1.56*** (1.31-1.85)
Instrumental limitations in daily activities (1/0)	1.69 (0.76-3.73)	1.25 (0.78-2.02)	**3.52*** (1.82-6.83)	**1.73*** (1.19-2.50)
Age 50-54 yr 55-59 yr 60-63 yr	1 **1.72*** (1.17-2.53) **2.51*** (1.42-4.43)	1 **8.08*** (5.91-11.04) **33.30*** (23.36-47.46)	1 **2.36*** (1.50-3.72) 1.31 (0.56-3.07)	1 **3.96*** (3.21-4.88) **8.75*** (6.83-11.21)
Education High Intermediate Low	1 **1.87*** (1.17-3.00) **2.80*** (1.69-4.64)	1 1.12 (0.89-1.43) **1.65*** (1.29-2.12)	1 1.56 (0.89-2.72) **2.20*** (1.28-3.77)	1 **1.39*** (1.14-1.71) **1.68*** (1.37-2.05)
Female	1.16 (0.81-1.66)	0.83 (0.68-1.01)	0.95(0.62-1.45)	0.92 (0.78-1.08)
Without partner	1.36 (0.90-2.05)	0.83 (0.64-1.06)	0.78 (0.45-1.37)	0.92 (0.75-1.13)
BMI <25 kg/m^2 25-30 kg/m^2 ≥30 kg/m^2	1 1.00 (0.66-1.51) **1.92*** (1.21-3.07)	1 **1.23*** (1.00-1.52) **1.40*** (1.05-1.84)	1 0.97 (0.60-1.56) 1.71 (0.98-2.97)	1 1.11 (0.93-1.33) **1.51*** (1.20-1.89)
Current smoker	1.21 (0.82-1.80)	0.87 (0.70-1.09)	1.46 (0.93-2.30)	0.97 (0.81-1.17)
Problematic alcohol use	1.04 (0.63-1.72)	**1.37*** (1.07-1.76)	1.65 (0.95-2.87)	**1.57*** (1.27-1.94)
Lack of leisure-time physical activity	1.29 (0.89-1.86)	**1.24*** (1.01-1.51)	0.98 (0.64-1.49)	**1.19*** (1.01-1.44)
High time pressure at work	0.72 (0.50-1.04)	1.02 (0.83-1.25)	1.23 (0.80-1.90)	1.00 (0.85-1.18)
High physical work demands	1.04 (0.73-1.50)	1.17 (0.96-1.42)	**1.57*** (1.03-2.40)	**1.19*** (1.01-1.40)
Lack of job control	**1.59*** (1.07-2.37)	**1.23*** (1.00-1.51)	**2.68*** (1.59-4.54)	**1.62*** (1.37-1.91)
Effort-reward imbalance at work	**1.51*** (1.05-2.16)	1.09 (0.89-1.34)	**1.62*** (1.06-2.48)	**1.22*** (1.03-1.44)

* p<0.05, OR=odds ratio, CI= confidence interval

Table 5 Multivariate associations between 4 different health measures and transitions into unemployment, retirement, and disability among 4611 initially employed subjects aged 50-63 years old in 11 European countries during two years of follow-up in the Survey on Health and Ageing in Europe (SHARE) (staying in paid employment as reference category).

		Unemployed (n=127)	Retired (n=482)	Disabled (n=90)	Total exit (n=699)
		OR 95%CI	OR 95%CI	OR 95% CI	OR 95% CI
Less than good perceived health (1/0)[1]		**2.16*** (1.47-3.19)	**1.38*** (1.07-1.79)	**4.59*** (2.97-7.10)	**1.95*** (1.59-2.39)
Adjusted for lifestyle factors		**2.04*** (1.37-3.02)	**1.35*** (1.04-1.76)	**4.52*** (2.91-7.02)	**1.88*** (1.53-2.31)
	change	10.3%	7.9%	2.0%	7.4%
Adjusted for work characteristics		**2.09*** (1.41-3.10)	**1.35*** (1.04-1.76)	**4.36*** (2.80-6.77)	**1.87*** (1.52-2.29)
	change	6.0%	7.9%	6.4%	8.4%
Adjusted for lifestyle + work		**1.96*** (1.32-2.92)	**1.32*** (1.01-1.72)	**4.24*** (2.71-6.62)	**1.78*** (1.45-2.20)
	change	14.7%	15.8%	6.1%	17.9%
Chronic disease (1/0)[1]		1.42 (0.96-2.09)	**1.38*** (1.10-1.73)	**2.74*** (1.78-4.22)	**1.74*** (1.45-2.09)
Adjusted for lifestyle factors		1.33 (0.90-1.97)	**1.36*** (1.08-1.71)	**2.71*** (1.76-4.19)	**1.67*** (1.39-2.02)
	change	21.4%	5.3%	1.7%	9.5%
Adjusted for work characteristics		1.39 (0.94-2.05)	**1.36*** (1.08-1.71)	**2.66*** (1.73-4.11)	**1.69*** (1.41-2.04)
	change	7.1%	5.3%	4.6%	6.8%
Adjusted for lifestyle + work		1.30 (0.88-1.93)	**1.28*** (1.01-1.62)	**2.62*** (1.69-4.07)	**1.63*** (1.35-1.96)
	change	28.6%	13.2%	4.0%	14.9%
Mobility problems (1/0)[1]		1.15 (0.78-1.71)	1.20 (0.95-1.51)	**3.32*** (2.15-5.12)	**1.46*** (1.21-1.75)
Adjusted for lifestyle factors		1.07 (0.71-1.59)	1.17 (0.93-1.48)	**3.35*** (2.15-5.22)	**1.40*** (1.16-1.70)
	change	53.3%	15.0%	-1.3%	13.0%
Adjusted for work characteristics		1.12 (0.75-1.66)	1.18 (0.94-1.49)	**3.22*** (2.08-4.99)	**1.43*** (1.19-1.72)
	change	20.0%	10.0%	4.3%	6.5%
Adjusted for lifestyle + work		1.03 (0.69-1.54)	1.15 (0.91-1.46)	**3.22*** (2.06-5.03)	**1.37*** (1.13-1.65)
	change	80.0%	25.0%	4.3%	19.6%
Instrumental limitations in daily activities (1/0)[1]		1.43 (0.64-3.19)	1.06 (0.63-1.78)	**3.19*** (1.62-6.25)	**1.55*** (1.04-2.30)
Adjusted for lifestyle factors		1.35 (0.60-3.02)	1.03 (0.61-1.74)	**3.19*** (1.62-6.29)	1.48 (0.99-2.20)
	change	18.6%	50.0%	0%	12.7%
Adjusted for work characteristics		1.39 (0.62-3.11)	1.03 (0.61-1.73)	**3.00*** (1.52-5.93)	1.47 (0.99-2.20)
	change	9.3%	50.0%	8.7%	14.6%
Adjusted for lifestyle + work		1.31 (0.58-2.93)	0.99 (0.59-1.69)	**2.98*** (1.50-5.91)	1.40 (0.93-2.08)
	change	18.6%	133.3%	18.7%	28.2%

[1] Adjusted for individual characteristics age, sex and educational level

Significant odds ratios between ill health and exit from paid employment decreased by 0% to 10% after adjustment for lifestyle factors, 4% to 9% after adjustment for working conditions, and 4% to 19% after adjustment for lifestyle factors and working conditions simultaneously. Adjustment with lifestyle factors and work related characteristics had a smaller influence on the association between ill health and work disability compared to the other pathways of exit from paid employment. In the fully adjusted models for each of the four health measures the lifestyle factors obesity and problematic alcohol use remained significant in at least one of the models. Regarding work related characteristics, lack of job control and effort-reward imbalance at work remained significant after full adjustment in at least one of the four models.

The population attributable fractions of a less-than-good self-perceived health for transition into unemployment, retirement, and disability were 27%, 9%, and 61%, respectively.

Discussion

During a two year follow-up, 17% of workers employed at baseline left paid employment, primarily due to early retirement. Controlling for individual and work related characteristics, poor self-perceived health was strongly associated with exit from paid employment due to retirement, unemployment, or disability (OR's from 1.32 to 4.24). In order of decreasing importance, chronic diseases, mobility problems and instrumental limitations also influenced exit from paid employment, most notably through disability. Significant associations between ill health and exit from paid employment changed 0 to 19% after adjustment for lifestyle and work characteristics.

Some limitations must be taken into account in this study. First, the attrition rate between baseline and follow-up was high (68%)[23]. Yet, in our analyses among subjects initially employed at baseline no differences were found between responders and non-responders during follow-up for all health measures at baseline.

Secondly, there are large variations between European countries in the association between ill health and various forms of exit from paid employment [5]. These variations may reflect differences between countries in institutional arrangements (e.g. availability of disability benefit schemes for those with health problems), or other factors (e.g. more or less selectivity of unemployment dependent on over-all levels of unemployment). All analyses were therefore adjusted for country. Due to small

numbers, country-specific or region-specific analyses were not feasible. The analyses stratified for regions Scandinavian (Sweden, Denmark), Bismarckian (Austria, Belgium, France, Germany, Netherlands, Switzerland) and Southern Europe (Greece, Italy, Spain) showed that the conclusions drawn from the total population were also valid within the regions. That is, in each region the health measure self-perceived health was most predictive for exit from paid employment, most notably through disability.

Third, all variables were based on self-reported data, which could have caused reporting bias. The problem with using self-reported health in an empirical analysis of labour force participation is that it may be an endogenous explanatory variable [16, 24, 25]. According to the justification hypothesis individuals justify their non-participation by claiming that they are in ill health. Subjects with intentions at baseline to quit paid employment in the near future may also have been more prone to report high work demands or a less beneficial effort-reward balance in order to justify their future exit from paid employment [17].

Fourth, the current study used a follow-up period of two years and, therefore, had limited discriminatory power and does not give insight in long-term effects of poor health on exit from paid employment or the relevant time windows for these effects. A European study showed that poor health had the strongest effects on leaving the workforce in the year before the transition [8]. Thus, it is expected that the reported influence of ill health on exit from paid employment is a fair reflection of the effects of ill health on work participation. The influence of ill health on exit from paid employment decreased for older workers, as the decision to continue work above 60 years is more influenced by other factors, such as eligibility criteria for early retirement and labour market.

Several studies have analyzed the effects of health on exit from paid employment of older workers [3, 5-7, 9, 26-29]. The results of this study support the selection hypothesis, whereby people with poor health are more likely to quit paid employment [30]. The influence of type of health measure differs by route of exit, but an overall effect on total exit was consistently present for all measures of ill health.

The relation between poor health and exit from paid employment may be explained by a mismatch between an individual's capacities and the requirements of the job [2]. Functional limitations might therefore be more important than self-perceived poor health for future loss of paid employment. However, the analyses showed that a poor self-perceived health was a stronger predictor for pathways of exit than functional limitations, expressed by either mobility problems or instrumental limitations in daily activities. An explanation could be that self-perceived health includes mental health as well, whereas functional limitations concern primarily physical health. The high

prevalence of depression in the cohort may have contributed to the association between self-perceived health and future exit from paid employment.

The analyses also showed that having ever being diagnosed with a chronic disease played a less profound role in exit from paid employment. This may be explained by the fact that people diagnosed with these chronic conditions who remained in paid employment are a selection of the fittest survivors [31], while those who already left paid employment due to these diseases have not been included in our sample as they had already left paid employment before the baseline investigation. Analyses on the role of onset of disease during the follow-up period was not feasible as only 12 subjects reported that the onset of their chronic disease had been diagnosed during the follow-up period.

The direct influence of ill health on exit from paid employment had odds ratios varying between 1.37 and 5.04. The corresponding population attributable fractions of a less-than-good self-perceived health for transition into unemployment, retirement, and disabled were 27%, 9%, and 61%, respectively. Under the assumption that the observed associations represent a causal process, these associations and population attributable fractions indicate that a good health is an important factor in maintaining paid employment. Based on this finding interventions aimed at prevention of exit from paid employment should prevent or minimize ill health. Given the strong associations at baseline between obesity and lack of leisure time physical activity with several measures of ill health, health promotion interventions should be considered that increase physical activity and support a healthy diet [32, 33].

The consistent associations at baseline between lack of job control, high physical work demands, and effort-reward imbalance with several measures of ill health, outline the importance of improvement of working conditions and work organization as well.

We observed that adjustment with lifestyle factors and work related characteristics showed reasonable changes in health related exit from paid employment. The change was only important for statistically significant associations because a small difference in odds ratio could otherwise result in a high proportion of change. The influence of lifestyle factors and work characteristics on the impact of ill health on labour force exit points at the importance of providing workers with health problems with possibilities that will enable them to continue working, for example by empowering workers with chronic diseases [34].

In the fully adjusted model obesity, problematic alcohol use, low job control, and effort-reward imbalance remained statistically significant for at least one of the pathways of exit in at least one of the models.

Different studies support the association between unhealthy lifestyles, such as lack of physical activity, obesity, and problematic alcohol use, and exit from paid employment [5, 29, 35-37]. In the fully adjusted multinominal models problematic alcohol use was consistently associated with entering work disability with ORs varying from 1.84-1.88. It has been suggested that this may be explained by problems with working times, work output, concentration, occupational safety, and cooperation, irrespective of health status [8]. In the multivariate model obesity was associated with becoming unemployed, (OR 1.67). This is in agreement with a French study that reported obesity as a risk factor for unemployment after controlling for self-reported health [36].

Smoking was not associated with early exit. Earlier studies have shown contradictory results, with significant associations for smoking [8, 38-41] as well as non-significant associations with different forms of exit from paid employment [36, 42, 43].

In the fully adjusted models lack of job control remained a significant predictor for exit through retirement and disability, whereas effort-reward imbalance predicted unemployment. Several studies have corroborated the observed direct influence of strenuous working conditions on exit from paid employment [7, 29, 38, 44, 45]. In a cross-sectional analysis of the SHARE survey at baseline, a high imbalance between efforts and rewards was also associated with intended early retirement after controlling for poor self-perceived health [19]. Hence, preventive measures towards problematic alcohol use, obesity, job control, and effort-reward imbalance will contribute to diminish the occurrence of health related early exit from paid employment.

This study only focused on exit from paid employment, but poor health could have an additional impact in terms of change of jobs and stalled careers. The Health and Retirement Survey [27] showed that workers after the onset of health problems often changed jobs within several years. This might also be true for the onset of poor health in earlier phases of the career (younger workers). Poor health may also have adverse effects on performance at work, as observed in the influence of poor health on sickness absence [46] and productivity loss at work [47, 48]. Duration of employment contract could be of influence on sustaining paid employment. However, only 7% of the subjects with paid employment had a temporary employment contract, and thus this parameter could not be evaluated in this study.

The health status of older European workers has a major influence on the likelihood of sustaining paid employment. Self-perceived poor health and, to a lesser extent, having a chronic disease, perceiving mobility problems and limitations seem predictive for future work participation. There is consistent evidence that social inequalities in health depend on work related factors as well as lifestyle behaviours [49, 50]. The results of this study suggest that labour market participation of older workers with ill health may be sustained by interventions that promote a healthier life and healthier working conditions. As exit from paid employment is often irreversible at older age, prevention of work loss by improving worker's health or improving ill workers' work circumstances and lifestyles should be a key priority. Important entry-points for policy could be lifestyle interventions, improvements of job control and effort-reward balance, and social policies to encourage employment among older persons with health problems.

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References

[1] Ilmarinen JE. Aging workers. *Occup Environ Med*. 2001;58:546-52.
[2] Stattin M. Retirement on grounds of ill health. *Occup Environ Med*. 2005;62:135-40.
[3] Cai L, Kalb G. Health status and labour force participation: evidence from Australia. *Health Econ*. 2006;15:241-61.
[4] Black C. Working for a healthier tomorrow. *Occup Environ Med*. 2009;66:1-2.
[5] Alavinia SM, Burdorf A. Unemployment and retirement and ill-health: a cross-sectional analysis across European countries. *Int Arch Occup Environ Health*. 2008;82:39-45.
[6] Bartley M. Unemployment and ill health: understanding the relationship. *J Epidemiol Community Health*. 1994;48:333-7.
[7] Karpansalo M, Manninen P, Kauhanen J, Lakka TA, Salonen JT. Perceived health as a predictor of early retirement. *Scand J Work Environ Health*. 2004;30:287-92.
[8] Leino-Arjas P, Liira J, Mutanen P, Malmivaara A, Matikainen E. Predictors and consequences of unemployment among construction workers: prospective cohort study. *BMJ* 1999;319:600-5.
[9] Schuring M, Burdorf L, Kunst A, Mackenbach J. The effects of ill health on entering and maintaining paid employment: evidence in European countries. *J Epidemiol Community Health*. 2007;61:597-604.
[10] Thomas C, Benzeval M, Stansfeld SA. Employment transitions and mental health: an analysis from the British household panel survey. *J Epidemiol Community Health*. 2005;59:243-9.
[11] Donders NC, van der Gulden JW, Furer JW, Tax B, Roscam Abbing EW. Work stress and health effects among university personnel. *Int Arch Occup Environ Health*. 2003;76:605-13.
[12] Siegrist J. Adverse health effects of high-effort/low-reward conditions. *J Occup Health Psychol*. 1996;1:27-41.
[13] Waddell G, Burton K, Aylward M. Work and common health problems. *J Insur Med*. 2007;39:109-20.
[14] Borsch-Supan A, Jurges H, Mackenbach J, Siegrist J, Weber G. *Health, Ageing and Retirement in Europe. First results from the survey of Health, Ageing and Retirement in Europe. First results from the survey of Health, Ageing and Retirement in Europe*. Mannheim: Mannheim Research Institute for the Economic of Ageing (MEA); 2005.
[15] Borsch-Supan A, Kartsen H, Jurges H. A new comprehensive and international view on ageing: introducing the 'Survey of Health, Ageing and Retirement in Europe'. *Eur J Ageing*. 2005;2:245-53.
[16] Dwyer DS, Mitchell OS. Health problems as determinants of retirement: are self-rated measures endogenous? *J Health Econ*. 1999;18:173-93.
[17] Idler EL, Benyamini Y. Self-rated health and mortality: a review of twenty-seven community studies. *J Health Soc Behav*. 1997 ;38:21-37.
[18] Karasek R, Brisson C, Kawakami N, Houtman I, Bongers P, Amick B. The Job Content Questionnaire (JCQ): an instrument for internationally comparative assessments of psychosocial job characteristics. *J Occup Health Psychol*. 1998;3:322-55.
[19] Siegrist J, Wahrendorf M, von dem Knesebeck O, Jurges H, Borsch-Supan A. Quality of work, well-being, and intended early retirement of older employees: baseline results from the SHARE Study. *Eur J Public Health*. 2007;17:62-8.
[20] van Oort FV, van Lenthe FJ, Mackenbach JP. Material, psychosocial, and behavioural factors in the explanation of educational inequalities in mortality in The Netherlands. *J Epidemiol Community Health*. 2005;59:214-20.
[21] Hennekens C, Buring B, Mayrent S. *Epidemiology in Medicine*. Boston: Lippincott Williams&Wilkins 1987.

[22] Statistical package for social sciences (SPSS). 15 ed. Chicago, IL 2006.
[23] Schröder M. Attrition. In: Borsch-Supan A, Brugiavini A, Jürges H, Kapteyn A, Mackenbach J, Siegrist J, et al., eds. *Health, ageing and retirement in Europe (2004-2007) Starting the longitudinal dimension*. Mannheim: Mannheim Research Institute for the Economics of Aging (MEA) 2008:325-30.
[24] Bound J. Self-reported versus objective measures of health in retirement models. *Journal of Human Resources*. 1991;26(1):106-38.
[25] Kalwij A, Vermeulen F. Health and labour force participation of older people in Europe: what do objective health indicators add to the analysis? *Health Econ*. 2008;17:619-38.
[26] Baanders AN, Rijken PM, Peters L. Labour participation of the chronically ill. A profile sketch. *Eur J Public Health*. 2002;12:124-30.
[27] Bound J, Schoenbaum M, Stinebrickner TR, Waidmann T. The dynamic effects of health on the labor force transitions of older workers. *Labour economic*. 1999;6:179-202.
[28] McDonough P, Amick BC, 3rd. The social context of health selection: a longitudinal study of health and employment. *Soc Sci Med* (1982). 2001;53:135-45.
[29] Friis K, Ekholm O, Hundrup YA, Obel EB, Gronbiek M. Influence of health, lifestyle, working conditions, and sociodemography on early retirement among nurses: The Danish Nurse Cohort Study. *Scand J Public Health*. 2007;35:23-30.
[30] Arrow JO. Estimating the influence of health as a risk factor on unemployment: a survival analysis of employment durations for workers surveyed in the German Socio-Economic Panel (1984-1990). *Soc Sci Med* (1982). 1996;42:1651-9.
[31] Detaille SI, Heerkens YF, Engels JA, van der Gulden JW, van Dijk FJ. Common prognostic factors of work disability among employees with a chronic somatic disease: a systematic review of cohort studies. *Scand J Work Environ Health*. 2009;35:261-81.
[32] Dauchet L, Amouyel P, Hercberg S, Dallongeville J. Fruit and vegetable consumption and risk of coronary heart disease: a meta-analysis of cohort studies. *J Nutr*. 2006;136:2588-93.
[33] Matson-Koffman DM, Brownstein JN, Neiner JA, Greaney ML. A site-specific literature review of policy and environmental interventions that promote physical activity and nutrition for cardiovascular health: what works? *Am J Health Promot*. 2005;19:167-93.
[34] Varekamp I, Heutink A, Landman S, Koning CE, de Vries G, van Dijk FJ. Facilitating Empowerment in Employees with Chronic Disease: Qualitative Analysis of the Process of Change. *J Occup Rehabil*. 2009;19:398-408.
[35] Biering-Sorensen F, Lund J, Hoydalsmo OJ, Darre EM, Deis A, Kryger P, et al. Risk indicators of disability pension. A 15 year follow-up study. *Dan Med Bull*. 1999;46:258-62.
[36] Jusot F, Khlat M, Rochereau T, Serme C. Job loss from poor health, smoking and obesity: a national prospective survey in France. *J Epidemiol Community Health*. 2008;62:332-7.
[37] Rissanen A, Heliovaara M, Knekt P, Reunanen A, Aromaa A, Maatela J. Risk of disability and mortality due to overweight in a Finnish population. *BMJ*. 1990;301:835-7.
[38] Eriksen W, Natvig B, Rutle O, Bruusgaard D. Smoking as a predictor of long-term work disability in physically active and inactive people. *Occup Med*. 1998;48:315-20.
[39] Liira J, Leino-Arjas P. Predictors and consequences of unemployment in construction and forest work during a 5-year follow-up. *Scand J Work Environ Health*. 1999;25:42-9.
[40] Lund T, Csonka A. Risk factors in health, work environment, smoking status, and organizational context for work disability. *Am J Ind Med*. 2003;44:492-501.
[41] Rothenbacher D, Arndt V, Fraisse E, Zschenderlein B, Fliedner TM, Brenner H. Early retirement due to permanent disability in relation to smoking in workers of the construction industry. *J Occup Environ Med*. 1998;40:63-8.

[42] Haahr JP, Frost P, Andersen JH. Predictors of health related job loss: a two-year follow-up study in a general working population. *J Occup Rehabil*. 2007;17:581-92.
[43] Lund T, Iversen L, Poulsen KB. Work environment factors, health, lifestyle and marital status as predictors of job change and early retirement in physically heavy occupations. *Am J Ind Med*. 2001;40:161-9.
[44] Blekesaune M, Solem PE. Working conditions and early retirement. A prospective study of retirement behavior. *Research on aging*. 2005;27(1):3-30.
[45] Solomon C, Poole J, Palmer KT, Coggon D. Health-related job loss: findings from a community-based survey. *Occup Environ Med*. 2007;64:144-9.
[46] Duijts SF, Kant I, Swaen GM, van den Brandt PA, Zeegers MP. A meta-analysis of observational studies identifies predictors of sickness absence. *J Clin Epidemiol*. 2007;60:1105-15.
[47] Meerding WJ, W IJzelenberg, Koopmanschap MA, Severens JL, Burdorf A. Health problems lead to considerable productivity loss at work among workers with high physical load jobs. *J Clin Epidemiol*. 2005;58:517-23.
[48] Schultz AB, Edington DW. Employee health and presenteeism: a systematic review. *J Occup Rehabil*. 2007;17:547-79.
[49] Vahtera J, Virtanen P, Kivimaki M, Pentti J. Workplace as an origin of health inequalities. *J Epidemiol Community Health*. 1999;53:399-407.
[50] Kuper H, Marmot M. Job strain, job demands, decision latitude, and risk of coronary heart disease within the Whitehall II study. *J Epidemiol Community Health*. 2003;57:147-53.

Chapter 3

The influence of health and work on early retirement

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Abstract

Objective: The influence of health and work on early retirement and incentives for longer working were determined.

Methods: A systematic review was conducted of longitudinal studies on factors for non-disability early retirement. Besides, seven focus group interviews (n=32) were conducted about reasons for planning retirement early and incentives to stay longer in work among workers with poor and excellent work ability.

Results: Eight longitudinal studies showed that important factors for early retirement were poor health, being single, high physical work demands, high work pressure, low job satisfaction, and lack of physical activity in leisure time. In addition, focus group participants reported shift work, social support, and appreciative leadership style also as factors.

Conclusions: Poor health and poor work circumstances are important factors in decisions to retire early. Social support and appreciative leadership style may be buffers in this process.

Introduction

Industrial sectors with highly qualified technical jobs, such as the printing industry, are among the sectors that will be faced with an aging worker population. In some ways, older workers are the most skilled and productive employees, but in other ways, they are the most vulnerable [1]. Older workers differ from their younger counterparts regarding physical and mental capabilities that accompany aging, which might have a negative impact on their safety and health at work. Therefore, there is a need for employers to anticipate the difference in physical and cognitive capacities of older workers and to develop programs and policies in line with the individual needs of the workers involved. With respect to working longer in good health, improving or sustaining work ability among older workers is seen as an important challenge [2, 3]. The work ability concept is based on the assumption that the ability of a worker to perform job tasks successfully depends on the equilibrium between physical and mental job demands with individual capacities, determined by health, professional knowledge and competencies, and values, attitudes and motivation to work. The work ability index (WAI) [4] is by far the most used, and well-accepted instrument to measure work ability. There is an overall decrease in work ability with age, but there are substantial inter-individual differences [1, 5]. Some studies have shown that a low work ability score predicts early-retirement and other types of displacement from the labour market during follow-up. Lower work ability predicted early retirement during 5-year follow-up in a Danish cohort of workers in different occupations [6]. Hopsu et al (2005)[7] reported that among cleaners, a higher work ability at baseline was predictive of staying at work during 4-year follow-up and 75% of all early retirees during follow-up had a poor or moderate work ability at baseline. Among workers in the food industry, the mean WAI score was lower among early pensioners than among pensioners retiring at the legal retirement age, i.e.25% of the last group had a poor or moderate work ability at baseline, whereas this percentage was 57% for early pensioners [8].

In general, leaving the labour market before old age pension is influenced by so-called push and pull factors [3, 9]. Push factors are negative considerations, which induce people toward early exit, such as poor health, lack of job satisfaction, changes in work and work organization, and being tired of working. Pull factors are positive considerations and increase employee's interest in early retirement. Among these are, for instance, getting more time for hobbies, desire to spend more time with the spouse who has already retired, and the possibility to perform voluntary work. The combination of pushes and pulls and the context in which they occur are determining the influence on the decision to retire [9].

This study explored work- and health-related factors that influence older workers to retire early and the incentives that might encourage postponing early retirement. First, a systematic review was conducted to gain background information regarding work- and health-related determinants of early retirement. Second, focus group interviews were conducted to explore reasons for planning to retire early among workers with decreased and excellent work ability and factors contributing to work longer.

Methods

Literature study determinants of early retirement

Identification of the studies

Relevant articles were identified by means of a computerized search of the bibliographical databases PubMed, from January 1966 to December 2007, and Web of Science during the period of January 1988 to December 2007. The search strategy constituted six steps (Table 1). The search was restricted to studies published in the English language. The focus was health- and work-related factors, thus excluding economic literature. For this study, premature exit from the labour market was restricted to early retirement, excluding work disability. The literature search identified 347 abstracts with 93 abstracts in both the databases, resulting in 254 unique abstracts.

Selection

Studies were excluded if (a) the study design was cross-sectional, or (b) subjects were not employed at baseline measurements, (c) the outcome measure early retirement was not clearly defined, (d) only subjects with specific chronic diseases were included in the study population, (e) no quantitative information on associations between health status, individual and work-related factors and early retirement was presented, or (f) major methodological problems were present, which hampered the interpretation of measures of association.

Based on titles, 102 out of 254 abstracts (40.2%) were discarded. Based on abstracts, another 85 abstracts were discarded because the outcome measure was not early-retirement (n=7), no information was presented on associations between determinants and early retirement (n=16), subjects were patients with a specific chronic disease (n=14) and miscellaneous reasons (n=48). In total, 67 articles were retrieved for full review, from which 7 studies were included in this review [10-17]. Reasons for exclusion of articles were cross-sectional study design (n=3), outcome measure was not early-retirement (n=36; from which 20 studies used disability pension as an outcome measure),

Table 1 Search strategy for a systematic review on the effects of work load and health on early-retirement

	Search terms	# items found PubMed	# items found WOS
#1	**Early-retirement** early-retirement	345	447
#2	**Work-related** occupation* OR work-related OR worker OR industrial OR work OR labour OR labor OR job	652995	>100.000
#3	**Physical work demands** physical* OR manual-material handling OR push* OR pull* OR lifting OR posture OR vibration OR workload OR repetitive movement* OR bend*	476773	>100.000
#4	**Psychosocial work demands** psychosocial-work* OR job stress* OR job-support OR work-pace OR mental-stress* OR monotonous-work OR job-dissatisfaction OR job-satisfaction OR autonomy OR work-schedule* OR work-time* OR work-pressure* OR social-support	70029	39888
#5	**Health** health-status* [MESH] OR perceived-health OR ill-health OR health	1079494	>100.000
#6	**#1 AND (#2 OR #3 OR #4 OR #5)**	174	173

WOS = Web of Science

only subjects with a specific chronic disease were included (n=3), no quantitative information on associations (n=16), and severe methodological shortcomings (n=2).

Data extraction

Determinants of early retirement were categorized into health status, demographic variables, physical work demands, psychosocial work demands, and lifestyle factors. The effect of age on early retirement was excluded, as early retirement is evermore age dependent.

The analysis focused on measures of association, expressed by, for example, an odds ratio (OR), or a regression coefficient. Whenever possible the measure of association was retrieved from the original article, together with the variables that were adjusted for in the statistical analysis. In case this information was not present, available raw data in a 2x2 table was used to calculate an OR and confidence interval (CI).

Heterogeneity of study results was tested with the Epipool [18].

Focus group interviews

The printing industry in the Netherlands is an illustrative example of a branch of industry with a rapidly aging workforce and limited number of new recruits. Therefore, workers over 40 years of age among three companies in this industry were selected as study population. Within each company, one focus group interview with workers with decreased work ability was planned and one with workers with excellent work ability. The latter focus groups were done as peer group to gain insight in differences in opinions and perceptions possibly influenced by work ability status.

The WAI [4] was used to select workers with a decreased and excellent work ability. The WAI consists of seven dimensions on physical and mental demands at work, previously diagnosed diseases, and limitations in work due to disease, sick leave, work ability prognosis, and psychological resources. The index is derived as the sum of the ratings on these dimensions. The range of the summative index is 7 to 49, which is classified into a poor (7-27), moderate (28-36), good (37-43), or excellent (44-49) work ability.

The study population, which was asked to fill in the WAI questionnaire, consisted of 246 men (85%) and 43 women (15%) (response 50%). The median age was 49 years old (40-62 years). The distribution of excellent, good, moderate, and poor work ability was 24.7%, 51.6%, 19.4%, and 4.2%, respectively.

Participants for the focus groups were invited by telephone by the researcher in ascending order of WAI score for the decreased work ability group and in descending order for the excellent group. Participation was restricted to a maximum of eight participants per interview or WAI score minimum of 44 for the excellent group and maximum of 36 for the decreased work ability group from which eight participated (67%); 22 subjects with moderate work ability were additional invited from which 11 participated (50%). Response was lower in the excellent work ability group; 46 subjects were invited from which 13 participated (28%).

Finally, three interview groups with decreased WAI and two interview groups with excellent WAI took place. Each focus group consisted of five to eight workers (total 32 workers). The mean WAI for the group with decreased work ability was 28.3. The mean WAI for the group with excellent work ability was 46.1. The mean age was significantly higher among workers with poor work ability (53 years) than among those with an excellent work ability (48 years). The groups with a decreased work ability included 74% workers whose occupation can be categorized as blue-collar worker and 26% as white-collar worker. Within the groups with excellent work ability, 62% were blue-collar workers, and 39% were white-collar workers.

All focus group interviews followed a semi-structured route with the following main

questions [19];

a. Which factors hamper your ability to stay in paid employment until 65 years of age?
b. Which changes in your work and individual situation would be contributing to prevent early retirement?

The focus group interviews for workers with decreased work ability were conducted first. The arguments that emerged consistently from these interviews were listed as statements concerning reasons for planning to retire early and contributing incentives to prevent early retirement. Subsequently, participants were asked by mail to rank the statements according to their perceived importance for early retirement on a scale from 1 'totally disagree' to 4 'totally agree'. Within the group, decreased work ability ranking forms were filled in by 17 of the 19 participants.

Subjects of the excellent groups were asked to rank the statements independent from each other during the interview, after which the focus group interviews followed the same route as described above. In total, complete data was available for 30 subjects, of which 17 decreased WAI and 13 excellent WAI. All interviews were audio recorded and summarized. At the start of the interviews subjects were informed that their names would remain confidential. Differences between both groups in ranking of the statements were analyzed using the Mann-Whitney test.

Results

In total, determinants of early retirement were reported in eight longitudinal studies (Table 2, Figure 1). Most Scandinavian and one European study defined early retirement as retirement during the age of 55 to 65 years [12-15, 17]. Other age definitions were used in an Italian study (before the age of 49 years)[11] and in a British study (50-59,5 years)[16]. A Norwegian study defined early retirement as a drop in income not related to disability [10]. The majority of included studies concerned large samples of the general working population, whereas three studies addressed specific occupational groups, i.e. nurses[12], waste collectors[15], and civil servants[16].

Six studies reported an influence of poor health on early retirement, with risks varying between 1.16 and 3.36, and 4 of 6 studies showed a statistically significant association [12, 14, 16, 17]. The demographic factors gender, education, and marital status were studied. In an Italian study [11], women had an increased risk of early retirement (OR=3.7). One Norwegian study showed that a lower education was positively associated with early retirement [10], whereas an Italian study showed an opposite association [11].

Table 2 Associations between health, individual and work-related determinants and early-retirement in epidemiological cohort studies among occupational populations.

Authors	Follow-up	Study population	Outcome	Determinant	Association	95% CI
Blekesaune et al. 2005 [10]	3.4 yr	19114 employees aged 60-67 yr	Non-disability retirement	Living together	OR 0.92	0.64-1.34
				High education	OR 0.96*	0.94-0.98
				Physical strains in job	OR 0.93	0.86-1.01
				Job stress	OR 1.04	0.91-1.19
				Low autonomy	OR 1.17*	1.11-1.24
Cardano et al. 2004 [11]	10 yr	127 384 Turin residents, aged 25-49yr	Early-retirement	Woman	OR 3.74*	3.32-4.20
				Low education	OR 0.75*	0.65-0.86
				Mother	OR 0.96	0.83-1.11
Frijs et al. 2007 [12]	9 yr	5538 nurses aged 51-59 yr	Early-retirement	Less than good health	HR 1.28*	1.16-1.41
				Evening work vs. day work	HR 0.89*	0.80-0.98
				Night work vs. day work	HR 1.04	0.92-1.19
				Shift work vs. day work	HR 0.80*	0.72-0.89
				High work pressure	HR 1.09*	1.01-1.17
				Low influence at work	HR 1.09*	1.01-1.18
				Physical demands at work	HR 1.08	1.00-1.17
				Leisure-time physically active	HR 1.13*	1.04-1.22
				BMI 25-30 vs. <25	HR 1.12*	1.04-1.21
				BMI >30 vs. <25	HR 1.06	0.91-1.24
Karpansalo et al. 2004 [14]	11 yr	1748 middle-aged men	Non-illness-based pension	Poor health	OR 3.36*	2.20-5.13
Karpansalo et al. 2005 [13]	1-6yr	1726 middle-aged men	Non-illness based pension	High depressive symptoms vs. low depressive symptoms	HR 1.86*	1.37-2.51
				Moderate depressive symptoms vs. low depressive symptoms	HR 1.04	0.78-1.37
Lund et al. 2001 [15]	2.5 yr	149 male waste collectors and municipal workers aged >56	Early-retirement	Extreme bending of the neck	OR 6.78*	2.56-17.96
				Musculoskeletal disorders of the knees	OR 1.56	0.67-3.60
				Current smoking	OR 0.80	0.27-2.38
				Former smoking	OR 0.64	0.21-1.99
				Having a partner	OR 2.79*	1.08-7.19
Mein et al. 2000 [16]	7 yr	1699 males civil servants age 50-59.5yr	Early-retirement	No job satisfaction	RR 1.99*	1.56-2.53
				Moderate health vs. good/very good health	RR 1.23	0.98-1.54
				Bad/very bad health vs. good/very good health	RR 1.55*	1.18-2.04
		833 females civil servants age 50-59.5 yr	Early-retirement	No job satisfaction	RR 1.63*	1.12-2.38
				Moderate health vs. good/very good health	RR 1.16	0.78-1.73
Schuring et al. 2007 [17]	1 yr	4514 workers age 55-65 yr	Early retirement	Poor health-low education vs. good health-high education	OR 1.7*	1.4-2.2
				Good health-low education vs. good health-high education	OR 1.3	1.0-1.6
				Poor health-intermediate education vs. good health-high education	OR 2.0*	1.6-2.7
				Good health-intermediate education vs. good health-high education	OR 1.4*	1.1-1.6
				Poor health-high education vs. good health-high education	OR 1.5	1.0-2.2
				Living together	OR 0.8	0.7-1.0

(OR=odds ratio, 95% CI= 95% confidence interval, * = p<0.05)

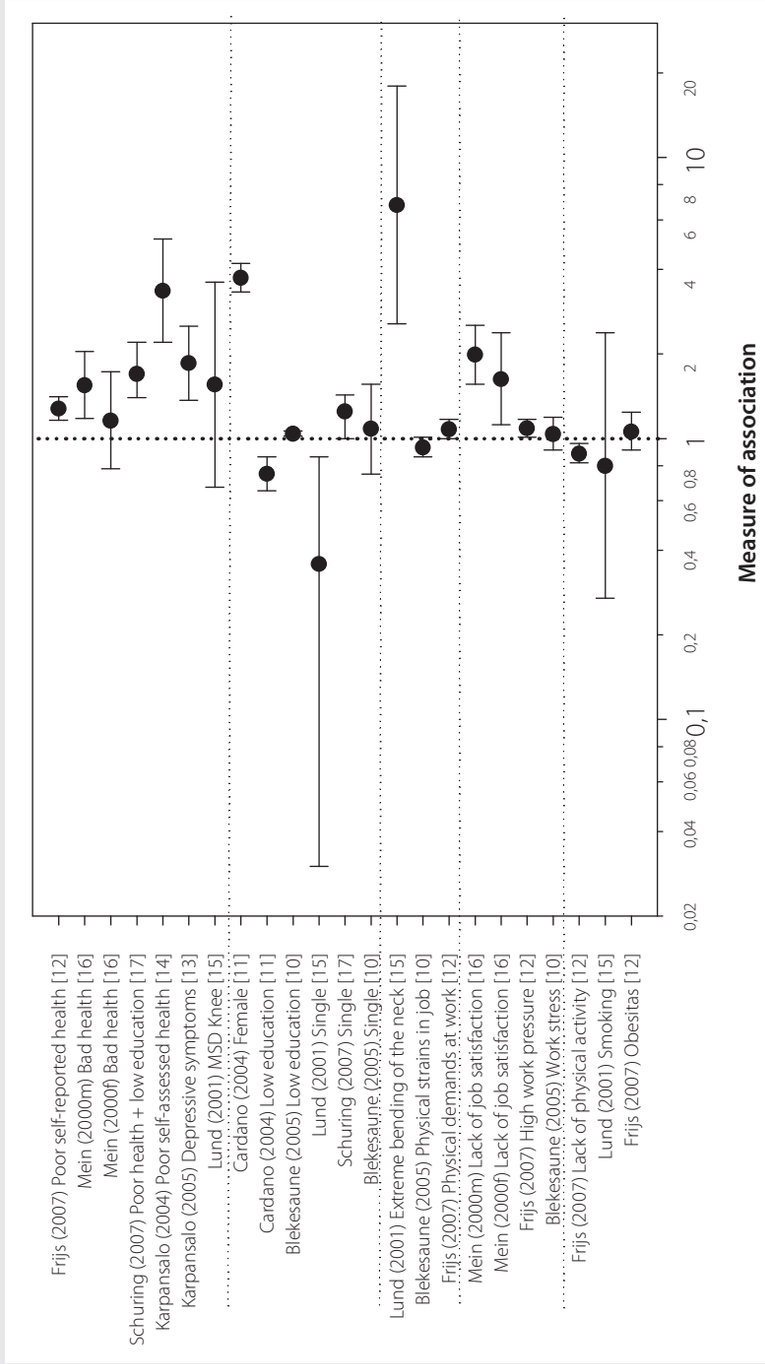


Figure 1 Schematical overview of the associations between health, individual and work related factors and early-retirement.

According to a Danish study living together increased the risk for early retirement [15], while studies in other countries showed no effects [10, 17].

Among waste collectors, working with bending of the neck was a risk factor [15], whereas two studies could not demonstrate that heavy physical work was associated with early retirement [10, 12]. A lack of job satisfaction was associated with early retirement among civil servants in Great Britain [16]. A high work pressure was a risk factor among Danish nurses [12], but not important in the general Norwegian working population [10].

With regard to lifestyle factors, one study showed that physically active nurses had a higher risk for early retirement [12], whereas no associations were found between smoking and obesity and early retirement [12, 15].

Results of the focus group interviews

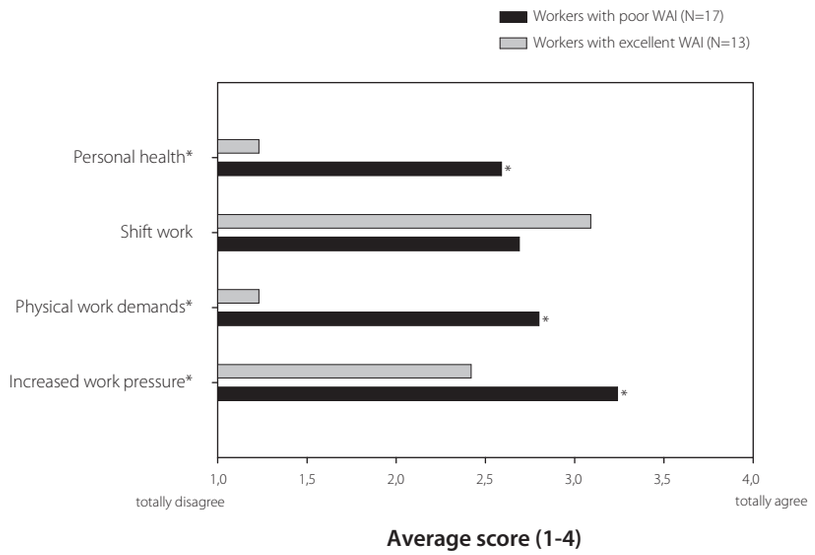
Reasons for planning to retire early

The majority of the subjects expressed doubts about their ability to carry on working until the age of 65 years old in there current job. *"With my current work situation I cannot carry on working until the age of 65 years old. Within two years I will be burnout." "Probably I would be able to keep working until 65 years old, but at that time I would not have the same creativity and alertness as right now."* Regarding the age of retirement, some subjects mentioned the negative side effects of an obligatory retirement age. Certain workers argued that a flexible age of retirement would probably motivate them to sustain working. One worker in the group with excellent work ability preferred to have more time for voluntary work and, therefore, quitting paid employment earlier.

All participants expressed good physical health as a relevant condition to prevent early retirement. Subjects wanted to perform excellent. When there physical and mental abilities are lacking, the incapacity to perform excellent is an extra pressure. In this respect, one subject stated that the ability to continue working was not age related but dependent on the physical abilities of the worker itself. *"Of course there will be more physical complaints by ageing, but it strongly differs per person."* However, new working techniques and changes in work methods were seen as more problematic for older workers. High work pressure was ranked highest as reason for planning to retire early (Figure 2).

Related aspects to work pressure mentioned were overtime work, few workers for the activities to be carried out, effects of work stress at home, conflict between quantity and quality of work, lack of social support from colleagues, lack of reward from colleagues and management, lack of competence and lack of task alternation: *"You need to perform*

Figure 2 Ranking of reasons to plan early retirement among workers in the printing industry.



* =p<0.05

the same output with less workers." "You don't have any time to take a short break during the work." "The pressure of cost budgets has increased tremendously by internet with more hurried orders."

Shift work was cited as a reason for planning early retirement in all five focus group interviews: *"I think approximately 90% of all workers perceive problems in the switch to the morning shift"*," *The time between shifts is too short to recover"*, *"It is also dependent of age; in the past I had no problems, but now I sleep much less"*, "*This week I had three different shifts. That is to much variation.*", and *"Shift work is top sport"*.

High physical work load was also often mentioned: *"I am not sure if I can carry on this physically heavy job until the age of 60 years"*. *"If I still would do my work over 5 years, it would be pretty heavy."* For older workers with physical complaints the lack of possibilities to adapt working tasks to their reduced capabilities was also mentioned.

Factors were also interrelated, for example, one subject remarked *"Six night shifts are heavy, but when you also have some overweight, you are sick in an eye blink"*.

Within the groups of subjects with a poor WAI and those with an excellent WAI, a high agreement was present for all reported reasons for planning to retire early. Nevertheless, the perceived importance of the factors, except for shift work, was statistically significantly higher among workers with a poor WAI.

Incentives to postpone early retirement

One of the questions on contributing factors to prevent early retirement was "What would you do to postpone early retirement of your personnel if you were the CEO of this company?" Irrespective of WAI category, in every focus group interview 'giving more rewards' was mentioned, which was also ranked highest (Figure 3): *"give workers the feeling they are appreciated, for example by giving them more compliments"*. Related to rewards, supervisors being present at the shop floor, and showing interest in the worker was mentioned. Subjects were also positive about improving personal fitness, because their physical condition was perceived as an important factor for their work ability. *"It would stimulate me to have access to a worksite gym."*

Regarding social support from colleagues, different aspects were mentioned, such as flexibility to rotate shifts among each other, helping colleagues, leaving a clean workplace for the next shift, all based on the principle: *"I do something for you, next time you do this for me in return."* Participants also expressed that more personnel would positively influence their ability to continue working: *"It would be useful to have more workers per machine."*

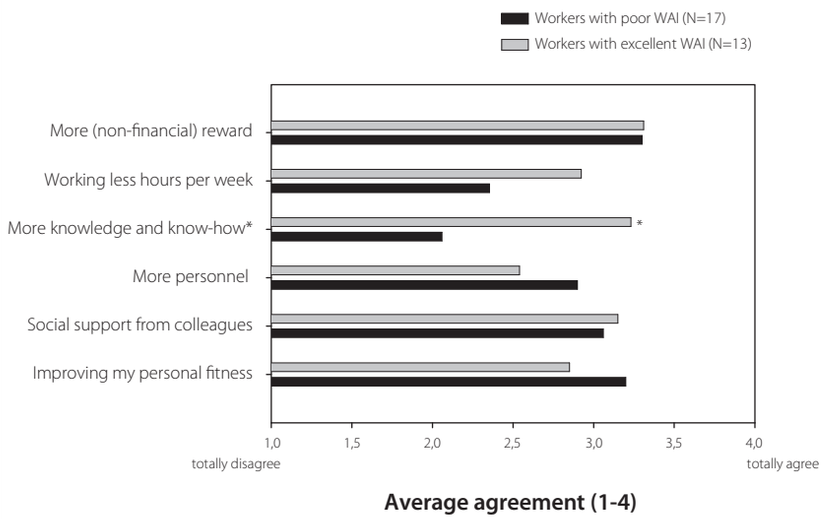
Job rotation, for example within autonomous teams, was also mentioned as a possibility to reduce work demands. A voice in time schedules, especially with shift work, would be of interest for workers with specific preferences.

According to participants, the supervisor would be best equipped to support workers in prolonging their working career because they would have the best insight in the specific situation of employees. Human resource officers were not mentioned often as professionals that could facilitate sustained employment. Some subjects referred to the workers' own responsibility with respect to addressing barriers to continue working or problems with physical or mental capacities to fulfil working demands.

In all focus group interviews, subjects were moderately positive about additional training on the job and gaining more knowledge to better match required competences. Regarding working fewer hours per week, opinions were more sceptical: *"It is no use, as I always work more than in my contract"* and *"Working fewer hours also has financial consequences"*. Some subjects were positive about the option to quit paid employment gradually as it would reduce the sudden change between working life and retirement.

With less consistency several, other interventions were mentioned, such as 'ergonomic

Figure 3 Ranking of the importance of incentives to prevent early retirement among workers in the printing industry.



* =p<0.05

interventions', 'improving climate control', 'interventions to prevent hearing loss', and 'focus on a good work ambience at the workplace'.
Subjects were aware that not every aspect of the work situation can be changed to everyone's wishes, but an explanation from the supervisor what was considered not to be feasible would be very welcome.
In general, there was good agreement between subjects with a poor WAI and those with an excellent WAI on type of required interventions (Figure 3).

Discussion

Longitudinal studies have shown that poor health and, to a lesser extent physical and psychosocial work load are important factors in early retirement. Focus group interviews among older workers confirmed the importance of these factors as reasons for early retirement but also showed the importance of appreciative leadership style, social support at work, and health promotion to postpone early retirement.

The literature review and the results of the focus group interviews showed the importance of poor health in early retirement. This is supported by studies within patient populations which show that workers with specific diseases have a higher risk for early-retirement [13, 15, 20-22]. Most studies did not report any information regarding the time window between a decreased health and early retirement. Schuring et al. (2007)[17] showed with different follow-up periods before a transition from work to early retirement that for the majority of early-retirees an accumulation of prolonged health complaints was the decisive factor rather than acute health problems.
For the demographic factors, education and marital status the literature review showed conflicting results. During the focus interviews having a spouse at home was not mentioned as a factor in retirement decisions, whereas this was mentioned as a pull factor in the literature [9]. There are some indications that the effect of poor health on work participation is modified by sociodemographic factors [17].
Only four studies analyzed the effect of work-related factors on early retirement [10, 12, 15, 16]. The lack of studies on work-related factors is striking as they dominate the push concept in retirement decisions. Especially, physical work demands have been studied seldom in relation to early-retirement, whereas for certain occupations, the legal retirement age is based on age-dependent physical capacities, such as fire-fighters, ambulance workers, police officers, and army officers [23-26]. In the focus group interviews high physical work demands were mentioned, but more in the sense of 'it belongs to the work characteristics, so deal with it'. The discussion regarding psychosocial aspects of work demand, working hours, and work organization was substantially longer. The interaction between these aspects and negative contribution to workers' health is well-known from the demand-control-support model [27]. A recent study among Dutch older workers showed that workers who perceived high job pressure intend to retire earlier [28]. However, the same study also showed that a high job pressure was significantly associated with a later retirement in the same cohort.
The perceived negative impact of shift work on work participation at older age was corroborated in a recent review, that outlined the complexity of this issue and confirmed that shift work may lead to health problems among aging workers [29]. All focus group interviews demonstrated the importance of (nonfinancial) rewards in the sense of feelings of appreciation, pat on the back, and receiving compliments. A cross-sectional study among European workers also showed an association between effort-reward imbalance and intention to early retirement [30]. Results are also in line with a Finnish study among aging workers, which demonstrated the importance of

appreciative and supportive leadership [31]. The effort-reward imbalance aspects discussed in the focus groups can be best described with the term relational injustice, alluding to the extent to which employees are treated with respect and fairness by their supervisors [32].

Because of financial consequences, participants said they would not favour to work fewer hours to prevent early retirement. In contrast, the American Health and Retirement Study [33] showed that three out of four older workers would prefer to reduce hours gradually rather than retire abruptly and that older subjects were increasingly interested in part-time opportunities.

The printing industry is characterized by a rapidly changing technology, whereby knowledge on how to operate machinery is outdated within a relatively short period of time. Despite acknowledging this problem, the workers in the focus groups showed almost no interest in receiving individual training and education, especially among subjects with a poor work ability. Increasing investment in human capital of older workers is a frequently mentioned instrument for improving labour market opportunities, improving work ability and delaying early retirement of older workers [2, 34]. The lack of interest in training is in line with European findings on lower participation in training among older workers. A possible explanation is presented by the human capital theory, which predicts that human capital investments are lower for older workers compared with younger workers, since there will be less financial benefits from the efforts required [34]. This may also contribute to higher lack of interest in training among workers with decreased work ability, because these workers have an increased risk for premature departure from working life and are, therefore, less inclined to invest in their professional career.

The systematic review showed no positive effect of a healthy lifestyle on prolonging working careers after controlling for health status [12, 15]. It seems lifestyle does not have a direct effect on continuing work. Reactions of workers in the focus group interviews also showed that the negative effects of an unhealthy lifestyle were regarded to indirectly affect their capabilities to perform their work, for example, overweight may contribute to a poor health, and physical activities in leisure time may be a method to cope with work stress.

Subjects with an excellent work ability recognized the factors mentioned by their colleagues with poor work ability, although these factors did not yet have an effect on their retirement intentions. A recent study on retirement intentions and actual retirement behaviour showed that there is a gap between factors that influence retirement intentions and actual behaviour, such as subjective life expectancy and job pressure

[28]. This study was also a combination of factors with a demonstrated influence on retirement and intentions to retire in the future. Ill health was a consistent factor in both approaches, but important factors brought up in the focus groups, such as high reward and supportive leadership, were not found in the literature study on actual retirement. Future research should focus on the discrepancy between retirement intentions and determinants of actual retirement and the consequences of these discrepancies for policies aimed at continuing work.

This study has some limitations. The literature search may not be comprehensive enough, because publications in languages other than English were not included, and the search was limited to two computer-based bibliographic databases. The search in Web of Science resulted in an additional 97 articles relative to Pubmed. Nevertheless, it cannot be ruled out that relevant publications would have been identified when using additional databases. The literature review was restricted to longitudinal studies on actual retirement behaviour. Despite extensive research on retirement, the number of eligible studies was small. This came as a surprise, given the current debate on policies to extend working careers.

Another limitation lies in the nature of the synthesis of results. A meta-analysis was not possible because of the large heterogeneity in definition and measurement of determinants. A test of homogeneity showed study results regarding poor health and marital status were heterogenic. Some studies focused on one specific occupation or gender. Comparability was hampered by differences in outcome definition and highly dependent of the social security system in the country of origin.

The focus groups may have been dominated by participants who were more articulate than others or by participants who are more dominant than others. This was as much as possible prevented by the discussion leader. Because of a selection on WAI scores, the mean age was significantly higher in the groups with a poor WAI. No significant differences were found regarding the distribution of blue- and white-collar workers between both groups.

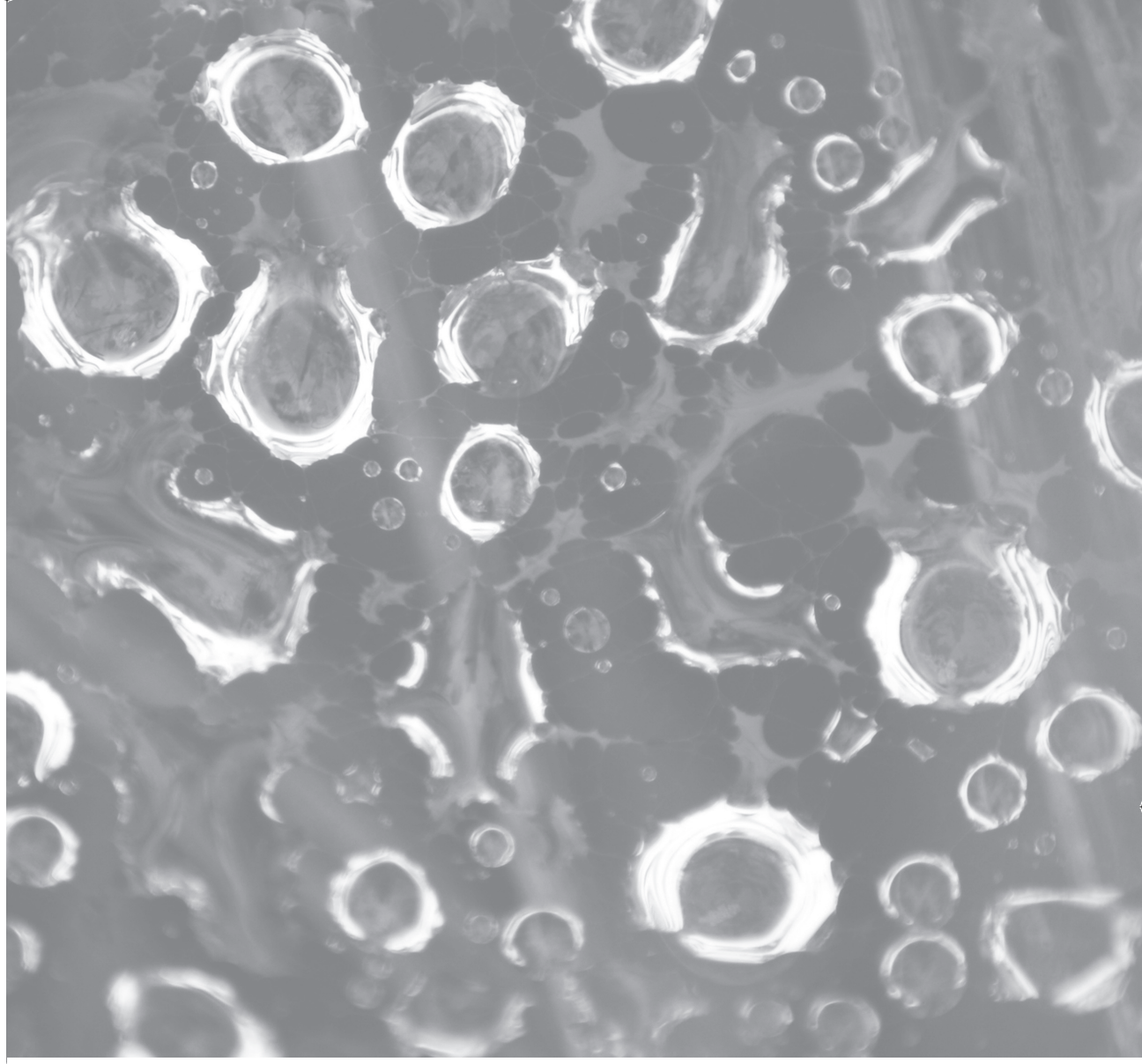
Conclusion and recommendations

Longitudinal studies have shown that poor health and, to a lesser extent high physical and psychosocial work demands are important factors in early retirement. Focus group interviews confirmed these results and added more insights into the retirement decision process. Postponing early retirement could be facilitated by reducing work load and by increasing social support from colleagues, appreciative and supportive leadership, and health promotion. Evaluative research is needed to determine the effectiveness of the proposed interventions on actual retirement behaviour.

References

[1] Silverstein M. Meeting the challenges of an aging workforce. *Am J Ind Med.* 2008;51:269-80.
[2] Ilmarinen J. Aging workers. *Occup Environ Med.* 2001;58:546-52.
[3] Stattin M. Retirement on grounds of ill health. *Occup Environ Med.* 2005;62:135-40.
[4] Tuomi K, Ilmarinen J, Jahkola A, Katajarinne L, Tulkki A. *Work ability index.* 2nd revised ed. Helsinki 1998.
[5] van den Berg TI, Elders LA, de Zwart BC, Burdorf A. The effects of work-related and individual factors on the Work Ability Index: a systematic review. *Occup Environ Med.* 2009;66:211-20.
[6] Sell L, Bultmann U, Rugulies R, Villadsen E, Faber A, Sogaard K. Predicting long-term sickness absence and early retirement pension from self-reported work ability. *Int Arch Occup Environ Health.* 2009;82:1133-1138.
[7] Hopsu L, Leppännen A, Ranta R, Louhevaara V. Perceived work ability and individual characteristics as predictors of early exit from working life in professional cleaners. *Int Congr Ser.* 2005;1280:84-8.
[8] Salonen P, Arola H, Nygard CH, Huhtala H, Koivisto M. Factors associated with premature departure from working life among ageing food industry employees. *Occup Med.* 2003;53:65-8.
[9] Shultz KS, Morton KR, Weckerle JR. The influence of push and pull factors on voluntary and involuntary early retirees' retirement decision and adjustment. *J Voc Beh.* 1998;53:45-57.
[10] Blekesaune M, Solem PE. Working conditions and early retirement - A prospective study of retirement behavior. *Res Aging.* 2005;27:3-30.
[11] Cardano M, Costa G, Demaria M. Social mobility and health in the Turin longitudinal study. *Soc Sci Med.* 2004;58:1563-74.
[12] Friis K, Ekholm O, Hundrup YA, Obel EB, Gronbaek M. Influence of health, lifestyle, working conditions, and sociodemography on early retirement among nurses: the Danish Nurse Cohort Study. *Scand J Public Health.* 2007;35:23-30.
[13] Karpansalo M, Kauhanen J, Lakka TA, Manninen P, Kaplan GA, Salonen JT. Depression and early retirement: prospective population based study in middle aged men. *J Epidemiol Community Health.* 2005;59:70-4.
[14] Karpansalo M, Manninen P, Kauhanen J, Lakka TA, Salonen JT. Perceived health as a predictor of early retirement. *Scand J Environ Health.* 2004;30:287-92.
[15] Lund T, Iversen L, Poulsen KB. Work environment factors, health, lifestyle and marital status as predictors of job change and early retirement in physically heavy occupations. *Am J Ind Med.* 2001;40:161-9.
[16] Mein G, Martikainen P, Stansfeld SA, Brunner EJ, Fuhrer R, Marmot MG. Predictors of early retirement in British civil servants. *Age Ageing.* 2000;29:529-36.
[17] Schuring M, Burdorf L, Kunst A, Mackenbach J. The effects of ill health on entering and maintaining paid employment: evidence in European countries. *J Epidemiol Community Health.* 2007;61:597-604.
[18] Fleiss JL. The statistical basis of meta-analysis. *Stat Methods Med Res.* 1993;2:121-45.
[19] Morgan DL, Kruger RA. *The focus group kit.* Thousans Oaks, CA: SAGE Publications 1998.
[20] Geuskens GA, Burdorf A, Hazes MW. Consequences of Rheumatoid arthritis for performance of social roles - A literature review. *J Rheumatol.* 2007;34:1248-60.
[21] Vijan S, Hayward RA, Langa KM. The impact of diabetes on workforce participation: results from a national household sample. *Health Serv Res.* 2004;39:1653-69.
[22] Solomon C, Poole J, Palmer KT, Coggon D. Health-related job loss: findings from a community-based survey. *Occup Environ Med.* 2008;64:144-9.
[23] Saupe K, Sothmann M, Jasenof D. Aging and the fitness of fire fighters: the complex issues involved in abolishing mandatory retirement ages. *Am J Public Health.* 1991;81:1192-4.

[24] Rodgers LM. A five year study comparing early retirements on medical grounds in ambulance personnel with those in other groups of health service staff. Part II: Causes of retirements. *Occup Med (Lond).* 1998;48:119-32.
[25] Rodgers LM. A five-year study comparing early retirements on medical grounds in ambulance personnel with those in other groups of health service staff. Part I: Incidences of retirements. *Occup Med (Lond).* 1998;48:7-16.
[26] Sluiter JK. High-demand jobs: age-related diversity in work ability? *Appl Ergon.* 2006;37:429-40.
[27] Karasek RAJ, Theorell T. *Healthy work: stress, productivity and the reconstruction of working life.* New York: Basic Books. 1990.
[28] van Solinge H, Henkens K. Living longer, working longer? The impact of subjective life expectancy on retirement intentions and behaviour. *Eur J Public Health.* 2010;20:47-51.
[29] Costa G, Milia LD. Aging and shift work: a complex problem to face. *Chronobiol Int.* 2008;25: 165-81.
[30] Siegrist J, Wahrendorf M, von dem Knesebeck O, Jurges H, Borsch-Supan A. Quality of work, well-being, and intended early retirement of older employees: baseline results from the SHARE Study. *Eur J Public Health.* 2007;17:62-8.
[31] Naumanen P. The health promotion model as assessed by ageing workers. *J Clin Nurs.* 2006;15: 219-26.
[32] Kivimaki M, Vahtera J, Elovainio M, Virtanen M, Siegrist J. Effort-reward imbalance, procedural injustice and relational injustice as psychosocial predictors of health: complementary or redundant models? *Occup Environ Med.* 2007;64:659-65.
[33] Karp FE. *Growing older in America: The Health and Retirement Study.* Washington, D.C.: National Institute on Aging; 2007.
[34] Fouarge D, Schils T. The effect of early retirement incentives on the training participation of older workers. *Labour.* 2009;23:85-109.



Part 2

Determinants of Work Ability

Chapter 4

The effects of work-related and individual factors on the Work Ability Index: a systematic review

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Abstract

Objectives. This paper systematically reviews the scientific literature on the effects of individual and work-related factors on the work ability index (WAI).

Methods. Studies on work ability published from 1985 to 2006 were identified through a structured search in PubMed, and Web of Science. Studies were included if the WAI was used as measure of work ability (defined by the extent to which a worker's capabilities is matched by the demands at work) and if quantitative information was presented on determinants of work ability.

Results. In total, 20 studies were included with 14 cross-sectional studies and six longitudinal studies. Factors associated with a poor work ability, as defined by WAI, were lack of leisure-time vigorous physical activity, poor musculoskeletal capacity, older age, obesity, high mental work demands, lack of autonomy, poor physical work environment, and high physical work load.

Conclusion. The WAI is associated with individual characteristics, lifestyle, demands at work, and physical condition. This multifactorial nature of work ability should be taken into account in health promotion programmes aimed at maintaining and promoting the participation of the labour force and improvement of the performance at work.

Introduction

Most Western countries with an ageing population face the challenge of a need to increase work participation, especially at older age. Governmental policies are implemented to increase the age of full retirement in order to balance the ratio of employed over dependent persons [1]. Yet, in most countries the average age of permanent departure from paid labour is well below the statutory pension age [2], so there is a need to develop interventions that will facilitate workers to be engaged in paid employment until pension age.

Ageing of workers is accompanied with changes in physical and mental capacities. However, individual differences are large and lifestyle factors such as physical activity in leisure time may substantially influence the balance between work capacity and work demands [3]. Work demands that are not sufficiently attuned to physical and mental capacities of workers may increasingly cause health problems and subsequently displacement from the workforce [2]. The contribution of (work-related) health problems to unemployment and early retirement among older workers is substantial [4].

In order to increase work participation and prolong the working life among older workers the concept of work ability has been developed in the early 1980s in Finland, and was later adopted in various other European and Asian countries. According to Ilmarinen [5], work ability is built on the balance between a person's resources and work demands. The bases for work ability are health, and functional capacity, but work ability is also determined by professional knowledge and competence (skills), values, attitudes, and motivation, and work itself.

Work ability has been measured in different ways. For example, by single questions asking respondents to range their current work ability on a 5- or 10-point scale [6]. Moreover, work ability has been defined as not being on long-term sick leave [7], or in total days on sick leave during the last 12 months [8]. Studies have shown that a poor work ability increased the risk on early retirement [9], long-term sickness absence, and work disability [10].

The Work Ability Index (WAI) [11] is by far the most used, and well-accepted instrument to measure work ability, as is demonstrated by its availability in 21 languages. Although several studies in different occupational settings have been conducted, there is a need for a systematic evaluation of the relative importance of work-related and individual determinants of work ability, measured with the WAI. This knowledge of determinants of work ability is important to tailor interventions aimed at increasing work participation among elderly workers, and maintenance or improvement of the productivity performance at work. In this article the epidemiological data on

determinants of work ability over the past 25 years have been reviewed. The aim of this systematic review is to identify the individual and work-related determinants of work ability, measured with the WAI among occupational populations.

Methods

Identification of the studies

Relevant articles were identified by means of a computerized search of the bibliographical databases PubMed January 1985-December 2006, and Web of Science over the period January 1988-December 2006. The following search string was used: "work ability". The search was restricted to studies published in the English language. The literature search identified 337 abstracts with 124 corresponding abstracts in both databases, resulting in 213 unique abstracts.

Selection

The initial selection of studies was performed by the first author (TB), and verified by the last author (AB). Studies were excluded if (a) the WAI was not applied to describe work ability in an occupational population, and/or (b) no quantitative information on associations between individual and work-related factors and work ability was presented. The WAI is an assessment of the ability of a worker to perform his /her job, taking into accounts the specific psychosocial and physical work-related factors, mental and physical capabilities, and health. The index consists of a questionnaire on physical and mental demands of an individual in relation to their work, diagnosed diseases, limitations in work due to disease, sick leave, work ability prognosis, and psychological resources. These seven dimensions are rated and the summative index ranges from 7-49, which is classified into poor (7-27), moderate (28-36), good (37-43), and excellent (44-49) work ability [11].

Based on title and abstract, 146 out of 213 abstracts (69%) were discarded due to lack of any quantitative description of associations between individual and work-related determinants and the WAI. Another seven articles (3%) did not use the WAI for measurement of work ability. Another four abstracts were duplicates and four abstracts did not have a full article. In total, 52 articles were retrieved for further review. Of these articles, 26 out of 52 (50%) were excluded due to lack of quantitative information on associations between determinants and work ability, and another 9 (17%) did not use the WAI. Thus, 17 (33%) publications remained that met our selection criteria [12-28]. One publication was included after an additional search in the

references of the articles included for review [29]. Since two publications reported the results of both a cross-sectional study and a follow-up study, in total 20 studies were included in this review [16,22].

Data extraction

The data extraction on selected full articles comprised the study population, study design, research setting, outcome(s), determinants, confounders or effect modifiers, and estimates of effects (with 95% confidence intervals). Determinants of work ability, as defined by the WAI were categorized as individual characteristics, and work related factors. Individual characteristics were demographic variables, physical condition, and lifestyle factors. Work related factors were physical work demands, and psychosocial work demands. Some studies reported also on other determinants that are partly included in the WAI measurement itself, e.g. health complaints, and work satisfaction. Due to this dependency between determinant and WAI, these determinants were not evaluated in this systematic review. Data extraction was performed by one author according to a standardized format (TB) and extracted data was reviewed by another author on consistency and completeness (AB). In case of doubt, data were discussed until agreement was reached (TB, AB).

The analysis focused on measures of association, expressed by for example an odds ratio (OR), or a regression coefficient. Whenever possible the measure of association was retrieved from the original article, together with the variables that were adjusted for in the statistical analysis. In case this information was not present, available raw data in a 2x2 table was used to calculate an odds ratio and confidence interval.

Classification of associations

In this review, three types of statistical associations are distinguished. The association is described as positive when a determinant is statistically significantly associated with an increased risk for a poor WAI or a reduced WAI. The association is describes as negative when a determinant is statistically significantly associated with a decreased risk for a poor WAI or a reduced WAI. In a null association no significant association was found between the determinant and WAI. In order to increase the comparability of the studies, the direction of the association presented in the original article was adjusted when needed to assure that an OR above 1 or a positive regression coefficient have a similar interpretation across all studies.

Quality assessment

The quality of the epidemiological studies (see Table 1) was assessed by two reviewers (TB and AB) using a standardized form based on seven items in a modified version of the guidelines for methodological quality assessment of the Dutch Cochrane Centre [30]:

- Study population; the characteristics of the population should be described in detail, at least age, gender, and occupation;
- Sample size and statistical power; the number of subjects should at least be 10 times the number of covariates;
- Response; the response at baseline should be at least 70%;
- Selection bias; substantial selection bias is not likely to be present;
- Measurement error: Substantial misclassification in determinants is most likely not present;
- The assessment of the determinants should be blinded to the WAI measurement;
- Confounding; the analysis should be adjusted for confounders.

Each criterion was rated when applicable, with a score of 1 being 'sufficiently met' , a score of 0 being 'not sufficiently met', and a question mark when information was lacking to rate this item. The total quality score was rated from 0 to 7.

Results

In total, determinants of work ability were reported in 14 cross-sectional studies, and six longitudinal studies. Individual characteristics were addressed in 18 studies and work-related characteristics in nine studies. Occupations most studied in relation to work ability were (Finnish) municipal workers and care givers. In fact, all longitudinal studies regarding work-related characteristics were carried out among Finnish municipal workers.

The majority of the studies focused on a poor WAI as a dichotomous outcome, either defined by specific threshold level (mostly 37), lowest 25% or 15% percentiles (Tables 2-5).

Table 1 Results of the quality assessment of 20 selected studies with quantitative information on associations between individual and work-related factors and work ability, as measured with the work ability index.

Study (first author)	Design	Quality score (0-7)	Study population	Sample size	Response	Selection bias	Measurement error	Blinding	Confounding
Aittomaki et al 2003 [12]	Cross-sectional	6	1	1	0	1	1	1	1
Eskelinen et al 1991 [13]	Cross-sectional	4	1	1	?	0	1	0	1
Fischer et al 2006 [14]	Cross-sectional	5	1	0	1	1	0	1	1
Goedhard et al 1998 [15]	Cross-sectional	2	0	1	?	?	1	?	0
Kaleta et al 2006 [28]	Cross-sectional	3	0	1	0	1	?	1	1
Laitinen et al 2005 [16]	Cross-sectional	5	1	1	0	1	1	?	1
Laitinen et al 2005 [16]	Prospective cohort	5	1	1	0	1	0	1	1
Martinez et al 2006 [29]	Cross-sectional	5	1	1	1	1	0	1	0
Monteiro et al 2006 [17]	Cross-sectional	6	1	1	1	1	?	1	1
Nygard et al 1991 [18]	Cross-sectional	4	1	1	?	1	1	0	0
Pohjonen 2001 [19]	Prospective cohort	5	1	1	?	?	1	1	1
Pohjonen 2001 [20]	Cross-sectional	6	1	1	1	1	0	1	1
Pranjic et al 2006 [21]	Cross-sectional	5	1	1	1	1	0	1	0
Punakallio et al 2004 [22]	Cross-sectional	6	1	1	1	1	1	?	1
Punakallio et al 2004 [22]	Prospective cohort	7	1	1	1	1	1	1	1
Sjögren-Rönkä et al 2002 [23]	Cross-sectional	6	1	1	1	1	1	0	1
Tuomi et al 1991 [24]	Prospective cohort	5	1	1	?	1	0	1	1
Tuomi et al 1997 [26]	Prospective cohort	6	1	1	1	1	0	1	1
Tuomi et al 2001 [25]	Cross-sectional	5	1	1	1	0	0	1	1
Tuomi et al 2004 [27]	Prospective cohort	5	1	1	0	1	0	1	1

1 = being 'sufficiently met' , 0 = being 'not sufficiently met', '?' = information was lacking

Table 2 Associations between individual determinants and work ability index in cross-sectional epidemiological studies among occupational populations.

Authors	Study population	WAI	Determinant	Association	95% CI	Adjustments[a]
Eskelinen et al. 1991[13]	89 municipal workers (M), mean age: 53 yr	Poor WAI lowest 25%	Reduced cardio respiratory capacity	OR 1.85	0.42-8.19	None
			Impaired mental performance level	OR 1.75	0.62-4.96	None
	85 municipal workers (F), mean age:52yr	Poor WAI lowest 25%	Impaired musculoskeletal capacity	**OR 9.12**	2.96-28.07	None
			Impaired mental performance level	OR 1.65	0.56-4.85	None
Fischer et al. 2006 [14]	696 care givers, mean age 34.9 yr	WAI <37	Sole breadwinner vs. double income	**OR 1.92**	1.32-2.81	1A,E 3A 4C 5A, B
			Raising underage children	**OR 1.56**	1.06-2.29	1A,D 3A 4C 5A, B
			Age ≥40 yr	**OR 0.71**	0.47-0.97	1D,E 3A 4C 5A, B
			BMI ≥30 kg/m^2	**OR 2.71**	1.55-4.77	1A,D,E 4C 5A, B
Goedhard et al. 1998 [15]	141 workers, mean age 39.5yr	WAI 7-49	Age (yrs)	**β -0.28**	Sign.	None
			VO_2max (ml/kg/min)	**β 0.17**	Sign.	Sickness claims (/yr)
Kaleta et al. 2006 [28]	94 workers (M), mean age 43.5yr	WAI <37	BMI >30 kg/m^2	OR 0.29	0.03-3.07	3B,C
			Current smoker	OR 1.61	0.30-8.60	3A,B
			LT physical activity <1000kcal/week	**OR 7.18**	1.10-31.09	3A,C
			Fibre intake <30 g/day	**OR 27.63**	3.44-221.71	None
	93 workers (F), mean age 42.3yr	WAI <37	BMI >30 kg/m^2	OR 1.37	0.36-8.15	3B,C
			Current smoker	**OR 14.84**	3.07-26.42	3A,B
			LT physical activity <750kcal/week	**OR 2.70**	1.82-8.46	3A,C
Laitinen et al. 2005 [16]	2674 Finnish workers (M), age 31 yr	Poor WAI (lowest 15%)	BMI≥35.0 kg/m^2	OR 1.00	0.4-2.4	1C, 3C
			Waist-to-hip ration ≥ 1.0	**OR 1.80**	1.2-2.8	1C, 3C
	2948 Finnish workers (F), age 31 yr	Poor WAI (lowest 15%)	BMI≥35.0 kg/m^2	**OR 2.70**	1.7-4.4	1C, 3C
			Waist-to-hip ration ≥ 1.0	**OR 2.10**	1.3-3.3	1C, 3C
Martinez & Latorre 2006 [29]	224 office workers, mean age 34.7yr	WAI < 37	Age ≥ 40 yr	OR 0.84	0.37-1.91	None
			Female	OR 1.43	0.67-2.99	None
			Low income	OR 0.98	0.47-2.03	None
			Low education	OR 1.09	0.51-2.30	None
			Not married	OR 1.12	0.54-2.33	None
Monteiro et al. 2006 [17]	651 municipal workers	WAI <36.5	Age group ≥ 55 yr	**OR 1.9**	1.18-3.18	1B,C,E 3B,C,A
			Female	OR 1.3	0.90-2.12	1A,C,E 3B,C,A
			Low education	**OR 1.2**	1.01-1.55	1A,B,E 3B,C,A
Nygard et al. 1991 [18]	137 municipal workers, mean age 55 yr	Poor WAI lowest 25%	Poor trunk muscular endurance	**OR 6.39**	2.41-16.94	None
			Impaired mental performance	OR 1.54	0.61-3.92	None
Pohjonen 2001 [20]	636 home care workers (F), mean age 42.3yr	Decrease in WAI classification	Age 50-62 vs. 19-34	**OR 3.57**	2.04-5.88	1C, E 3B 4AB,C 5A
			Hard life situation outside work	**OR 1.96**	1.03-3.75	1A,C 3B 4AB,C 5A
			LT physical activity <1 time a week	OR 1.77	0.88-3.55	None
Punakallio et al. 2004 [22]	135 fire-fighters (M), mean age 40.7yr	Decrease in WAI classification	Poor functional balance	OR 2.4	0.9-5.4	1A
			Poor sway velocity (mm/s)	OR 1.8	0.7-4.5	1A
			Poor mean amplitude (mm)	OR 1.3	0.5-3.2	1A
			Poor-to-moderate perceived balance	**OR 9.8**	3.8-24.9	1A
Sjögren-Rönka et al. 2002 [23]	88 office workers, mean age 45.7yr	WAI 7-49	Good spine forward flexion	**β 0.24**	Sign.	2A,C 3B
			High self-confidence	**β 0.29**	Sign.	2A,B,C 3B
Tuomi et al. 2001 [25]	1101 Finnish active workers, mean age 58.4yr	WAI 7-49	Physical exercise during free time	**β 1.07**	Sign.	3C
			Alcohol drinking (yes/no)	**β 1.53**	Sign.	3B,C
			BMI (kg/m^2)	**β -0.78**	Sign.	3B,C
			Smoking	β 0.57	p 0.30	3B

[a] For the identification of the covariates, see Table 6.
(β=linear regression coefficient, BMI= body mass index, F=females, LT=leisure-time, M=males, OR=odds ratio, sign. = p<0.05, VO2max=maximum oxygen consumption, 95% CI= 95% confidence interval).

Table 3 Associations between individual determinants and work ability index in longitudinal epidemiological studies among occupational populations.

Authors	Follow-up	Study population	WAI outcome	Determinant	Measure of association	95% CI	Adjustments[a]
Laitinen et al. 2005 [16]	L (17 yr)	2674 Finnish workers (M) Age 14-31yr	Poor WAI (lowest 15%)	BMI≥24.5 kg/m^2	OR 1.5	0.8-3.0	1C, 3C
				BMI<15.49 kg/m^2	**OR 2.2**	1.1-4.7	1C, 3C
				Always overweight during follow-up	OR 0.8	0.6-1.2	1C, 3C
		2948 Finnish workers (F) Age 14-31yr	Poor WAI (lowest 15%)	BMI≥24.5 kg/m^2	**OR 2.0**	1.1-3.2	1C, 3C
				BMI<15.49 kg/m^2	**OR 2.8**	1.6-5.1	1C, 3C
				Always overweight during follow-up	OR 1.4	1.0-2.0	1C, 3C
Pohjonen 2001[19]	L (5yr) 1993-1998	132 home care workers (F), mean age: 41 yr	Decrease WAI classification	Poor balance	**OR 6.53**	1.8-23.3	1A, T_0
				Poor sit-up	**OR 8.88**	2.4-32.6	1A, T_0
				Poor VO_2max (ml/min/kg)	OR 1.94	0.4-8.5	1A, T_0
				BMI≥30 kg/m^2	**OR 7.51**	1.9-30.0	1A, T_0
Punakallio et al. 2004 [22]	L (3yr) 1996-1999	135 fire-fighters (M), mean age 40.7yr	Decrease WAI classification	Poor functional balance (e)	OR 3.6	1.0-12.7	1A, T_0
				Poor sway amplitude (ec)(mm)	OR 2.3	0.9-6.1	1A, T_0
				Poor-to-moderate perceived balance	OR 2.4	0.9-6.6	1A, T_0
Tuomi et al. 1991 [24]	L (4 yr) 1981-1985	4255 municipal workers, mean age 50yr	Decrease in WAI	Age (yr)	**β -0.10**	Sign.	1A 3A,C 4A,C 5A,B
				BMI (kg/m^2)	**β -0.05**	Sign.	1A 3A,C 4A,C 5A,B
				Cigarette smoker	**β -0.04**	Sign.	1A 3A,C 4A,C 5A,B
		1064 municipal workers with musculoskeletal disease		Marital status (no/yes)	**β -0.06**	Sign.	1A 3A,C 4A,C 5A,B
				Low basic education	**β -0.15**	Sign.	1A 3A,C 4A,C 5A,B
				Life satisfaction	**β 0.11**	Sign.	1A 3A,C 4A,C 5A,B
				Physical exercise	**β 0.08**	Sign.	1A 3A,C 4A,C 5A,B
				Age (yr)	**β -0.13**	Sign.	1A 3A,C 4A,C 5A,B
		522 municipal workers with cardiovascular disease		Low basic education	**β -0.16**	Sign.	1A 3A,C 4A,C 5A,B
				Life satisfaction	**β 0.19**	Sign.	1A 3A,C 4A,C 5A,B
				Physical exercise	**β 0.10**	Sign.	1A 3A,C 4A,C 5A,B
				Age (yr)	**β -0.09**	Sign.	1A 3A,C 4A,C 5A,B
		118 municipal workers with mental disease		Low basic education	**β -0.19**	Sign.	1A 3A,C 4A,C 5A,B
				Life satisfaction	**β 0.23**	Sign.	1A 3A,C 4A,C 5A,B
				Age (yr)	**β -0.16**	Sign.	1A 3A,C 4A,C 5A,B
Tuomi et al. 1997 [26]	L (11yr) 1981-1992	818 municipal workers, mean age: 47yr	Increase (≥3) in WAI	Age (yr)	OR 1.0	0.9-1.2	1A 3B 4B 5A,B
			Decline (≥10) in WAI	Age (yr)	OR 1.1	1.0-1.2	1A 3B 4B 5A,B
			Increase (≥3) in WAI	Increased vigorous physical exercise	OR 1.8	1.0-3.5	5A, 4C
			Decline (≥10) in WAI	Decreased vigorous physical exercise	**OR 1.8**	1.2-2.8	5 A,B 4C
Tuomi et al. 2004 [27]	L (2 year) 1998-2000	1389 metal and retail workers, mean age 43.9yr	Increase in WAI	Improvements in economic position	**β 0.53**	Sign.	1A,B 3B,C 4A,B,C, 5A,B
				Increase in physical exercise	**β 0.29**	Sign.	1A,B 3C 4A,B,C 5A,B

[a] For the identification of the covariates, see Table 6.
(**β**=linear regression coefficient, BMI= body mass index, F=females, L=longitudinal study design, LT=leisure-time, M=males, OR=odds ratio, sign. = p<0.05, T_0=baseline results VO_2max=maximum oxygen consumption, 95% CI= 95% confidence interval).

Table 4 Associations between work-related determinants and work ability index in cross-sectional epidemiological studies among occupational populations.

Authors	Study population	WAI	Determinant	Measure of association	95% CI	Adjustments[a]
Aittomäki et al. 2003 [12]	429 municipal workers (M), >40 yr	WAI<32	Blue-collar worker	OR 0.95	0.42-2.19	1A, E 4C
	1398 municipal workers (F), >40 yr	WAI<32	Blue-collar worker	OR 1.11	0.67-1.84	1A, E 4C
Fischer et al. 2006 [14]	696 care givers, mean age 34.9 yr	WAI<37	Shift work	OR 1.61	0.89-2.91	1D,E,A 3A 4C 5A, B
			Never organized workplace	OR 0.69	0.32-1.51	1D,E,A 3A 4C 5A, B
			Often conflict with patients	OR 1.39	0.82-2.35	1D,E,A 3A 4C 5A, B
			>2 times verbal abuse (past month)	OR 1.67	1.00-3.04	1D,E,A 3A 4C 5A, B
			High-strain job	OR 1.21	0.70-2.10	1D,E,A 3A 4C 5A, B
			Often thermal discomfort	OR 1.55	1.00-2.40	1D,E,A 3A 4C 5A, B
			Often lifting patients	OR 2.02	0.96-4.25	1D,E,A 3A 4C 5A, B
Pohjonen 2001 [20]	636 home care workers (F), mean age 42.3yr	Decrease WAI classification	High time pressure	OR 1.05	0.53-2.07	4A,B,C 5A
			Poor possibilities to control one's own work	**OR 1.95**	1.02-3.72	1A,C, E 3B 4A,B,C 5A
			Poor management	OR 1.58	0.86-2.94	4A,B,C 5A
			High mental work demands	OR 1.40	0.79-2.48	None
			Poor ergonomic conditions	**OR 2.54**	1.21-5.30	1A,C, E 3B 4AB,C 5A
Pranjic et al. 2006 [21]	534 physicians, mean age 44yr	Decrease WAI classification	Often exposed to mobbing	**OR 4.75**	4.14-5.35	4C
Sjögren-Rönka et al.2002 [23]	88 office workers, mean age 45.7yr	WAI 7-49	High mental stress	**β -0.17**	Sign.	2A, B, C 3B
Tuomi et al. 2001 [25]	1101 Finnish active workers, mean age 58.4yr	WAI 7-49	Muscular work	β -0.22	0.067	4A,C 5A,B
			Poor work postures	**β -0.44**	Sign.	4A,C 5A,B
			Intelligence demand	**β 0.46**	Sign.	4A,C 5A,B
			Poor work tools and rooms	**β -0.35**	Sign.	4A,C 5A,B
			Poor physical climate	**β -0.29**	Sign.	4A,C 5A,B
			Restless work environment	**β -0.33**	Sign.	4A,C 5A,B
			Poor management	**β -0.54**	Sign.	4B,C
			Lack of freedom	**β -0.31**	Sign.	4B,C
			Uninspiring work	**β -0.65**	Sign.	4B,C
			Utilization of work experience	**β 0.94**	Sign.	4B,C
			Possibilities for development and influence at work	**β 0.65**	Sign.	4C
			Job retraining	**β -3.41**	Sign.	4C
			Subjective improvement in work and tasks	**β 1.05**	Sign.	4A,C 5A,B
			Subjective improvement in work environment and tools	β 0.47	0.089	4A,C 5A,B
			Subjective increase in mental work load	**β -1.21**	Sign.	4A,C 5A,B

[a] For the identification of the covariates, see Table 6.
(β=linear regression coefficient, F=females, M=males, OR=odds ratio, sign. = p<0.05, 95% CI= 95% confidence interval).

Table 5 Associations between work-related determinants and work ability index in longitudinal epidemiological studies among occupational populations.

Authors	Follow-up	Study population	WAI outcome	Determinant	Measure of association	95% CI	Adjustments[a]
Tuomi et al. 1991 [24]	L (4 yr) 1981-1985	4255 municipal workers, mean age 50yr	Change in WAI	High physical demands	β **-0.06**	Sign.	1A 3A,C 4A,C 5A,B
				Good possibilities to develop	β **0.03**	Sign.	1A 3A,C 4A,C 5A,B
				Poor physical environment	β **-0.05**	Sign.	1A 3A,C 4A,C 5A,B
				Poor work schedule	β **-0.03**	Sign.	1A 3A,C 4A,C 5A,B
				Physical stress at work	β **-0.08**	Sign.	1A 3A,C 4A,C 5A,B
		1064 municipal workers with musculoskeletal disease	Change in WAI	Muscular work	β **-0.09**	Sign.	1A 3A,C 4A,C 5A,B
				Poor work posture	β **-0.10**	Sign.	1A 3A,C 4A,C 5A,B
				Change of work load in the past 2 yr	β **-0.07**	Sign.	1A 3A,C 4A,C 5A,B
				Poor work temperature	β **-0.16**	Sign.	1A 3A,C 4A,C 5A,B
				Poor management	β **-0.10**	Sign.	1A 3A,C 4A,C 5A,B
				Lack of freedom	β **-0.07**	Sign.	1A 3A,C 4A,C 5A,B
				Poor work schedule	β **-0.08**	Sign.	1A 3A,C 4A,C 5A,B
		522 municipal workers with cardiovascular disease	Change in WAI	Muscular work	β **-0.27**	Sign.	1A 3A,C 4A,C 5A,B
				Sitting work	β **-0.15**	Sign.	1A 3A,C 4A,C 5A,B
				Responsibility for people	β **0.10**	Sign.	1A 3A,C 4A,C 5A,B
				Poor tools and rooms	β **-0.08**	Sign.	1A 3A,C 4A,C 5A,B
				Poor physical climate	β **-0.10**	Sign.	1A 3A,C 4A,C 5A,B
				Noisy and restless workplace	β **-0.09**	Sign.	1A 3A,C 4A,C 5A,B
				Poor work schedule	β **-0.07**	Sign.	1A 3A,C 4A,C 5A,B
		118 municipal workers with mental disease	Change in WAI	Lack of freedom	β **-0.27**	Sign.	1A 3A,C 4A,C 5A,B
Tuomi et al. 1997 [26]	L (11yr) 1981-1992	818 municipal workers, mean age: 47yr	Increase (+≥3) in WAI	No harmful lack of freedom	OR 0.9	0.8-1.0	None
				Decreased noisy and restless workplace	**OR 3.4**	1.6-7.2	1A 3B 4B,C 5A
				Decreased management strain	OR 2.0	1.0-3.7	1A 3B 4B,C 5A
				Decreased role ambiguity	OR 2.1	0.9-5.1	None
				Increased freedom	OR 2.8	1.0-7.8	None
				Increased satisfaction with supervisor's attitude	**OR 3.6**	1.8-7.2	3B, 5A
			Decrease (-≥10)	Decreased possibilities for development and influence at work	**OR 2.4**	1.4-4.3	1A 3B 4B,C 5A,B
				Increased role ambiguity	**OR 1.9**	1.4-2.7	1A 3B 4B,C 5A,B
				Decreased freedom	OR 1.4	1.0-2.0	None
				Decreased possibility for recognition and esteem at work	**OR 2.4**	1.4-4.3	3B 5A,B
			Increase (+≥3) in WAI	Decreased muscular work	**OR 2.8**	1.2-6.6	None
				Improved work postures	**OR 2.9**	1.3-6.5	1A 3B 4B,C 5A
				Decreased repetitive movements	OR 2.1	1.0-3.4	3B, 4C
Tuomi et al. 1997 [26]	L (11yr) 1981-1992	818 municipal workers, mean age: 47yr	Decrease (-≥10)	Poor work temperature	OR 1.1	1.0-1.1	3B 5A,B
				Increased muscular work	**OR 1.8**	1.2-2.8	3B 5A,B
				Increased difficult work postures	OR 1.5	1.0-2.2	None
				Increased standing in one place	OR 1.7	1.0-2.9	3B 4C 5A,B
Tuomi et al. 2004 [27]	L (2 year) 1998-2000	1389 Finnish active workers in metal industry and retail, mean age 43.9yr	Increase in WAI	Increase in opportunities for influence	β **0.51**	Sign.	1A,B 3B,C 4A,B,C 5A,B
				Increase in promotion of employee well-being	β **0.53**	Sign.	1A,B 3B,C 4A,B,C 5A,B
				Decrease in uncertainty at the workplace	β **0.70**	Sign.	1A,B 3B,C 4A,B,C 5A,B
				Decrease in mental demands at work	β **0.89**	Sign.	1A,B 3B,C 4A,B,C 5A,B
				Decrease in physical demands at work	β **1.35**	Sign.	1A,B 3B,C 4A,B,C 5A,B

[a] For the identification of the covariates, see Table 6.
(β=linear regression coefficient, F=females, L=longitudinal study design, M=males, OR=odds ratio, sign. = p<0.05, 95% CI= 95% confidence interval)

Individual characteristics

The demographic factor most studied was age (seven studies)(Table 2 and 3). Four out of seven studies reported a decreased WAI with older age [15, 17, 20, 24], two studies demonstrated no association [26, 29] and one study found a higher risk for a poor WAI among younger workers. [14] Sex (n=2) [17, 29] was not associated with WAI, whereas a lower education was associated with a lower WAI in one study [17] and had no effect in another study [29]. Being a sole breadwinner, and degradation in economic position were associated with lower WAI [14, 27], whereas no relation was observed for low income [29]. Four studies reported on other individual characteristics. A lower WAI was associated with hard life situation outside work [20], raising underage children [14], and low self-confidence [23], and not significantly associated with marital status [29].

One out of three studies found a positive association between a better cardio-respiratory fitness, expressed by maximum oxygen uptake, and a higher WAI [15]. All four studies on poor musculoskeletal capacity reported a significant association with a poor WAI with risk estimates varying from 6.4 to 9.1 [13,18, 19, 23]. Poor functional balance in home care workers was associated with poor WAI [19], whereas this association was not observed in two studies among fire fighters [22]. Both studies on general cognitive mental performance showed no significant associations [13, 18].

Overweight was positively associated with a poor WAI in four out of seven studies [14, 19, 24, 25]. Lack of leisure-time physical activity was associated with a lower WAI in four out of five studies [25-28]. In one study smoking was associated with lower WAI [24], whereas in two studies no significant association was found [25, 28]. One study reported a positive effect of alcohol drinkers versus teetotalers on WAI [25]. In one study a diet with low fiber intake was reported with an odds ratio of 27.6 for a poor WAI [28].

Work-related factors

A large variety of psychosocial factors at work were addressed, varying from poor management to satisfaction with supervisor (Table 4 and 5). Five out of seven studies reported a positive association between high mental work demands and a poor WAI [21, 23-25, 27], whereas among home care workers [20], and care givers [14] no significant associations were reported. Three out of four studies reported a positive association with a poor WAI for lack of autonomy [20, 25, 27], whereas one study failed to corroborate this association [26]. High physical demands, such as increased muscular work, poor work postures, and poor ergonomic conditions were positively associated with a lower WAI in four out of seven studies [20, 24, 26, 27]. Regarding the physical work environment, two out of four studies reported a lower WAI with thermal

discomfort and poor physical climate [24, 25], whereas another two studies did not find any association [14, 26].

Quality rating

Quality scores ranged from 2 to 7 (Table 1). A low response at baseline (less than 70%), and measurement error were most present shortcomings in quality. There were no statistically significant differences in quality score for design, type of determinant (individual vs. work related), and whether a significant association was reported or not. Due to the large heterogeneity in definitions of determinants, a meta-analysis was not possible.

Discussion

This review showed factors associated with a decreased work ability were lack of leisure-time vigorous physical activity, poor musculoskeletal capacity, older age, obesity, and high physical and psychosocial work demands. No conclusions can be drawn regarding the relative importance of the determinants, because of the large heterogeneity in study characteristics (study populations, sample size, definition of determinants).

Limitations

This systematic review has some limitations. The literature search may not be comprehensive enough, because publications in languages other than English were not included, and the search was limited to two computer-based bibliographic databases. The search in Web of Science resulted in an additional 51 articles relative to Pubmed, but all of these were finally excluded. However, it cannot be ruled out that relevant publications would have been identified when using additional databases.

In the selection of relevant literature, 16 abstracts (8%) were excluded, since work ability was used as a generic term without a clear method of measurement. These studies merely focused on generic work ability without measuring. In the full review of selected articles, nine articles (18%) were excluded since work ability was not quantified (n=1) or measured differently from the WAI (n=8), for example using one question on current work ability with differing scales (n=4) or based on the number of sick leave days (n=2). This latter finding suggests that the WAI is indeed the most often used instrument to quantify the work ability in occupational populations.

An important limitation is that the majority of studies were of cross-sectional design

and, as a consequence, causality cannot be determined. A clear example is the study reporting on a negative association between job retraining and a poor WAI [31]. It may be argued that job training is not a causal factor for poor WAI, but that workers with a poor WAI were likely to have received job retraining in order to increase their work ability.

Another limitation lies in the nature of the synthesis of results. A meta-analysis was not possible, because of the large heterogeneity in definition and measurement of determinants. For example, musculoskeletal capacity was characterized from a poor trunk muscular endurance to good spine forward flexion. Although the review was limited to studies using the same measurement method for work ability, comparability was hampered by differences in outcome definition (WAI as linear variable vs. dichotomized for poor work ability with different cut-offs). Besides, studies with different study designs (cross-sectional versus longitudinal) were included.

The selected studies were dominated by Finnish studies (70%), with also heavy emphasis on research among municipal workers. Therefore, some caution is needed in the generalisibility of the study results to other occupational populations in other countries.

Interpretation of null associations

This review not only described individual and work-related determinants associated with a poor WAI, but also evaluated negative and null associations (Table 6). The number of null associations was independent of type of determinant and study design. A null association may be the result of (i) a small sample size and lack of statistical power, (ii) lack of exposure variability, (iii) presence of another risk factor or confounder, and (iv) non-differential measurement error. The first reason for an inconclusive result, a small sample size, may explain the non-significant associations for cardiorespiratory capacity [13, 19], overweight [28], and poor functional balance [22] in study populations with less than 100 subjects. Similarly, a definition of a body mass index equal or higher than 35 will probably not give a sufficient number of cases for a meaningful analysis [16]. Lack of exposure variability could be another explanation for null associations. For example, when the population was restricted to workers older than 40 years or workers within the same occupation, the population will be more homogenous and, hence, will have limited contrast in age and work-related determinants and, thus, their influence on WAI will be difficult to determine [24]. The presence of another risk factor or confounder seems a likely explanation for the null associations in studies not controlled for confounders [13, 29]. Finally, a null association could also be due to substantial non-differential misclassification in the

determinants. Misclassification is especially expected in self-reported measures with limited answer categories, for example leisure-time physical activity in three levels of frequency per week [20]. The quality assessment indeed showed most studies lost points because substantial misclassification in determinants was likely to occur. The total quality score however showed no differences for type of determinant or significance of reported associations.

Individual determinants

For individual determinants the range in magnitude of associations was larger in cross-sectional studies than in longitudinal studies. A cross-sectional study design is more sensitive to bias, which may explain the larger differences in measure of association. For some determinants the available number of studies was too small to draw meaningful conclusions, that is for, gender (two studies), education (two studies), mental performance (two studies). For other determinants the number of significant associations equaled the number of null associations, for example overweight (four positive associations against three null associations).

In one study a negative association was found between older age (≥ 40 year) and poor WAI [14]. The study population consisted mainly of female health care workers with an age below 35 years, hence, the negative association is most likely due to a strong "healthy worker selection effect". Another negative association was found for alcohol drinking [25]. This association may have been the result of the fact that the effects of problematic alcohol use were not evaluated separately, whereas moderate alcohol has beneficial effects on health.

Work-related determinants

Despite the large differences in definition of the determinants and the validity of the measurement techniques applied, the studies consistently showed that important determinants for WAI were high mental work demands, poor autonomy, and high physical work demands. A recent study also demonstrated significant associations between these work-related determinants and work ability [32].All work-related determinants were measured by means of self-report. This assessment technique may lead to spurious results, when subjects with a poor WAI overestimate their physical and mental workload in the workplace relative to those with an excellent WAI. It is unclear if an objective measurement of the work demands would show similar results.

Table 6 Summary of epidemiological studies with positive and negative associations between individual and work related factors, and poor or decreased WAI (OR=odds ratio).

Factor	Positive association			Null associations			Negative associations		
	Logistic regression		Other analysis	Logistic regression		Other analysis	Logistic regression		Other analysis
	No	Range OR	No	No	Range OR	No	No	Range OR	No
1. Demographic factors									
A. Older age	2	1.90-3.57	2	2	0.84 - 1.00	0	1	0.71	0
B. Female	0		0	2	1.30 - 1.43	0	0		0
C. Low education	1	1.20	0	1	1.09	0	0		0
D. Low income	1	1.92	1	1	0.98	0	0		0
E. Other	2	1.56-1.96	1	1	1.12	0	0		0
2. Physical condition									
A. Poor cardiorespiratorycondition	0		1	2	1.86 – 1.94	0	0		0
B. Poor musculoskeletal capacity	3	6.39-9.12	1	0		0	0		0
C. Poor mental performance	0		0	2	1.54 – 1.75	0	0		0
D. Poor balance	1	6.53	0	2	2.40 – 3.60	0	0		0
3. Lifestyle factors									
A. Overweight	2	2.71-7.51	2	3	0.29 – 1.50	0	0		0
B. Lack of leisure-time physical activity	2	1.80-7.18	2	1	1.77	0	0		0
C. Smoking	0		1	1	1.61	1	0		0
D. Other	1	27.63	0	1	0.80	0	0		1
4. Work-related psychosocial and organizational factors									
A. High mental work demands	1	4.75	4	2	1.40 – 1.21	0	0		0
B. Poor autonomy	1	1.95	2	1	1.40	0	0		0
C. Other	1	3.60	3	2	0.69 – 1.58	0	0		1
5. Work-related physical factors									
A. High physical demands	2	1.80 – 2.54	2	2	0.95 – 2.02	1	0		0
B. High physical exposure	0		2	2	1.10 – 1.55	0	0		0

Some determinants, which feature prominently in the model of Ilmarinen [5] were not included in the observed studies. Health, functional capacity, and work were (over) represented in research, in respect to professional competence, and values, attitudes and motivation for work. Health, functional capacity and work-related risk factors have a well-studied history in the field of work and health. The influence of competence and values, attitudes, and motivation on health-related performance at work clearly lags behind. This in agreement with the invitation of MacDonald et al. [33] to incorporate work organization into occupational health research. Besides, through increased medical standards and improvements in the work environment, it is expected that aspects of human resources management will become more important for improving work ability. This requires the development of valid measurement instruments, which until now are largely absent.

Implication for interventions

This study has presented important information to consider in programs aimed at maintaining or improving work productivity and work participation. The interventions should focus on the identified determinants associated with a lower work ability. Several work-related determinants have also been identified as important risk factors for the occurrence of sickness absence [34] and for prolonged duration of sickness absence [35] and, hence, it is expected that interventions to promote maintaining or regaining a good work ability will also prevent partly (temporary) work disability. At individual level, it seems beneficial to target interventions at increasing leisure-time vigorous physical activity, increasing musculoskeletal capacity, and decreasing body mass index (i.e. obesity). Work related interventions should focus on an increase in autonomy at work, and decreases in physical and psychosocial demands. Professional competence and attitudes and values towards work may also be essential points of interventions in workers with decreased work ability, but their potential impact could not be demonstrated in this review.

The importance of lack of vigorous physical activity and obesity of determinants of a poor work ability suggest that health promotion intervention may be beneficial. Indeed, intervention studies on increasing physical activity in leisure time and improved physical condition have shown positive effects, but were too small for a statistically significant change in the short term [36-39].

Other intervention studies on work-related determinants have shown promising results. Among employees in the construction industry with a high disability risk, an assessment and individual program for half a year focusing on optimizing functioning at work showed a slight, but insignificant, improvement in WAI [40]. Among farmers

experiencing low back or shoulder pain occupationally-oriented rehabilitation courses including training of ergonomically correct work techniques lasting 3 weeks, showed that changes in lifting techniques were minor after 1 year follow-up, but the WAI improved significantly for both men and women [41]. Among blue-collar workers with a high disability risk, an occupational health intervention program showed an increase in WAI, after 6 months' follow-up, yet this positive effect was not present after 2 years [42]. Among truck drivers, stress management [39], and among farmers, training of work techniques [43], were both not significant in changing WAI. Thus, interventions on work-related determinants have been conducted, but so far have failed to convincingly demonstrate significant improvements in WAI.

Concluding remarks

Health promotion at work can be aimed at increasing leisure-time physical activity, prevention of overweight, increasing musculoskeletal capacity and decrease of physical and psychosocial work load. This review could not demonstrate the impact of professional competences, attitudes, and work values on work ability, as defined by the WAI. In addition, factors such as the organisational context within companies and social and economic policies that influence labour participation are also lacking. Future research on determinants of work ability should incorporate the social and economic environment of workers.

References

[1] Ilmarinen JE. Aging workers. *Occup Environ Med* 2001;58:546-52.

[2] Stattin M. Retirement on grounds of ill health. *Occup Environ Med* 2005;62:135-40.

[3] Tuomi K, Ilmarinen J, Seitsamo J, Huuhtanen P, Martikainen R, Nygard CH, et al. Summary of the Finnish research project (1981-1992) to promote the health and work ability of aging workers. *Scand J Work Environ Health* 1997;23 (suppl 1):66-71.

[4] Schuring M, Burdorf L, Kunst A, Mackenbach J. The effects of ill health on entering and maintaining paid employment: evidence in European countries. *J Epidemiol Community Health* 2007;61:597-604.

[5] Ilmarinen J. *Towards a longer worklife*. Helsinki: FIOH Bookstore, 2005.

[6] Bobko NA. Work ability, age and its perception, and other related concerns of Ukraine health care workers. *Exp Aging Res* 2002;28:59-71.

[7] Lindberg P, Vingard E, Josephson M, Alfredsson L. Retaining the ability to work - associated factors at work. *Eur J Public Health* 2006;16:470-475.

[8] Lindberg P, Josephson M, Alfredsson L, Vingard E. Promoting excellent work ability and preventing poor work ability: the same determinants? Results from the Swedish HAKuL study. *Occup Environ Med* 2006;63:113-120.

[9] Salonen P, Arola H, Nygard CH, Huhtala H, Koivisto AM. Factors associated with premature departure from working life among ageing food industry employees. *Occup Med (Lond)* 2003;53:65-8.

[10] Burdorf A, Frings-Dresen MHW, van Duivenbooden C, Elders LAM. Development of a decision model to identify workers at risk of long-term disability in the construction industry. *Scand J Work Environ Health* 2005;31:31-36.

[11] Tuomi K, Ilmarinen J, Jahkola A, Katajarinne L, Tulkki A. *Work ability index*. 2nd revised ed. Helsinki 1998.

[12] Aittomaki A, Lahelma E, Roos E. Work conditions and socioeconomic inequalities in work ability. *Scand J Work Environ Health* 2003;29:159-65.

[13] Eskelinen L, Kohvakka A, Merisalo T, Hurri H, Wagar G. Relationship between the self-assessment and clinical assessment of health status and work ability. *Scand J Work Environ Health* 1991;17 (suppl 1):40-7.

[14] Fischer FM, Borges FN, Rotenberg L, Latorre Mdo R, Soares NS, Rosa PL, et al. Work ability of health care shift workers: What matters? *Chronobiol Int* 2006;23:1165-79.

[15] Goedhard WJ, Rijpstra TS, Puttiger PH. Age, absenteeism and physical fitness in relation to work ability. *Stud Health Technol Inform* 1998;48:254-7.

[16] Laitinen J, Nayha S, Kujala V. Body mass index and weight change from adolescence into adulthood, waist-to-hip ratio and perceived work ability among young adults. *Int J Obes (Lond)* 2005;29:697-702.

[17] Monteiro MS, Ilmarinen J, Corraa Filho HR. Work ability of workers in different age groups in a public health institution in Brazil. *Int J Occup Saf Ergon* 2006;12:417-27.

[18] Nygard CH, Eskelinen L, Suvanto S, Tuomi K, Ilmarinen J. Associations between functional capacity and work ability among elderly municipal employees. *Scand J Work Environ Health* 1991;17 (suppl 1):122-7.

[19] Pohjonen T. Age-related physical fitness and the predictive values of fitness tests for work ability in home care work. *J Occup Environ Med* 2001;43:723-30.

[20] Pohjonen T. Perceived work ability of home care workers in relation to individual and work-related factors in different age groups. *Occup Med (Lond)* 2001;51:209-17.
[21] Pranjic N, Males-Bilic L, Beganlic A, Mustajbegovic J. Mobbing, stress, and work ability index among physicians in Bosnia and Herzegovina: survey study. *Croat Med J* 2006;47:750-8.
[22] Punakallio A, Lusa S, Luukkonen R. Functional, postural and perceived balance for predicting the work ability of firefighters. *Int Arch Occup Environ Health* 2004;77:482-90.
[23] Sjogren-Ronka T, Ojanen MT, Leskinen EK, Tmustalampi S, Malkia EA. Physical and psychosocial prerequisites of functioning in relation to work ability and general subjective well-being among office workers. *Scand J Work Environ Health* 2002;28:184-90.
[24] Tuomi K, Eskelinen L, Toikkanen J, Jarvinen E, Ilmarinen J, Klockars M. Work load and individual factors affecting work ability among aging municipal employees. *Scand J Work Environ Health* 1991;17 (suppl 1):128-34.
[25] Tuomi K, Huuhtanen P, Nykyri E, Ilmarinen J. Promotion of work ability, the quality of work and retirement. *Occup Med (Lond)* 2001;51:318-24.
[26] Tuomi K, Ilmarinen J, Martikainen R, Aalto L, Klockars M. Aging, work, life-style and work ability among Finnish municipal workers in 1981-1992. *Scand J Work Environ Health* 1997;23 (suppl 1):58-65.
[27] Tuomi K, Vanhala S, Nykyri E, Janhonen M. Organizational practices, work demands and the well-being of employees: a follow-up study in the metal industry and retail trade. *Occup Med (Lond)* 2004;54:115-21.
[28] Kaleta D, Makowiec-Dabrowska T, Jegier A. Lifestyle index and work ability. *Int J Occup Med Environ Health* 2006;19:170-7.
[29] Martinez MC, Latorre Mdo R. [Health and work ability among office workers] Saude e capacidade para o trabalho em trabalhadores de area administrativa. *Rev Saude Publica* 2006;40:851-8.
[30] Dutch Cochrane Centre. Guideline for methodological quality assessment of observational studies [in Dutch]. www.cochrane.nl/downloads, accessed 1 Sep 2007.
[31] Tuomi K, Huuhtanen P, Nykyri E, Ilmarinen J. Promotion of work ability, the quality of work and retirement. *Occupational Medicine-Oxford* 2001;51:318-324.
[32] Alavinia SM, van Duivenbooden C, Burdorf A. Influence of work-related factors and individual characteristics on work ability among Dutch construction workers. *Scand J Work Environ Health* 2007;33:351-7.
[33] Macdonald LA, Harenstam A, Warren ND, Punnett L. Incorporating work organization into occupational health research: an invitation for dialogue. *Occup Environ Med* 2008;65:1-3.
[34] Alexanderson K. Sickness absence: a review of performed studies with focused on levels of exposure and theories utilized. *Scand J Soc Med* 1998;26:241-9.
[35] Dekkers-Sánchez PM, Hoving JL, Sluiter JK, Frings-Dresen MH. Factors associated with long-term sick leave in sicklisted employees: a systematic review. *Occup Environ Med* 2008;65:153-7.
[36] Smolander J, Blair SN, Kohl HW, 3rd. Work ability, physical activity, and cardiorespiratory fitness: 2-year results from Project Active. *J Occup Environ Med* 2000;42:906-10.
[37] Pohjonen T, Ranta R. Effects of worksite physical exercise intervention on physical fitness, perceived health status, and work ability among home care workers: five-year follow-up. *Prev Med* 2001;32:465-75.
[38] Nurminen E, Malmivaara A, Ilmarinen J, Ylostalo P, Mutanen P, Ahonen G, et al. Effectiveness of a worksite exercise program with respect to perceived work ability and sick leaves among women with physical work. *Scand J Work Environ Health* 2002;28:85-93.

[39] Karazman R, Kloimuller I, Geissler H, Karazman-Morawetz I. Effects of ergonomic and health training on work interest, work ability and health in elderly public urban transport drivers. *Int J Ind Erg* 2000;25:503-511.
[40] de Boer AG, Burdorf A, van Duivenbooden C, Frings-Dresen MH. The effect of individual counselling and education on work ability and disability pension: a prospective intervention study in the construction industry. *Occup Environ Med* 2007;64:792-7.
[41] Nevala-Puranen N. Effects of occupationally-oriented rehabilitation on farmers' work techniques, musculoskeletal symptoms, and work ability. *J Occup Rehab* 1996;6:191-200.
[42] de Boer AG, van Beek JC, Durinck J, Verbeek JH, van Dijk FJ. An occupational health intervention programme for workers at risk for early retirement; a randomised controlled trial. *Occup Environ Med* 2004;6:924-9.
[43] Perkio-Makela M. Influence of exercise-focused group activities on the physical activity, functional capacity, and work ability of female farmers-a three-year follow-Up. *Int J Occup Saf Ergon* 1999;5:381-94

Chapter 5

The influence of psychosocial factors at work and life style on health and work ability among professional workers

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Abstract

Objectives. The purpose of this article is to explore the associations of psychosocial factors at work, life style, and stressful life events on health and work ability among white-collar workers.

Methods. A cross-sectional survey was conducted among workers in commercial services (n=1141). The main outcome variables were work ability, measured by the work ability index (WAI), and mental and physical health, measured by the Short-Form Health Survey (SF-12). Individual characteristics, psychosocial factors at work, stressful life events, and lifestyle factors were determined by a questionnaire. Maximum oxygen uptake, weight, height, and biceps strength were measured during a physical examination.

Results. Work ability of white-collar workers in commercial services industry was strongly associated with psychosocial factors at work such as teamwork, stress handling, and self-development and, to a lesser extent, with stressful life events, lack of physical activity, and obesity. Determinants of mental health were very similar to those of work ability, whereas physical health was influenced primarily by life style factors. With respect to work ability, the influence of unhealthy life style seems more important for older workers, than for their younger colleagues.

Conclusion. Among white-collar workers mental and physical health were of equal importance to work ability, but only mental health and work ability shared the same determinants. The strong associations between psychosocial factors at work and mental health and work ability suggest that in this study population health promotion should address working conditions rather than individual life style factors.

Introduction

Many western countries face the challenge of an aging population, which also affects the workforce. From the biological perspective, aging means a progressive deterioration in various physiological systems, which is accompanied by changes in physical and mental capacities of workers [1]. Aging of the workforce will result in an increased prevalence of work-relevant symptoms and diseases. Therefore, the role of (functional) health in working life is of interest, especially since modern welfare states are prolonging working life by increasing the statutory retirement age. A recent study on the relation between health and working life showed that a perceived poor health predicts staying or becoming unemployed [2]. This calls for better adjustments of the working life demands with the individual's health as a crucial element for a longer career at work. Within this framework, the concept of work ability has been developed as an important tool to identify workers at risk for imbalance between health, capabilities and demands at work.

The work ability concept is based on the assumption that work ability is determined by an individual's perception of the demands at work and the ability to cope with them. The Work Ability Index (WAI) is a well-accepted instrument to conceptualize work ability. Several studies have shown that a low score on the index is highly predictive of work disability during follow-up [3,4]. Previous research, predominantly in physical demanding jobs, showed that the WAI is negatively influenced by older age, high physical work demands, high psychosocial work demands (e.g. lack of possibilities to control one's own work), unhealthy lifestyle (lack of physical activity), and a poor physical fitness [1, 5-7].

Few studies have addressed determinants of work ability in occupational populations with predominantly mental demands at work. Among office workers Sjögren-Rönkä [8] showed that low stress at work and a better self-confidence were directly related to higher work ability. Seniority in the job and job satisfaction were also associated with a better work ability among office workers [9]. However, the knowledge of determinants of work ability in mentally demanding occupations is scarce and hence, it remains unclear whether in these jobs the relative importance of personal and work-related factors is similar to their well-known contribution in physically demanding jobs.

The purpose of this study was to explore the associations of psychosocial factors at work, stressful life events, and life style on health and work ability among white-collar workers.

Methods

Subjects

In the period between 2003 and 2007 a total of 2,666 white-collar workers from six companies in commercial services were invited for a health examination. Twenty percent of the subjects were employed at three consultancy firms, 62% at two insurance companies and 18% at an information technology company. The health examination consisted of two parts, i.e. a questionnaire and a physical examination. Both parts were offered independently to workers and their participation was entirely voluntary. The response to the questionnaire was 69.4% (n=1850). The response to the physical examination was 67.8% (n=1808). Selection of subjects with both a filled out questionnaire and a physical examination comprised the study population of 1141 (42.8%) subjects.

Work ability

Work ability was measured with the Work Ability Index (WAI). The WAI consists of an assessment of the physical and mental demands on an individual in relation to his work, previously diagnosed diseases, limitations in work due to disease, sick leave, work ability prognosis, and psychological resources. The WAI consist of seven dimensions and the index is derived as the sum of the ratings on these dimensions. The range of the summative index is 7-49, which is classified into a poor (7-27), moderate (28-36), good (37-43), or excellent (44-49) work ability.[10]

Functional health status

Functional health status was assessed using the Short-Form Health Survey (SF-12) version 2, the shortened alternative for the 36-item health survey. This measure provides two weighted summary scores assessing physical function (physical health component summary, PCS) and mental well-being (mental health component summary, MCS) [11]. The mental health summary score ranges from 8 to 74, whereas the physical health summary score ranges from 4 to 73, with a higher score indicating a better health state.

Psychosocial factors at work

Psychosocial factors at work were measured by the Stress monitor [12]. The original monitor consists of four dimensions, whereas three dimensions (teamwork, stress handling, and self-development) were used in the current study. The three dimensions consist of 27 items on a five-point scale varying from 'totally disagree' to 'totally agree'.

The dimension teamwork (Chronbach's alpha = 0.85) reflects social support and work spirit and consists of 12 items, e.g. "I can rely on my colleagues and trust them" and "We are not a team at work". The stress handling dimension (Cronbach's alpha= 0.77) reflects active coping and self-efficacy and consists of seven items, such as "In difficult situations I do not wait and see, but take action" and "I can cope well with the demands of my job". The dimension self-development (Cronbach's alpha =0.82) reflects possibilities for self-fulfilment and consists of eight items. Examples are: "My abilities are full employed" and "I need a new challenge". The scores on items within each dimension were transformed to a 0-100 scale with a higher score indicating good teamwork, better stress handling, and more opportunities for self-development in work. The sum scores for the variables teamwork, stress handling, and self-development were not normally distributed. Tertiles were calculated to assign subjects into low, intermediate and high levels per dimension.

Stressful life events

The occurrence of stressful life events in the past 12 months was measured using a shortened Social Readjustment Rating Questionnaire (SRRQ) [13]. The original SRRQ consists of 43 life events (e.g., divorce, job change, death of family members and so forth), listed by rank order based on their mean life change values. Life change values classify the impact of the events and were obtained by scaling the life events based on the amount of coping required to deal with the event. The total score counts the life change values of all events in the past 12 months. In the current study the 25 events most appropriate for the population under study were selected. In theory, the total score can range from none of these events (0) up to all events (1077).

Life style factors

Life style factors were measured with the Dutch version of the Stanford Wellness Inventory [14]. Lifestyle factors of interest concerned moderate physical activity, vigorous activity, smoking, and alcohol use. The questionnaire has single questions on regular participation in moderate activities for 30 minutes or more and participation in vigorous activities for 20 minutes or more, both on a five-point scale ranging from 'never' to '5 days or more per week'. Those who reported moderate physical activity on at least 5 days per week were considered in agreement with the recommendation on moderate-intensity physical activity, and subjects with vigorous exercises at least 3 times per week were considered in agreement with the recommendation on vigorous-intensity physical activity [15]. Current smoking was assessed with the question "Do you smoke?". A five-point-response scale was used to assess alcohol

drinking by average number of alcohol drinks per week (1-7, 8-14, 15-21, 22-28, more than 28). Problematic drinkers were defined as those who consumed more than 14 units of alcohol per week for women and more than 21 units for men [16].

Physical examination

Physical examinations were performed using MicroFit equipment in accordance with the protocol of the American College of Sports Medicine [17]. During the physical examination biometry was recorded, including weight, height, biceps strength, and cardio respiratory fitness. The body mass index (BMI) was used to define subjects as normal (BMI ≤ 25), overweight (BMI 25-30), or obese (BMI ≥30). Maximal isometric muscular strength of the biceps was measured after one practice trial with a calibrated dynamometer with the subjects in standing position with 90° flexion in the elbows for three seconds. The isometric biceps strength was calculated as the average of several hundred readings over the 3-second period. Cardio respiratory fitness was assessed by a 12-minute sub maximal bicycle ergometer test, supervised by instructors. Subjects pedaled at 60 rev.min^{-1} for 12 minutes on the cycle ergometer at an exercise intensity designed to produce a heart rate between 120 and 170 beats per minute in order to reach a level of 80% of the theoretical maximal heart rate of the participant for three minutes after a warming up period of minimal three minutes. This level was sustained for 3 minutes and the heart rate was measured at the end of each minute. The VO_2max (mL.min^{-1}.kg^{-1}) was calculated by the work intensity (watts) and heart rates at the end of all the stages at exercise level.

Statistics

The effects of individual characteristics (age and sex), life style, psychosocial factors at work, stressful life events, life style, and physical condition on the outcome variables work ability, and mental and physical health were investigated with linear regression analysis. Probability plots and Kolmogorov-Smirnov tests showed that none of the determinants measured at continuous level were normally distributed. However, the evaluation of the distributions of residuals in the regression analyses showed that for those variables measured at ratio scale (i.e. age, VO_2max, and biceps strength), the assumption of linearity was not violated. These variables were included in the linear regression analyses as continuous variables. Due to considerable ceiling effects for the psychosocial variables and skewed distribution for life stress events, these variables were treated as categorical variables, defined by cut-off values based on tertiles.

The analysis started with univariate regression models to determine the single effects of all determinants of interest. A backward regression technique was used to determine

the multivariate model with the best overall fit. In this analysis independent variables with a p-value of 0.05 or less were retained in the final model.

The results of the regression analyses are presented by the regression coefficients and associated standard errors. A regression coefficient is an expression of the change in the work ability score due to a change in one unit of measurement of the independent variable of interest. For categorical variables this reflects the effect on the work ability score of the presence of this determinant.

The regression analysis on determinants of work ability was stratified for three age groups. All significant determinants in the multivariate model for one age group were included in the models for other age groups as well in order to provide an appropriate comparison.

All analyses were carried out with the Statistical Package for Social Sciences version 11.0 for Windows [18].

Results

The study population included 769 men (67%) and 372 (33%) women in a variety of jobs (Table 1). The median for age was 35.7 years (18-63). The distribution of excellent, good, moderate and poor work ability was 42.8, 45.4, 9.7, and 2.1%, respectively. Subjects scored almost equal on mental health as on physical health, whereas the Pearson correlation coefficient between both measures of health was -0.20. The Pearson correlation coefficients between WAI and mental and physical health were 0.49 and 0.35, respectively. The three psychosocial factors at work were strongly interrelated with Pearson correlation coefficients varying from 0.45 to 0.57.

Table 2 shows mental health was statistical significant influenced by psychosocial factors at work, stressful life events, and life style factors, whereas physical health was influenced by lifestyle factors and physical condition in the univariate model. The multivariate model explained 22% of the variance in mental health. An increase in age with one year increased the mental health score with 0.1 point, and decreased the physical health score with 0.1 point. In the multivariate analysis most determinants remained statistically significant, albeit with a lower regression coefficient, especially for teamwork and self-development. The multivariate model explained only 5% of the variance in physical health. It is of interest to note that neither problematic alcohol use nor overweight or obesity was associated with physical health.

Table 1 Characteristics of 1141 commercial workers who participated in a voluntary medical examination).

Characteristics	Cases	Median (min-max)	Frequency (%)
Individual characteristics			
Age (year)	1141	35.7 (18-63)	
Male	769		67.4%
Work ability			
Excellent (44-49)	488	42.1 (9-49)	42.8%
Good (37-43)	518		45.4%
Moderate (28-36)	111		9.7%
Poor (7-27)	24		2.1%
Health			
Mental health component summary (MCS)(8-74)	1141	54.2 (10.9-67.9)	
Physical health component summary (PCS)(4-73)	1141	53.4 (18.2-70.6)	
Psychosocial factors at work			
Teamwork (0-100)	1136	81.0 (27-100)	
Stress-handling (0-100)	1136	68.0 (11-100)	
Self-development (0-100)	1136	78.0 (9-100)	
Stressful life events (0-100)	1136	5.5 (0 - 38.4)	
Life style			
Lack of moderate physical activity (<5 days per week)	798		70.2%
Lack of vigorous physical activity (<3 times per week)	886		78.0%
Current smoker	145		12.8%
Problematic alcohol use	42		4.5%
Physical examination			
Overweight (BMI 25-30kg/m^2)	371		34.6%
Obesity (BMI ≥30kg/m^2)	57		5.3%
VO_2max (ml/kg/min)	1117	35.9 (11.4-61.7)	
Biceps strength (kg)	1134	37.0 (8.0-94.0)	

Table 3 shows work ability was statistically significant influenced by psychosocial factors at work, stressful life events, lack of vigorous physical activity, and obesity in the univariate model. The multivariate model explained 29% of the variance in work ability. Again, in the multivariate model most determinants remained statistically significant, although with lower regression coefficients. The influence of stressful life events increased in the multivariate model.

No significant interaction was observed for age, sex, and psychosocial factors at work.

Table 2 Results of backward regression analysis: effects of psychosocial factors at work, stressful life events, lifestyle and physical condition on mental health and physical health among workers in commercial services (n=1141).

	Mental Health (MCS)				Physical health (PCS)			
	Univariate model		Multivariate model		Univariate model		Multivariate model	
	β	SE	β	SE	β	SE	β	SE
Individual characteristics								
Age (year)	0.09*	0.03	0.07*	0.02	-0.07*	0.02	-0.09*	0.02
Male	2.41*	0.51	1.52*	0.47	1.66*	0.38	1.91*	0.38
Psychosocial factors at work								
Low vs. high teamwork	-5.90*	0.56	-2.71*	0.66	-0.92*	0.43	n.s	
Intermediate vs. high teamwork	-2.39*	0.57	-0.70	0.58	-0.68	0.45	n.s	
Low vs. high stress-handling	-6.94*	0.56	-4.71*	0.62	-0.26	0.45	n.s	
Intermediate vs. high stress-handling	-2.39*	0.58	-1.42*	0.59	0.01	0.46	n.s	
Low vs. high self-development	-5.44*	0.60	-2.12*	0.65	-0.73	0.46	n.s	
Intermediate vs. high self-development	-2.19*	0.58	-0.59	0.57	-0.81	0.45	n.s	
Stressful life events								
High vs. low stressful life events	-3.13*	0.59	-3.13*	0.54	-0.62	0.44	n.s	
Intermediate vs. low stressful life events	-1.91*	0.59	-1.98*	0.53	-0.05	0.44	n.s	
Life style								
Lack of moderate physical activity	-0.14	0.53	n.s.		-0.01	0.39	n.s	
Lack of vigorous physical activity	-1.27*	0.58	-1.37*	0.52	-1.79*	0.43	-1.71*	0.42
Current smoker	-2.02*	0.72	-1.96*	0.65	-1.14*	0.54	n.s	
Problematic alcohol use	-1.76	1.27	n.s.		-1.61	0.92	n.s	
Physical examination								
Obesity (BMI ≥30) vs. normal (BMI<25)	-0.84	1.14	n.s		-1.54	0.83	n.s	
Overweight (BMI 25-30) vs. normal	0.34	0.54	n.s		-0.30	0.39	n.s	
VO_2 max (ml/kg/min)	-0.01	0.03	n.s		0.05*	0.02	n.s	
Biceps strength (kg)	0.03	0.02	n.s		0.04*	0.02	n.s	

n.s= not significant, p>0.05

Table 3 Results of backward regression analysis: effects of psychosocial factors at work, stressful life events, lifestyle and physical condition on work ability among workers in commercial services (n=1141).

	Work ability Univariate model		Work ability Multivariate model	
	β	SE	β	SE
Individual characteristics				
Age (yr)	-0.07*	0.02	-0.09*	0.01
Male	2.13*	0.31	2.08*	0.28
Psychosocial factors at work				
Low vs. high teamwork	-4.02*	0.32	-1.32*	0.40
Intermediate vs. high teamwork	-1.52*	0.34	-0.20	0.35
Low vs. high stress-handling	-4.39*	0.34	-2.75*	0.35
Intermediate vs. high stress-handling	-1.41*	0.35	-0.79*	0.35
Low vs. high self-development	-4.11*	0.35	-2.20*	0.39
Intermediate vs. high self-development	-1.67*	0.34	-0.91*	0.34
Stressful life events				
High vs. low stressful life events	-1.36*	0.36	-2.01*	0.32
Intermediate vs. low stressful life events	-0.97*	0.36	-1.14*	0.32
Life style				
Lack of moderate physical activity	0.49	0.32	n.s	
Lack of vigorous physical activity	-0.71*	0.35	-0.71*	0.31
Current smoker	-0.68	0.44	n.s	
Problematic alcohol use	-0.52	0.74	n.s	
Physical examination				
Obesity (BMI ≥30) vs. normal (BMI<25)	-2.02*	0.68	-1.21*	0.59
Overweight (BMI 25-30) vs. normal (BMI<25)	-0.49	0.32	-0.32	0.28
VO_2 max (ml/kg/min)	0.03	0.02	n.s	
Biceps strength (kg)	0.03	0.01	n.s	

n.s= not significant, p>0.05

Table 4 shows that in each age group sex, stress handling, and self-development were associated with the work ability index. Lifestyle factors were associated with work ability only in the oldest age group of workers, over 45 years. Obesity no longer was statistically significant.

Table 4 Results on backward regression analysis per age-group: effects of psychosocial factors at work, stressful life events, lifestyle and physical condition on work ability among workers in commercial services (n=1141).

	Work ability Multivariate model					
	Age ≤ 32 year (n=335)		Age 32-45 year (n=366)		Age >45 year (n=200)	
	β	SE	β	SE	β	SE
Individual characteristics						
Male	1.43*	0.42	1.37*	0.49	3.19*	0.83
Psychosocial factors at work						
Low vs. high teamwork	-0.44	0.61	-1.40*	0.63	-1.07	0.98
Intermediate vs. high teamwork	-0.49	0.50	-0.39	0.60	-0.58	0.89
Low vs. high stress-handling	-2.85*	0.55	-3.22*	0.63	-2.44*	0.95
Intermediate vs. high stress-handling	-0.96	0.52	-1.08	0.61	-0.83	0.86
Low vs. high self-development	-2.59*	0.64	-1.64*	0.59	-3.57*	1.01
Intermediate vs. high self-development	-1.27*	0.51	-0.92	0.57	-1.63	0.84
Stressful life events						
High vs. low stressful life events	-1.25*	0.49	-1.67*	0.51	-2.60*	0.84
Intermediate vs. low stressful life events	-0.64	0.53	-1.78*	0.52	-0.34	0.72
Life style						
Lack of moderate physical activity	-0.28	0.47	0.02	0.51	1.45*	0.70
Lack of vigorous physical activity	-0.58	0.49	-0.56	0.53	-1.62*	0.79
Problematic alcohol use	1.70	0.93	-0.85	1.19	-2.62*	1.33

n.s= not significant, p>0.05

Discussion

This study showed that work ability of white-collar workers in commercial services industry was strongly associated with psychosocial factors at work, such as teamwork, stress handling, self-development, and, to a lesser extent, with stressful life events, lack of physical activity, and obesity. Work ability was strongly associated with mental and physical health. Determinants of mental health were very similar to those of work ability, whereas physical health was influenced primarily by lack of life physical activity.

Some limitations must be taken into account in this study. First, the cross-sectional design does not permit exploration of causal relationships between the determinants and work ability. Therefore, it remains unknown whether, for example, a poor stress handling will decrease work ability or decreased work ability will cause a poorer stress handling. Nevertheless, the results are still of interest as they give a first insight into important factors for interventions among white-collar workers. Second, data were drawn from voluntary participants. Information on non-response for both measures showed that age and sex did not bias response. Non-response differences between questionnaire and physical examination did not show any bias; none of the questionnaire variables were associated with not participating in the physical examination; and also none of the physical examination variables were associated with not participating in the questionnaire. Third, the reliability of the physical examination highly depends on the professional skills of the instructor and the standardization of the examination. The maximum oxygen uptake was indirectly calculated using the heart rate, which can be easily increased by minor distractions, such as room temperature, and talking during the test.

In this study among white-collar workers in commercial services industry the proportion of workers with poor work ability was 2.1% and the mean WAI was 41.1 (sd=5.1). These results are slightly higher than the Finnish reference data in mentally demanding work (mean 39) [10].

Work ability in this study population was influenced by sex, age, psychosocial factors at work, stressful life events, and life style factors. These factors together explained 29% of the total variance in work ability in this study population. Male sex increased work ability with 2 points, which means 4% of the maximum score. An increase in age of 40 years decreases the WAI score with four points, which is 7.3% of the maximum score, which indicates a rather modest influence of age on work ability. Psychosocial factors each had an effect on WAI comparable to sex, whereas the combined effect of the psychosocial factors is approximately 1.5-fold the effect of 40 years of aging.

Lack of vigorous physical activity decreases the WAI score with only 0.7 points, which is no more than 1.5% of the maximum score. Obesity (5% of the population) compared to normal weight decreases the WAI score with 1.2 points, which is 2.4% of the maximum score.

Each psychosocial factor at work was negatively associated with work ability. Univariate results showed comparable strength in associations, while the multivariate model showed lower regression coefficients, especially for teamwork. It seems that the association between teamwork and work ability was more influenced by other determinants included in the multivariate model, than the associations between work ability and stress handling and self-development.

In previous research, inconsistent results were found regarding the influence of psychosocial factors at work on work ability. For example, in the metal industry an increase in teamwork and increase in opportunities for development was not predictive of an increase in work ability during a 2-year follow-up [19]. Negative associations between mental stress and work ability have been found among office workers (β=-0.17), but this association was minimized when including age in the regression model [8]. Among bus drivers, significant associations were observed for high control by superiors and lack of responsibility at work with lower WAI scores [20].

The negative association of stressful life events with work ability in the current study is in agreement with earlier findings by Pohjonen [21], who found an increased risk for poor work ability (OR=3.62 (2.2-5.9)) for a hard life situation outside of work.

The results showed that a lack of vigorous physical activity was associated with decreased work ability, whereas associations between work ability and biceps strength and maximum oxygen uptake were not found in the multivariate model. The lack of significant results for maximum oxygen uptake and biceps strength is in line with findings of Eskelinen et al. [22], Nygard et al. [23], and Pohjonen [6]. It may be hypothesized that in mentally demanding jobs a good physical condition is not required to meet the work demands and, thus, will have no influence on work ability.

Stratification by age showed the importance of lifestyle in the oldest age group, but not among younger workers. This effect may be explained by the fact that health problems due to an unhealthy lifestyle, most notably diabetes mellitus and cardiovascular disease, occur primarily at older age. In the total study population, obesity was significantly associated with a lower work ability, whereas no significant associations were found in the stratified analyses. This is partly due to lack of statistical power in these strata with smaller numbers of workers, since the magnitude of the regression coefficients were comparable but the standard errors increased substantially.

The Pearson correlation coefficient of mental and physical health was -0.20, which was in line with results of Van Duijn et al. [24] In a univariate analysis both mental health and physical health were associated with work ability. However, determinants of work ability were similar to determinants of mental health. This finding can be explained by the fact that the work setting of the white-collar workers in the current study is characterized by high mental demands. An exception to the similarity in factors influencing both mental health and work ability was, smoking. Smoking was related to mental health, but not to work ability.

The results of the current study outline the importance of work-related factors in white-collar workers, with regard to work ability. The combined impact of psychosocial factors is much stronger than is for individual factors, and is amendable to change, in contrast to individual factors as age, and sex.

In conclusion, among white-collar workers in commercial services industry psychosocial factors at work, stressful life events, lack of vigorous physical activity, and obesity were significant related to work ability. The strong associations between psychosocial factors at work and mental health and work ability suggest that in this study population health promotion should address working conditions rather than individual life style factors, although the importance of life style factors seems to increase with aging of the worker.

References

[1] Ilmarinen J. Aging and work – coping with strengths and weaknesses. *Scand J Work Environ Health* 1997;23: 3-5.

[2] Schuring M, Burdorf A, Kunst AE, Mackenbach JP. Socio-economic inequalities in health and its effect on entering and maintaining paid employment: evidence in European countries. *J Epidemiol Commun Health* 2007;61: 597-604.

[3] Liira J, Matikainen E, Leino-Arjas P, Malmivaara A, Mutanen P, Rytkönen H, Juntunen J. Work ability of middle-aged Finnish construction workers – a follow-up study in 1991-1995. *Int J Ind Ergonom* 2000;25: 477-81.

[4] Tuomi K, Toikkanen J, Eskelinen L, Backman AL, Ilmarinen J, Jarvinen E, Klockars M. Mortality, disability and changes in occupation among aging municipal employees. *Scand J Work Environ Health* 1991;17 (suppl 1): 58-66.

[5] Alavinia SM, Duivenbooden van C, Burdorf A. Influence of work-related factors and individual characteristics on work ability among Dutch construction workers. *Scand J Work Environ Health* 2007;33: 351-57.

[6] Pohjonen T. Age-related physical fitness and the predictive values of fitness tests for work ability in home care work. *J Occup Environ Med* 2001;43: 723-30.

[7] Tuomi K, Huuhtanen P, Nykyri E, Ilmarinen J. Promotion of work ability, the quality of work and retirement. *Occup Med* 2001;51: 318-24.

[8] Sjögren-Rönkä T, Ojanen MT, Leskinen EK, Mustalampi ST, Mälkiä EA. Physical and psychosocial prerequisites of functioning in relation to work ability and general subjective well-being among office workers. *Scand J Work Environ Health* 2002;28: 184-90.

[9] Martinez MC, Latorre MRDO. Health and work ability among office workers. *Rev Saúde Pública* 2006;40: 851-8.

[10] Tuomi K, Ilmarinen J, Jahkola A, Katajarinne L, Tulkki A. *Work ability Index*. 2nd revised edn, Helsinki: Finnish Institute of Occupational Health, 1998.

[11] Ware JE, Kosinski MA, Turner-Bowker DM, Gandek B. *Sf-12v2 How to score version 2 of the sf-12 health survey*. Quality Metric Incorporated. Health Assessment Lab Boston, Massachusetts. Lincoln, Rhode Island, 2002.

[12] Petri C, van der Velden PG, Kleber RJ. Hoe gaat het met u? – een praktische Stress monitor [*How are you? – A practical stress monitor*]. Thema, Zaltbommel, 2001.

[13] Holmes TH, Rahe RH. The social readjustment rating scale. *J Psychosom Res* 1967;11: 213-8.

[14] Sallis JF, Haskell WL, Wood PD, Fortmann SP, Rogers T, Blair SN et al. Physical activity assessment methodology in the Stanford five-city project. *Am J Epidemiol* 1985;121: 91-106.

[15] Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, et al. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *J Am Med Assoc* 1995;273: 402-7.

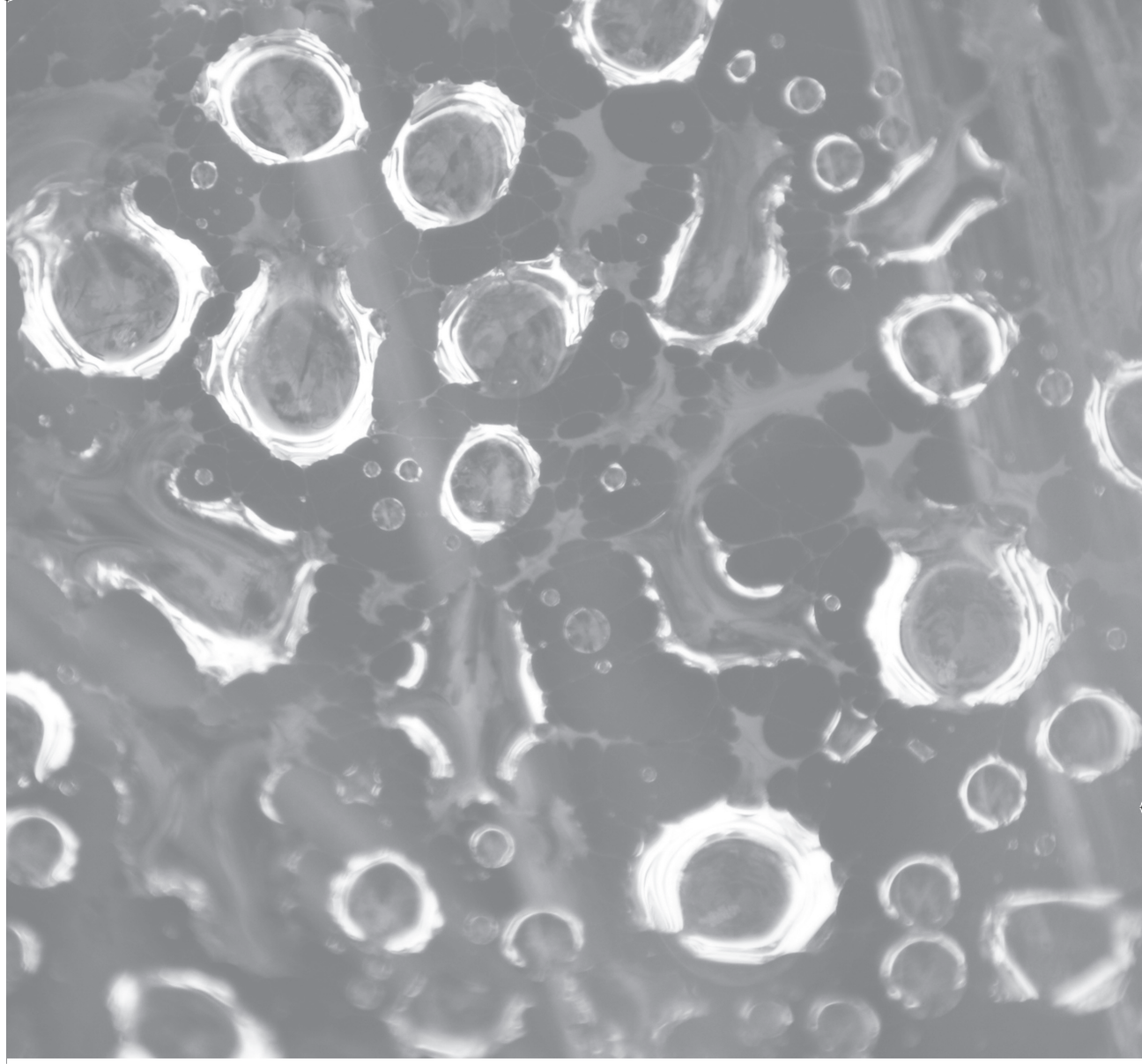
[16] Health Council of the Netherlands. *Guidelines for a healthy diet*. Health Council of the Netherlands. Publication no. 2006/21, The Hague, 2006.

[17] American College of Sports and Medicine. *ACSM's guidelines for exercise testing and prescription*. cop. 2000, 6th edition. Senior ed. B.A. Franklin; ass.ed. MH. Whaley et al. Lippincott Williams & Wilkins, Philadelphia, PA, 1975.

[18] Statistical package for social sciences (SPSS), version 11. Chigago, IL, 1999.

[19] Tuomi K, Vanhala S, Nykyri E, Janhonen M. (2004) Organizational practices, work demands and the well-being of employees: a follow-up study in the metal industry and retail trade. Occup Med 54:115-21.

[20] Kloimüller I, Karazman H, Geissler I, Karazman-Morawetz I. The relation of age, work ability index and stress-inducing factors among bus drivers. *Int J Ind Ergonom* 2000;25: 497-502.
[21] Pohjonen T. Perceived work ability of home care workers in relation to individual and work-related factors in different age groups. *Occup Med* 2001;51: 209-17.
[22] Eskelinen L, Kohvakka A, Merisalo T, Hurri H, Wägar G. Relationship between the self-assessment and clinical assessment of health status and work ability. *Scand J Work Environ Health* 1991;17 (suppl 1):40-7.
[23] Nygård C, Eskelinen L, Suvanto S, Tuomi K, Ilmarinen J. Associations between functional capacity and work ability among elderly municipal employees. *Scand J Work Environ Health* 1991;17 (suppl 1): 122-7.
[24] Duijn van M, Lötters F, Burdorf A. Interrelationships between pain, disability, general health and quality of life and associations with work related and individual factors. *Spine* 2004;19: 2178-83.



Part 3

Consequences of a decreased work ability

Chapter 6

Impact of work-related factors, lifestyle, and work ability on sickness absence among Dutch construction workers

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Abstract

Objective The objective of this study was to evaluate the relative contribution of individual characteristics, lifestyle factors, work-related risk factors, and work ability on the occurrence of short (< 2 weeks), moderate (2-12 weeks), and long (> 12 weeks) durations of sickness absence.

Methods Altogether 5,867 Dutch construction workers with complete sick leave registration were followed from the day of their medical examination in 2005 until the end of the year 2006. The main outcome of the study was the duration of sickness absence, as registered by an occupational health service. Independent variables consisted of individual characteristics, lifestyle factors, work-related factors, and the work ability index. We used Poisson regression analyses with repeated occurrence of sick leave to calculate rate ratios (RR) and 95% confidence intervals of independent variables for the three categories of sick leave duration.

Results Predictors for sick leave lasting 2-12 weeks and >12 weeks were: older age, obesity, smoking, manual materials handling, lack of control at work, lung restriction, and a less-than-excellent work ability. For most predictors, higher RR values were observed with longer duration of sickness absence. Obesity, smoking, manual materials handling, and lack of job control remained important risk factors for moderate and long durations of sick leave after adjusting for the strong effects of work ability on sickness absence. The highest population attributable fractions were observed for: age over 50 years (18%), manual materials handling (20%), and good (18%), moderate (28%), and poor (2%) work ability.

Conclusion This study suggests that a variety of preventive measures targeted at smoking, obesity, physical load, psychosocial work factors as well as work ability will contribute to reduction in the occurrence of sick leave.

Introduction

Sickness absence is an expression of the complex relation between health and work characteristics [1] and is thought to have a multifactorial etiology [2]. A range of factors can influence the occurrence and duration of sickness absence such as individual characteristics, health behavior, and work related factors [2 – 5]. Older workers take sick leave less often, but their periods of absence are generally longer than younger workers [6 – 9]. Labriola et. al. [10] have shown that obesity, smoking, and poor health are associated with sickness absence. In general, blue-collar workers take more sick leave than their white-collar counterparts, both more often and for a longer period of time [3, 9, 11, 12]. Sickness absence is also related to high physical and psychosocial demands at work, especially low decision authority and low job control [2, 13, 14].

There is ample evidence that construction workers have a higher risk of health problems that may lead to sickness absence and subsequent work related disability [15, 16]. A prospective study among construction workers showed that physical load was a risk factor for sickness absence. [17] The high physical load in the construction industry is largely determined by manual materials handling and repetitive, awkward postures [15, 18].

The work ability index (WAI) has been promoted in recent years as a valuable tool in occupational health programs aimed at decreasing the number of early exits from the work place [19]. Although the relationship between work-related factors, individual health and the WAI is well known [20], there is limited information on its predictive value for future sickness absence. A study by Kujala et al. showed that a decreased work ability among young employees had a predictive value for long-term sickness absence [21].

The aim of our study was to evaluate the relative impact of individual characteristics, lifestyle factors, work-related risk factors, and work ability on the occurrence of short, moderate, and long spells of sickness absence among Dutch construction workers.

Material and methods

Study population and design

The study population consisted of workers in the construction industry in the Netherlands who participated in the voluntary periodic medical examination in 2005. Such examinations are offered to all construction workers at least every four years. The Arbouw Foundation, responsible for the organization and contracting of the examinations, estimates that the annual participation is about 60% of all invited construction workers. In the Netherlands, the periodic examination is offered by over 20 different occupational health services with local branches and consists of a questionnaire and physical examination. Of the 19,753 examined workers, registration of sickness absence and complete questionnaire data were available for 5867 male workers from one large occupational health service. Given the very small number of female workers (N = 245), the analysis was limited to male construction workers. Sickness absence registration for other workers was done by the construction companies themselves, incomplete, or unavailable for analysis. The workers were followed from the day of their medical examination until the end of 2006. The mean follow-up time was 437 days, with a minimum of 374 days and a maximum of 699 days.

Sickness absence

During the follow-up period, the sickness absence register was maintained by the occupational health service, which recorded the occurrence and duration of every absence episode. The primary measure of interest was the duration of sickness absence period during the follow-up, which was categorized as being of short (< 14 days), moderate (2 -21 weeks), and long (> 12 weeks) duration. In The Netherlands, in almost all situations, a worker will be paid a full salary during the first year of sickness absence; a worker is not eligible for a permanent disability pension during the first two years on sick leave. Six weeks after the first day of sick leave, the law requires that worker and employer agree upon a written rehabilitation plan.

Work-related factors

The work-related factors in the questionnaire consisted of physical and psychosocial items. Ascertained by dichotomized questions [19], physical load referred to the regular presence in the current job of manual materials handling, awkward back postures, static work postures, repetitive movements, whole body vibration, and hand arm vibration. Psychosocial work characteristics of the job were assessed with

an abbreviated Dutch version of Karasek's job content questionnaire [22], which included two "yes or no" questions on job demands and on job control. In addition, there were dichotomized questions on supervisor and co-worker support, and job satisfaction were asked [19].

Individual characteristic and lifestyle factors

Information on age, height, weight, and type of job were collected during the medical examination. The Body Mass Index (BMI) was calculated by dividing body weight in kilograms by the square of body height in meters, and used to define subjects as normal (< 25 kg/m^2), overweight (25-30 kg/m^2), or obese (> 30 kg/m^2). The lifestyle factors of interest included smoking, alcohol consumption, and physical activity during leisure time. Subjects were classified as current smokers or non-/ex-smokers. An open question on average number of alcoholic drinks consumed per week was used to define problematic alcohol use as the consumption of 15 units of alcohol or more per week [23]. Physical activity during leisure time was addressed by a single open question on the frequency of physical activity for at least 30 minutes per day and a single question, with 5 answer categories, on the frequency of strenuous (sweat-inducing) physical activity. Those who reported being physically active for 30 minutes per day, at least 5 days a week, were considered to be doing moderately intense physical activity. Subjects doing vigorous exercises at least 3 times per week were considered to be doing vigorously intense physical activity [24].

Health

Total blood cholesterol and high-density lipoprotein cholesterol were measured in venous blood samples. Spirometry was conducted to measure forced expiratory volume (FEV1) and forced vital capacity (FVC). The FEV1 and FVC were expressed as percentages of the predicted values, based on reference equations [25]. According to the spirometry findings, workers were divided into normal, obstructive, and restrictive lung diseases, in line with the American Thoracic Society criteria [26]. The age, total blood cholesterol, high-density lipoprotein cholesterol, smoking habits, and systolic blood pressure of each participant were used to calculate the Framingham Risk Score for the 10-year risk for coronary heart disease events (coronary heart disease death and myocardial infarction) [27]. The 10-year risk prediction was dichotomized into "no risk" (0-9%), and "cardiovascular risk" (more than 10%) of coronary heart death and myocardial infarction [28].

Work ability

Work ability was measured by the WAI questionnaire consisting of an assessment of seven dimensions: an indivual's (i) physical and (ii) mental demands in relation to his work, (iii) diagnosed diseases, (iv) experienced limitations in work due to disease, (v) occurrence of sick leave in the previous 12 months, (vi) work ability prognosis, and (vii) mental resources. The WAI index is derived as the sum score of the ratings on each dimension. The range of the summative index is 7-49, which is classified into "poor" (7-27), "moderate" (28-36), "good" (37-43), and "excellent" (44-49) work ability [29].

Statistical analysis

All descriptive data are presented as mean and standard deviation, or percentage when appropriate. The dependent variable in the statistical analysis was the duration of sickness absence during the follow-up, categorized as being of short, moderate, or long duration. For each duration of sickness absence, we used "workers without sick leave" as the reference group. Since Poisson regression analysis is a robust method when there is a slight variation in the occurrence of events over the follow-up time and the event of interest is less common (eg, long duration sick leave) [30,31] we used a Poisson regression analysis with repeated occurrence of sickness absence. This approach yields effect estimates that are referred to as rate ratios (RR). The follow-up time was defined by the actual time at risk and, thus, was restricted to the first day of sickness absence. In case of multiple sickness absence periods, the follow-up time was calculated from the first day of return to work until the next episode of sickness absence or end of follow-up. Since subjects were not all followed for the same period of time, the logarithm of the actual follow-up time was used as an offset variable to take the actual time at risk into account.[30] In the first step in the analysis, all variables with a P-value < 0.10 were selected in univariate Poisson regression models with the three durations of sickness absence as dependent variables. The one-sided P-value of the Cochrane-Armitage test was used to test the hypothesis of a trend between a explanatory variable and the dependent variable. Subsequently, we used a backward selection procedure to retain important variables with a significant effect ($P < 0.05$) in the final multivariate Poisson regression models, with the significance level evaluated by the scaled deviance between the full model and the reduced model. In order to make comparisons across the three durations of sick leave, variables with a significant RR in one model were included in another model. All analyses were carried out with the statistical package SAS version 9.13 [32].

Results

Table 1 describes the baseline characteristics of the study population in the construction industry in the Netherlands, stratified by the longest duration of sickness absence during follow-up. The mean age of the workers was 44 years (standard deviation (SD) 11), ranging from 16-62 years. Most workers held a blue-collar job (77.4%). The mean BMI for the study population was 26.2 (SD 3.6); 47.4 % were overweight and 13.0% were obese. The distribution of excellent, good, moderate, and poor work ability was 33.0%, 50.2%, 15.6%, and 1.2%, respectively. Among the 5867 workers, 1981 (34%) workers had at least one episode of sickness absence, with a total of 2544 periods of short duration, 614 periods of moderate duration, and 152 periods of long duration. The analyses of trends showed that a higher BMI, smoking, poor health, higher physical and psychosocial load at work, and lower work ability at baseline were increasingly prevalent among workers with a longer duration of sickness absence during follow-up.

Table 2 shows the influence of individual characteristics, lifestyle factors, health indicators, and the WAI on sickness absence in the univariate Poisson regression analyses. White-collar workers had consistently a lower risk of sick leave compared with blue-collar workers. The RR increased by the category of duration of sickness absence for: older age, overweight, obesity, problematic alcohol use, lung obstruction, lung restriction, and a moderate WAI.

Table 3 describes the univariate associations between work-related factors and sick leave. The physical work-related factors were associated with short, moderate, and long spells of sickness absence. For most physical risk factors, the observed RR were higher for moderate and long durations of sickness absence than for short spells. Among the psychosocial factors, high work demands were not associated with the occurrence of sick leave. For most psychosocial risk factors, larger RR were found with longer duration of sick leave.

Table 4 shows that risk factors for sickness absence of < 2 weeks were: younger age, smoking, working with awkward back postures, lack of job control, and a less-than-excellent work ability. For sick leave of 2-12 weeks, important risk factors included: older age, obesity, smoking, manual materials handling, lack of job control, lung restriction, and a reduced work ability. The risk factors for sick leave of >12 weeks were comparable to those of moderate durations; however, some factors failed to reach significance due to large confidence intervals.

Table 1 Baseline characteristic of individual factors, lifestyle factors, health indicators, work-related factors, and work ability index in a longitudinal study among 5867 male construction workers in the Netherlands.

	No sickleave (N=3886)	Short spell of sickleave < 2 weeks (N=1284)	Moderate spell of sickleave 2-12 weeks (N=547)	Long spell of sickleave >12 weeks (N=150)
Individual characteristics				
Age (mean ± SD)	44.0 ± 11.06	42.4 ± 11.5	45.7 ± 10.5	47.0 ± 9.8
BMI (mean ± SD)*	26.1 ± 3.62	26.0 ± 3.5	26.7 ± 3.6	27.2 ± 4.3
White-collar job (%)*	24.9	21.9	11.0	14.0
Lifestyle factors				
Smoker %*	31.2	33.3	37.5	34.7
Problematic alcohol drinker %	14.0	12.2	16.3	16.7
Normal physical activity %*	67.9	67.8	76.2	71.4
Vigorous physical activity %	19.9	20.1	20.5	23.1
Health indicators				
Lung obstruction %*	2.0	2.9	2.9	4.7
Lung restriction %*	0.8	1.5	1.3	3.3
Cardiovascular risk %*	29.2	28.0	34.6	33.3
Work-related physical factors				
Manual materials handling %*	45.1	48.1	57.6	58.7
Awkward back postures %*	21.8	26.4	33.6	33.3
Static work postures %*	34.0	37.5	46.4	44.7
Repetitive movement %*	18.8	22.7	31.4	30.0
Whole body vibration %*	13.5	15.3	19.2	16.3
Hand-arm vibration %*	15.2	17.9	21.9	17.6
Work-related psychosocial factors				
Lack of job control %*	32.5	36.2	45.3	38.7
High work demands %*	58.9	61.1	62.0	60.7
Lack of support at work %*	12.1	13.5	14.6	19.1
Dissatisfaction with work %*	4.0	4.9	6.2	8.7
Work ability index				
Excellent %*	36.5	29.1	22.6	18.7
Good %	49.2	53.8	50.6	43.3
Moderate %*	13.2	16.0	26.0	36.0
Poor %*	1.1	1.1	1.8	2.0

* significant trend (P < 0.05) in Cochrane-Armitage test
(BMI = body mass index)

Table 2 Crude rate ratios (RR) and 95% confidence intervals (95% CI) of individual and lifestyle characteristics, and health indicators for sickness absence in a longitudinal study among 5867 male construction workers in the Netherlands.

	Short spell of sickleave < 2 weeks (N=1284)		Moderate spell of sickleave 2-12 weeks (N=547)		Long spell of sickleave > 12 weeks (N=150)	
	RR	95 % CI	RR	95 % CI	RR	95 % CI
Individual characteristics						
Age						
< 40 years	1.00	Reference	1.00	Reference	1.00	Reference
40 – 50 years	0.73*	0.64 – 0.84	1.36*	1.06 – 1.73	1.41	0.87 – 2.28
>= 50 years	0.70*	0.61 – 0.80	1.67*	1.32 – 2.10	2.08*	1.33 – 3.24
BMI (kg/m^2)						
Normal weight	1.00	Reference	1.00	Reference	1.00	Reference
Overweight	0.99	0.88 – 1.11	1.20	0.99 – 1.45	1.34	0.93 – 1.95
Obese	0.98	0.82 – 1.17	1.52*	1.18 – 1.96	2.06*	1.31 – 3.26
White-collar job	0.77*	0.67 – 0.89	0.36*	0.27 – 0.47	0.49*	0.31 – 0.77
Lifestyle factors						
Smoker	1.24*	1.10 – 1.39	1.35*	1.13 – 1.62	1.18	0.84 – 1.66
Problematic alcohol use	0.98	0.83 – 1.16	1.27*	1.00 – 1.61	1.31	0.84 – 2.04
Normal physical activity	1.05	0.92 – 1.20	1.59*	1.27 – 1.99	1.14	0.76 – 1.72
Vigorous physical activity	1.10	0.96 – 1.27	1.06	0.85 – 1.32	1.20	0.81 – 1.78
Health indicators						
Lung obstruction	1.44*	1.04 – 2.00	1.68	0.98 – 2.88	2.35*	1.08 – 5.11
Lung restriction	1.72*	1.10 – 2.70	1.48	0.67 – 3.27	3.88*	1.53 – 9.80
Cardiovascular risk	0.94	0.83 – 1.06	1.28*	1.07 – 1.54	1.24	0.88 – 1.75
Work ability index						
Good	1.46*	1.28 - 1.66	1.76*	1.41 - 2.20	1.68*	1.07 - 2.63
Moderate	2.02*	1.71 - 2.38	3.35*	2.60 - 4.31	5.15*	3.23 - 8.21
Poor	1.66	0.96 - 2.89	3.64*	1.88 - 7.04	3.58*	1.08 - 11.91

* P < 0.05.
(BMI = body mass index)

Table 3 Crude rate ratios (RR) and 95% confidence interval (95% CI) of work-related factors for sickness absence in a longitudinal study among 5867 male construction workers in the Netherlands.

	Short spell of sickleave < 2 weeks (N=1284)		Moderate spell of sickleave 2-12 weeks (N=547)		Long spell of sickleave > 12 weeks (N=150)	
	RR	95 % CI	RR	95 % CI	RR	95 % CI
Work-related factors						
Physical factors						
Manual materials handling	1.22*	1.09 – 1.36	1.66*	1.39 – 1.98	1.76*	1.26 – 2.44
Awkward back posture	1.41*	1.25 – 1.60	1.74*	1.45 – 2.09	1.73*	1.23 – 2.44
Static postures	1.26*	1.13 – 1.41	1.65*	1.39 – 1.97	1.52*	1.10 – 2.11
Repetitive movement	1.42*	1.24 – 1.61	1.88*	1.56 – 2.27	1.80*	1.26 – 2.56
Whole body vibration	1.24*	1.06 – 1.45	1.50*	1.20 – 1.88	1.23	0.79 – 1.91
Hand-arm vibration	1.29*	1.11 – 1.49	1.57*	1.26 – 1.95	1.16	0.76 – 1.79
Psychosocial factors						
Lack of control	1.29*	1.15 – 1.45	1.65*	1.39 – 1.96	1.32	0.95 – 1.85
High work demands	1.07	0.95 – 1.20	1.10	0.92 – 1.31	1.04	0.75 – 1.45
Lack of support at work	1.31	0.95 – 1.34	1.30*	1.02 – 1.66	1.68*	1.11 – 2.55
Dissatisfaction with work	1.12	0.95 – 1.31	1.46*	1.02 – 2.08	2.24*	1.25 – 4.01

* P < 0.05.

Most of the univariate associations between lifestyle factors, physical and psychosocial work factors and all categories of sickness absence (as observed in table 3) had substantially lower RR when adjusted for each other and the WAI. However, obesity, smoking, manual materials handling, and lack of job control remained important risk factors for moderate and long durations of sickness absence after adjustment for the other risk factors. The population-attributable fractions of significant risk factors were comparable for moderate and long duration sickness absence but slightly larger for the latter. A duration of sickness absence of >12 weeks had the highest population-attributable fractions for: age over 50 years (18%), manual materials handling (20%), and good (18%), moderate (28%), and poor (2%) work ability.

Table 4 Adjusted rate ratios (RR) and 95% confidence intervals (95% CI) of individual, lifestyle and work-related factors, health indicators, and work ability for sickness absence in a longitudinal study among 5867 male construction workers in the Netherlands.

	Short spell of sickleave < 2 weeks (N=1284)		Moderate spell of sickleave 2-12 weeks (N=547)		Long spell of sickleave >12 weeks (N=150)	
	RR	95 % CI	RR	95 % CI	RR	95 % CI
Individual characteristics						
Age						
< 40 years	1.00	Reference	1.00	Reference	1.00	Reference
40 – 50 years	0.68*	0.59 – 0.78	1.24	0.96 – 1.59	1.24	0.76 – 2.02
>= 50 years	0.61*	0.53 – 0.70	1.39*	1.08 – 1.78	1.55	0.96 – 2.49
BMI (kg/m^2)						
Normal weight	1.00	Reference	1.00	Reference	1.00	Reference
Overweight	1.04	0.92 – 1.18	1.09	0.89 – 1.33	1.14	0.78 – 1.66
Obesity	1.02	0.85 – 1.22	1.34*	1.02 – 1.76	1.63*	1.00 – 2.63
Lifestyle factors						
Smoker	1.14*	1.01 – 1.28	1.29*	1.07 – 1.56	1.16	0.81 – 1.64
Work-related physical factors						
Manual materials handling	1.00	0.89 – 1.13	1.38*	1.13 – 1.68	1.54*	1.06 – 2.23
Awkward back posture	1.18*	1.03 – 1.36	1.12	0.90 – 1.39	0.99	0.65 – 1.50
Work-related psychosocial factors						
Lack of control	1.17*	1.04 – 1.31	1.44*	1.20 – 1.72	1.12	0.78 – 1.59
Health indicators						
Lung restriction	1.48	0.93 – 2.35	1.23*	0.57 – 2.65	3.20*	1.19 – 8.62
Work ability index						
Excellent	1.00	Reference	1.00	Reference	1.00	Reference
Good	1.49*	1.30 – 1.70	1.53*	1.22 – 1.93	1.46	0.93 – 2.30
Moderate	2.10*	1.75 – 2.52	2.46*	1.86 – 3.25	3.76*	2.24 – 6.31
Poor	1.65	0.94 – 2.91	2.35*	1.18 – 4.68	2.40	0.70 – 8.22

* P < 0.05.
(BMI = body mass index)

When adjusted for individual characteristics, lifestyle factors, and work characteristics two dimensions of the WAI were significant predictors for moderate and long durations of sickness absence: (i) the presence of sickness absence in the past 12 months prior to the medical examination and (ii) experienced limitations due to health problems. Both WAI dimensions predicted a moderate duration of sickness absence with a RR of 1.40 (95% CI 1.30-1.51) and 1.22 (95% CI 1.11-1.34), respectively. The corresponding figures for a long duration sickness absence were 1.53 (95% CI 1.32-1.7) and 1.24 (95% CI 1.04-1.48). The presence of diagnosed diseases and the physical and mental demands in relation to the job had RR close to unity, when adjusted for the covariates included in the analyses in table 4.

Discussion

This study confirmed that sickness absence among Dutch construction workers is a multifactorial phenomenon with individual, lifestyle and work related factors as important predictors of sickness absence, especially sick leave >2 weeks. Predictors for sick leave of 2-12 weeks and >12 weeks included: older age, obesity, smoking, manual materials handling, lack of control at work, lung restriction, and a less-than-excellent work ability. For most predictors higher RR values were observed with longer duration of sickness absence. Obesity, smoking, manual materials handling, and a lack of job control remained important risk factors for moderate and long durations of sickness absence after adjustment for the strong effects of work ability on sick leave.

Some limitations must be taken into account in this study. First of all, the data were drawn from the voluntary medical examination of workers, and information on non-respondents was not available. We do not know whether due to a larger number of unhealthy workers taking part in the physical examination. A selective participation may have influenced the results of our study, but the potential effect of this source of differential bias is unknown. Secondly, there is a substantial variation in quality of laboratory tests and spirometry measurements among the different offices of the occupational health service. A large measurement error could result in a substantial underestimation of the importance of these measurements on future sickness absence.

It has been shown in several studies that younger age is primarily associated with a higher frequency of sickness absence, but that older workers tend to be absent for longer spells [6-9]. The effect of age in our study was consistent with these findings, showing that younger age was a risk factor for short duration sickness absence, but that

moderate and long spells of sick leave occurred more often in older workers. While the association between overweight and sickness absence was not significant, obesity was associated with sickness absence of 2-12 weeks (RR 1.34) and >3 months (RR 1.63). In their literature review, Aldana & Pronk [33] showed that excessive body weight had the strongest association with absenteeism. It has also been shown that obese employees were 1.74 and 1.61 times more likely to experience high and moderate levels of absenteeism, respectively [34]. The association between smoking and increased risk of sickness absence confirms previous studies [35, 36]. In our study of construction workers with a considerable physical work load, normal and vigorous physical activity during leisure time were not associated with any duration of absenteeism after adjustment for other risk factors. Other studies among samples of the general workforce with less physically strenuous jobs have shown that exercise reduces sick leave over a period of four years [37] and that vigorous physical activity during leisure time for at least three times a week had a positive effect on sick leave [38].

Although white-collar jobs had a strongly reduced probability on any sick leave, we did not include this variable in the multivariate model, since job type was strongly associated with the occurrence of work-related factors, especially factors of physical load. Inclusion of job type as well as physical load factors in the same model caused multicollinearity with substantially larger confidence intervals for all variables.

The most important work factors that determined moderate *and* long durations of sick leave was manual materials handling; a lack of job control determined a moderate duration of sick leave only. The effect of physical load on moderate and long spells of sickness absence were consistent with previous reports [39]. Uncomfortable working conditions (such as heavy physical work), monotonous movements, and holding a highly physical, demanding job have been shown to be associated with sickness absence [3, 40 – 44]. Findings from other prospective studies indicated that stressful working conditions, combined with low decision latitude and low social support at work, were related to sickness absence [45 – 47]. Despite the fact that several studies have investigated the effects of physical and psychosocial factors on absenteeism separately, only a few studies have analyzed the effect of such exposure simultaneously on different durations of sickness absence [40, 48, 49].

Among the objective health measures, a restrictive pulmonary abnormality, based on spirometry findings, was a predictor for any duration of sickness absence. The effect of a lung restriction was somewhat larger than the effect of lung obstruction (Table 2), but, due to the strong association between both respiratory diseases, their relative effect could not be established. In the multivariate analyses, we decided to include lung restriction as the variable with the largest effect in the univariate analysis.

The Framingham risk score did not show any significant effect on absenteeism after adjustment. Although subjects with a higher Framingham risk score are at risk for future cardiovascular events, in most cases they did not report any cardiovascular health problems. Therefore, it was unexpected that no association was observed.

Several studies have investigated the predictive value of the WAI on early exit from the work force [19, 21, 50]. The result of this study showed that the WAI predicts sickness absence, especially periods of longer duration. Although this study was conducted in the construction industry consisting mainly of blue-collar workers who experienced a high physical work load, the results were consistent with a community-based study among the general workforce in Finland which showed that a reduced WAI was a predictor of long-term sickness absence [21]. The inclusion of the WAI in the multivariate regression model reduced the influence of physical and psychosocial work related factors on sick leave. Since it has been shown that up to 22% of variance in work ability can be attributed to physical and psychosocial factors, these factors also have an indirect effect on sick leave through their influence on WAI [20]. Nevertheless, manual materials handling, and lack of job control remained important risk factors for moderate and long duration of sickness absence after adjusting for the strong effects of work ability on sick leave.

The strong effect of the WAI on sickness absence was primarily due to two dimensions in this index: (i) the presence of sickness absence in the past 12 months prior to the medical examination and (ii) experienced limitations due to health problems. The presence of diagnosed diseases, and the physical and mental demands in relation to the job did not had increased RR when adjusted for other important covariates in the statistical models. The fact that previous sick leave predicted the duration of sickness absence during follow-up is an expected result. It is of interest to note that disease-related job impairments experienced by workers predicted future sick leave, but that the presence of these diseases was not a significant predictor. This finding corroborates a previous study [51] which demonstrated that impairments due to health problems were more important for productivity loss at work than the health problems themselves.

The "illness flexibility model" [51, 52] clarifies the complicated relationship between different factors and the decision to either take sick leave or stay at work inspite of illness. All of these factors have prompted many work places to create their own procedures to diminish lost work time due to sick leaves [53, 54]. In this regard, it is of interest to note that, for most predictors, a significant trend was observed with higher RR values for a longer duration of sickness absence. This knowledge can be of great help to occupational physicians and policy-makers in enhancing working conditions

and health behavior, and consequently reducing their impact on sickness absence. In conclusion, this study suggests that a variety of preventive measures targeted at smoking, obesity, physical load, psychosocial work factors, and work ability will contribute to diminishing the occurrence of sick leave, especially absence of a longer duration.

References

[1] Benavides FG. Ill health, social protection, labour relations, and sickness absence. *Occup Environ Med*. 2006; 63:228-9.

[2] Niedhammer I, Bugel I, Goldberg M, Leclerc A, Gueguen A. Psychosocial factors at work and sickness absence in the Gazel cohort: a prospective study. *Occup Environ Med*. 1998;55:735-41.

[3] Voss M, Floderus B, Diderichsen F. Physical, psychosocial, and organizational factors relative to sickness absence: a study based on Sweden Post. *Occup Environ Med*. 2001;58:178-84.

[4] Kristensen T. Sickness absence and work strain among Danish slaughterhouse workers: an analysis of absence from work regarded as coping behaviour. *Soc Sci Med*. 1991;32:15-27.

[5] Duijts SF, Kant I, Swaen GM, van den Brandt PA, Zeegers MP. A meta-analysis of observational studies identifies predictors of sickness absence. *J Clin Epidemiol*. 2007;60:1105-15.

[6] Lund T, Labriola M, Villadsen E. Who is at risk for long-term sickness absence? A prospective cohort study of Danish employees. *Work*. 2007;28:225-30.

[7] Eshoj P, Jepsen JR, Nielsen CV. Long-term sickness absence - risk indicators among occupationally active residents of a Danish county. *Occup Med (Lond)*. 2001;51:347-53.

[8] Alexanderson K. Sickness absence: a review of performed studies with focused on levels of exposures and theories utilized. *Scand J Soc Med*. 1998;26:241-9.

[9] Marmot M, Shipley M, North F, Syme SL. Sickness absence as a measure of health status and functioning: from the UK Whitehall II study. *J Epidemiol Community Health*. 1995;49:124-30.

[10] Labriola M, Lund T, Burr H. Prospective study of physical and psychosocial risk factors for sickness absence. *Occup Med (Lond)*. 2006;56:469-74.

[11] Sharp C, Watt S. A study of absence rates in male and female employees working in occupations of equal status. *Occup Med (Lond)*. 1995;45:131-6.

[12] North F, Syme SL, Feeney A, Head J, Shipley MJ, Marmot MG. Explaining socioeconomic differences in sickness absence: the Whitehall II Study. *BMJ*. 1993;306:361-6.

[13] Andrea H, Beurskens AJ, Metsemakers JF, van Amelsvoort LG, van den Brandt PA, van Schayck CP. Health problems and psychosocial work environment as predictors of long term sickness absence in employees who visited the occupational physician and/or general practitioner in relation to work: a prospective study. *Occup Environ Med*. 2003;60:295-300.

[14] Blank N, Diderichsen F. Short-term and long-term sick leave in Sweden: relationships with social circumstances, working conditions and gender. *Scand J Soc Med*. 1995;23:265-72.

[15] Brenner H, Ahern W. Sickness absence and early retirement on health grounds in the construction industry in Ireland. *Occup Environ Med*. 2000;57:615-20.

[16] Peterson JS, Zwerling C. Comparison of health outcomes among older construction and blue-collar employees in the United States. *Am J Ind Med*. 1998; 34:280-7.

[17] Elders LAM, Heinrich J, Burdorf A. Risk factors for sickness absence because of low back pain among scaffolders: a 3-year follow-up study. *Spine*. 2003;28:1340-6.

[18] Burkhart C, Schulte PA, Robinson C, Sieber WK, Vossenas P, Ringen K. Job tasks, potential exposures, and health risks of laborers employed in the construction industry. *Am J Ind Med*.1993;24:413-25.

[19] Tuomi K, Huuhtanen P, Nykyri E, Ilmarinen J. Promotion of work ability, the quality of work and retirement. *Occup Med (Lond)*. 2001;51:318-24.

[20] Alavinia SM, van Duivenbooden C, Burdorf A. Influence of work-related factors and individual characteristics on work ability among Dutch construction workers. *Scand J Work Environ Health*. 2007;33:351-7.

[21] Kujala V, Tammelin T, Remes J, Vammavaara E, Ek E, Laitinen J. Work ability index of young employees and their sickness absence during the following year. *Scand J Work Environ Health*. 2006;32:75-84.

[22] Karasek R, Brisson C, Kawakami N, Houtman I, Bongers P, Amick B. The Job Content Questionnaire (JCQ): an instrument for internationally comparative assessments of psychosocial job characteristics. *J Occup Health Psychol*. 1998;3: 322-55.

[23] Health Council of the Netherlands. *Guidelines for a healthy diet 2006*. The Hague: Health Council of the Netherlands 2006; publication no. 2006/21

[24] Pate R R, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, et al. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA*. 1995;273:402-7.

[25] Stocks J. Quanjer PH. Reference values for residual volume, functional residual capacity and total lung capacity. ATS Workshop on Lung Volume Measurements. Official Statement of The European Respiratory Society. *Eur Respir J*. 1995;8: 492-506.

[26] Pellegrino R, Viegi G, Brusasco V, Crapo RO, Burgos F, Casaburi R, et al. Interpretative strategies for lung function tests. *Eur Respir J*. 2005;26:948-68.

[27] Executive Summary of the Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). *JAMA*. 2001;285:2486-97.

[28] Greenland P, LaBree L, Azen SP, Doherty TM, Detrano RC. Coronary artery calcium score combined with Framingham score for risk prediction in asymptomatic individuals. *JAMA*. 2004;291:210-5.

[29] Tuomi K, Ilmarinen J, Jahkola A, Katajarinne L, Tulkki A. *Work ability index*. 2nd revised edn, Occupational Health Care 19. Helsinki: Finnish Institute of Occupational Health; 1998.

[30] Christensen KB, Andersen PK, Smith-Hansen L, Nielsen ML, Kristensen TS. Analyzing sickness absence with statistical models for survival data. *Scand J Work Environ Health*. 2007;33:233-9.

[31] Pearce N, Checkoway H, Dement J. Exponential models for the analysis of time-related factors, illustrated with asbestos textile worker mortality data. *J Occup Med* 1988;30:517-22.

[32] SAS. SAS software version 8.2 1991-2001; Cary NC: SAS institute.

[33] Aldana SG, Pronk NP, Health promotion programs, modifiable health risks, and employee absenteeism. *J Occup Environ Med*. 2001;43:36-46.

[34] Tucker LA, Friedman GM. Obesity and absenteeism: an epidemiologic study of 10,825 employed adults. *Am J Health Promot*. 1998;12:202-7.

[35] Christensen KB, Lund T, Labriola M, Bültmann U, Villadsen E. The impact of health behaviour on long term sickness absence: results from DWECS/DREAM. *Ind Health*. 2007;45:348-51.

[36] Sindelar JL, Duchovny N, Falba TA, Busch SH. If smoking increases absences, does quitting reduce them? *Tob Control*. 2005;14:99-105.

[37] van den Heuvel SG, Boshuizen HC, Hildebrandt VH, Blatter BM, Ariëns GA, Bongers PM. Effect of sporting activity on absenteeism in a working population. *Br J Sports Med*. 2005;39:e15.

[38] Proper KI, van den Heuvel SG, De Vroome EM, Hildebrandt VH, Van der Beek AJ. Dose-response relation between physical activity and sick leave. *Br J Sports Med*. 2006;40:173-8.

[39] Ekberg K, Wildhagen I. Long-term sickness absence due to musculoskeletal disorders: the necessary intervention of work conditions. *Scand J Rehabil Med*. 1996;28:39-47.

[40] Lund T, Labriola M, Christensen KB, Bültmann U, Villadsen E. Physical work environment risk factors for long term sickness absence: prospective findings among a cohort of 5357 employees in Denmark. *BMJ*. 2006;332:449-52.

[41] Hoogendoorn WE, Bongers PM, de Vet HC, Ariëns GA, van Mechelen W, Bouter LM. High physical work load and low job satisfaction increase the risk of sickness absence due to low back pain: results of a prospective cohort study. *Occup Environ Med.* 2002;59:323-8.
[42] Boedeker W. Associations between workload and diseases rarely occurring in sickness absence data. *J Occup Environ Med.* 2001;43:1081-8.
[43] Trinkoff AM, Storr CL, Lipscomb JA. Physically demanding work and inadequate sleep, pain medication use, and absenteeism in registered nurses. *J Occup Environ Med.* 2001;43:355-63.
[44] Houtman ILD, Bongers PM, Smulders PGW, Kompier MAJ. Psychosocial stressors at work and musculoskeletal problems. *Scand J Work Environ Health.* 1994;20:139-45.
[45] Head J, Kivimäki M, Martikainen P, Vahtera J, Ferrie JE, Marmot MG. Influence of change in psychosocial work characteristics on sickness absence: The Whitehall II Study. *J Epidemiol Community Health.* 2006;60:55-61.
[46] Stansfeld S, Head J, Ferrie J. Short-term disability, sickness absence, and social gradients in the Whitehall II Study. *Int J Law Psychiatry.* 1999;22:425-39.
[47] Melchior M, Niedhammer I, Berkman LF, Goldberg M. Do psychosocial work factors and social relations exert independent effects on sickness absence? A six year prospective study of the GAZEL cohort. *J Epidemiol Community Health.* 2003;57:285-93.
[48] Väänänen A, Toppinen-Tanner S, Kalimo R, Mutanen P, Vahtera J, Peiró JM. Job characteristics, physical and psychological symptoms, and social support as antecedents of sickness absence among men and women in the private industrial sector. *Soc Sci Med.* 2003;57:807-24.
[49] Devereux JJ, Vlachonikolis IG, Buckle PW. Epidemiological study to investigate potential interaction between physical and psychosocial factors at work that may increase the risk of symptoms of musculoskeletal disorder of the neck and upper limb. *Occup Environ Med.* 2002;59:269-77.
[50] Tuomi K, Ilmarinen J, Klockars M, Nygård C-H, Seitsamo J, Huuhtanen P, et al. Finnish research project on aging workers in 1981-1992. *Scand J Work Environ Health.* 1997;23 Suppl 1:7-11.
[51] Alavinia SM, Molenaar D, Burdorf A. Productivity loss in the workforce: associations with health, work demands, and individual characteristics. *Am J Ind Med.* 2009;52:49-56.
[52] Johansson G, Lundberg I. Adjustment latitude and attendance requirements as determinants of sickness absence or attendance. Empirical tests of the illness flexibility model. *Soc Sci Med.* 2004;58:1857-68.
[53] Hansson M, Bostrom C, Harms-Ringdahl K. Sickness absence and sickness attendance--what people with neck or back pain think? *Soc Sci Med.* 2006;62: 2183-95.
[54] Martimo K-P. Reducing sickness absenteeism at the workplace--what to do and how? [Editorial] *Scand J Work Environ Health.* 2006;32:253-5.

Chapter 7

The importance of job control for workers with decreased work ability to remain productive at work

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Abstract

Objectives Workers with decreased work ability are at greater risk of reduced productivity at work. We hypothesized that work-related characteristics play an important role in supporting workers to remain productive despite decreased work ability.

Methods The study population consisted of 10,542 workers in 49 different companies in the Netherlands in 2005-2009. Productivity loss at work was defined on a 10-point scale by asking how much work was actually performed during regular hours on the last regular workday as compared with normal. Independent variables in the logistic regression analysis were individual characteristics, work-related factors, and the work ability index. Additive interactions between work-related factors and decreased work ability were evaluated by the Relative Excess Risk due to Interaction (RERI).

Results The odds ratios and 95% confidence intervals (CI) for the likelihood of productivity loss at work were 2.03 (1.85-2.22), 3.50 (3.10-3.95), and 5.54 (4.37-7.03) for a good, moderate, and poor work ability, compared with an excellent work ability (reference group).

Productivity loss at work was associated with lack of job control, poor skill discretion, and high work demands. There was a significant interaction between decreased work ability and lack of job control (RERI = 0.63 95% CI 0.11-1.16) with productivity loss at work.

Conclusion The negative effects on work performance of decreased work ability may be partly counterbalanced by increased job control. This suggests that interventions among workers with (chronic) disease that cause a decreased work ability should include enlargement of possibilities to plan and pace their own activities at work.

Introduction

Various publications have addressed the negative consequences of impaired health, illness and disease for productivity loss at work. In a systematic review Schultz et al. showed that different health conditions, such as impaired mental health, allergies, and arthritis are associated with productivity loss at work [1]. Likewise, individual studies have shown that the prevalence of productivity loss at work had a broad range varying between 7% and 60% among workers with impaired health [2-6]. The average productivity loss at work ranged between some 12% and 34%, which accounts for 1.0 to 2.7 hours per day for an 8 hours work day [3-6].

A recent study also showed that a decreased ability to cope with work due the health problems and consequent functional limitations was associated with higher productivity loss at work [7]. Besides health related productivity loss a reasonable proportion of productivity loss at work will occur due to non-health related causes, for example machine breakdown, quality problems, and logistic problems [1, 8]. Also different work characteristics, such as high physical work demands or high psychosocial work demands may be related to productivity loss at work. For example, Alavinia et al.[7] showed that lack of job control, adjusted for presence of health problems with functional limitations, was associated with productivity loss at work (OR 1.36, 1.14-1.63). Among younger workers with upper extremity symptoms a combination of high physical load as well as high job strain was also associated with productivity loss at work [5]. Therefore, work-related factors, such as high physical and psychosocial work demands, could be important for productivity loss at work, either through their direct influence on productivity or an indirect effect through their influence on workers' health. It is an important question whether the distinguished determinants of productivity loss act completely independent from each other. It may be expected that in certain situations workers with health problems or a decreased work ability have possibilities to prevent productivity loss at work [2, 7, 9]. We hypothesize that work-related characteristics play an important role in supporting workers to remain productive, despite a decreased work ability.

The research questions were 1) what is the association between decreased work ability and productivity loss at work?, 2) what is the association between physical and psychosocial work demands and productivity loss at work?, and 3) is the association between decreased work ability and productivity loss at work influenced by high physical or psychosocial work load?

Methods

Study population

The study population consisted of workers in 49 different Dutch companies in the Netherlands in 2005-2009. Companies from a whole range of sectors participated, i.e. commercial services (41%), non-commercial services (37%), industrial manufacturers (18%), and construction (4%). These companies had commissioned an occupational health organization to launch a program to investigate the work ability of the workforce and as part of this program a questionnaire survey was conducted on health, work demands, work ability, and productivity at work. Companies participating in this program invited all their workers to participate. The occupational health organization had send an invitation to all eligible workers by regular mail, and provided them with an individualized password to fill out the questionnaire on a secured website. At the time of enrolment, written informed consent was obtained from all participants to provide Erasmus MC for this specific study with their anonymous data. This procedure follows the Dutch Code for Medical Research, which stipulates that use of anonymous data is in agreement with the Dutch Law for Protection of Personal Data.

In the original study population non-responders accounted for 7905 subjects (42%). Some workers did not fill out questions on productivity at work (0.8%), work ability index (1.1%), or work-related factors (3.6%). Complete data on productivity loss at work, work ability, and work-related factors were present for 10 542 subjects (56%), which were made available to the Erasmus Productivity Loss at Work database (ELPW database).

Productivity

The main outcome of this study, productivity loss at work, was collected using the quantity scale of the Quantity and Quality (QQ) instrument [10]. Respondents were asked to indicate how much work they had actually performed during regular hours on their last regular workday relative to a normal workday. The quantity of productivity was measured on a 10-point numerical rating scale with 0 representing "nothing" and 10 representing "normal quantity". The outcome was dichotomized into those with productivity loss at work (score less than 10) and those without (productivity score = 10). The quality of productivity was not measured because the quality and quantity question are highly correlated [6].

Work ability index

The Work Ability Index (WAI) [11-13] is a measure for the degree to which a worker, given his health, is physically and mentally able to cope with the demands at work. The WAI consists of an assessment of the physical and mental demands of an individual in relation to his work at this moment, diagnosed diseases, and limitations in work due to disease, sick leave over the past 12 months, work ability prognosis within 2 years, and psychological resources recently. The WAI constitutes of seven dimensions, the index being derived as the sum of the ratings on these dimensions. The range of the summative index is 7-49 classifies work ability into poor (7-27), moderate (28-36), good (37-43), or excellent (44-49). Decreased work ability was defined as a score lower than 37 (poor and moderate).

Work-related factors

The work-related factors in the questionnaire consisted of items on physical and psychosocial demands. Physical load in the current job concerned the regular presence of manual materials handling, awkward back postures in which the back is bent or twisted, static work postures, repetitive movements, and bending and/or twisting of the upper body. For all physical loads a four point scale was used with rating 'seldom or never', 'now and then', 'often', and 'always' during a normal workday. The answers 'often' and 'always' were classified as high exposure [14].

The psychosocial work load was measured according to the demand-control model by Karasek [15, 16]. The three dimensions job control (5 items), skill discretion (3 items), and work demands (5 items) were assessed using an abbreviated version of the original questionnaire (Cronbach's alpha = 0.76) [17]. Questions on job control concerned workers' influence on the planning of tasks, ability to interrupt work if necessary, and whether or not they had a say on completion of deadlines. Skill discretion covered creativity, varied work, and required skills and abilities. Work demands related to excessive work, working hard, working fast, insufficient time to complete the work, and conflicting demands. For each question, a four-point scale was used with ratings 'seldom or never', 'now and then', 'often', and 'always' during a normal workday. The sum score was calculated for each dimension separately and workers with a median sum score or higher were regarded as exposed to the psychosocial risk factor [7].

Statistical analysis

Descriptive statistics were used to describe the characteristics of the study population.

Since the magnitude of productivity loss was not normally distributed, the dichotomous variable productivity loss at work (yes/no) was used as dependent variable in the logistic regression analysis to explore the association between productivity loss at work and independent variables individual characteristics, work ability, work ability dimensions, psychosocial work demands, and physical work load. The odds ratio (OR) was estimated as measure of association with corresponding 95% confidence intervals (95%CI). In the first step of the analysis, univariate associations were evaluated. Subsequently, all variables in the univariate analyses with $p<0.05$ were investigated in a multivariate analysis using a forward technique with significance level $p<0.05$.

Population attributable fractions (PAFs) were calculated for less than good work ability, using the formula PAF = Pe (OR-1)/(1+Pe(OR-1)), whereby Pe is the prevalence in the study population [18].

We were interested in the potential interaction between a decreased work ability and poor working conditions on the presence of productivity loss. Therefore, interactions between work ability and work-related factors were estimated for work-related factors which remained statistically significant at $p<0.05$ in the multivariate model. Interaction was considered to be present when the combined association of both factors (decreased work ability as well as poor working conditions) was larger than the sum of the independent associations of decreased work ability and poor working conditions. Interaction terms were defined by product terms of dichotomized variables, resulting in four exposure categories. Subjects with a good or excellent work ability and good working conditions were defined as reference category. The Relative Excess Risk due to Interaction (RERI) was estimated as measure for interaction with confidence levels based on covariances in line with the delta method of Hosmer and Lemeshow [19], using the following formula: RERI= RR(Decreased WAI and poor working condition) – RR (Decreased WAI and good working condition) – RR (Good WAI and poor working condition) +1 [20]. In order to calculate RERI from a logistic regression analysis, we assumed that the odds ratios could be used as a fair approximation of relative risks. RERI can be interpreted as a measure of departure from additivity in which a RERI of zero means no departure from additivity. The additive interaction is considered statistically significant when zero is outside the 95% confidence interval (CI). All analyses were carried out with the Statistical Package for Social Sciences version 15.0 for Windows [21].

Results

About 44% of the subjects reported productivity loss at work during the last workday, with an average loss of 11.4% compared with a regular workday (Table 1). This indicates an average loss of 0.9 hours on an 8 hour work day. The mean age of the study population was about 44 years, ranging from 18-68 years. The distribution of excellent, good, moderate, and poor work ability was 32.8%, 47.4%, 16.4%, and 3.4%, respectively. Work related factors were moderate interrelated with Pearson correlations ranging from -0.10 to 0.39 for psychosocial work characteristics, whereas Pearson correlations between physical work factors ranged from -0.11 to 0.52, and Pearson correlations between psychosocial and physical work factors ranged from 0.03 to 0.26.

Table 1 Individual characteristics, work-related factors, work ability index, and productivity loss at work among 10 542 workers in the Netherlands.

Variable	Frequency
Age category	
18-39 Yr	33.5% (N=3529)
40-49 Yr	34.4% (N=3627)
50-68 Yr	32.1% (N=3386)
Female worker	42.8% (N=4512)
Psychosocial work demands	
Lack of job control	59.4% (N=6266)
Poor skill-discretion	73.5% (N=7747)
High work-demand	58.7% (N=6189)
Physical work demands	
Manual materials handling	6.4% (N=671)
Awkward back postures	13.7% (N=1447)
Static working postures	43.8% (N=4621)
Repetitive movements	46.2% (N=4873)
Bending or twisting upper body	33.3% (N=3510)
Work ability score	
Excellent	32.8% (N=3454)
Good	47.4% (N=4999)
Moderate	16.4% (N=1730)
Poor	3.4% (N=359)
Productivity loss (score<10)	44.3% (N=4666)

The odds ratios and 95% confidence intervals (CI) for the likelihood of productivity loss were 2.03 (1.85-2.22), 3.50 (3.10-3.95), and 5.54 (4.37-7.03) for a good, moderate, and poor work ability, compared with an excellent work ability (reference group).
The population attributable fraction for productivity loss at work due to less than good work ability was 10%. Associations between decreased work ability and productivity loss were most influenced by the dimensions 'general work ability' (dimension 1), 'work ability in relation to physical and mental demands' (dimension 2), and 'prognosis of work ability' (dimension 6) (Table 2). The four health-related dimensions (number of diagnosed diseases, subjective estimation of work impairment due to disease, sickness absence during the past year, and psychological resources) did not remain significant in the multivariate model, when adjusted for other dimensions.

Table 2 Univariate and multivariate associations of work ability dimensions and productivity loss at work among 10 542 workers.

WAI dimension		Productivity loss (1/0)			
		Univariate		Multivariate	
	Mean (sd)	OR	95% CI	OR	95% CI
1. General work ability (0-10)	8.18 (1.60)	0.68*	0.66-0.70	0.73*	0.70-0.76
2. Work ability in relation to physical and mental demands (2-10)	8.29 (1.22)	0.69*	0.66-0.71	0.87*	0.83-0.91
3. Diagnosed diseases (1-7)	4.66 (1.82)	0.91*	0.89-0.93	-	
4. Impairment due to diseases (1-6)	5.11 (1.31)	0.82*	0.79-0.84	-	
5. Sickness absence (1-5)	4.19 (0.95)	0.80*	0.77-0.84	-	
6. Prognosis work ability (1, 4, 7)	6.56 (1.27)	0.84*	0.82-0.87	0.96*	0.93-0.99
7. Psychological resources (1-4)	3.43 (0.65)	0.64*	0.60-0.68	-	

* P < 0.05.

Older workers and females showed inverse associations with productivity loss at work (Table 3). The psychosocial factors lack of job control, high work load, and poor skill-discretion were associated with productivity loss at work, with odds ratios remaining quite comparable in the multivariate analysis. The physical factors awkward back postures, static working postures, and repetitive movements showed statistically significant associations in the univariate analyses, which did not remain significant in

Table 3 Univariate and multivariate associations of individual characteristics and work-related factors with productivity loss among 10 542 workers.

	Univariate model		Multivariate model	
Variable	**OR**	**95% CI**	**OR**	**95% CI**
Age category				
18-39 Yr (Ref)	1.00		1.00	
40-49 Yr	0.83*	0.76-0.91	0.83*	0.75-0.91
50-68 Yr	0.81*	0.74-0.89	0.82*	0.74-0.90
Female worker	0.91*	0.85-0.99	0.87*	0.81-0.95
Psychosocial work demands				
Lack of job control	1.38*	1.28-1.50	1.32*	1.22-1.43
Poor skill-discretion	1.28*	1.18-1.40	1.20*	1.10-1.32
High work-demand	1.30*	1.20-1.40	1.28*	1.18-1.39
Physical work demands				
Manual materials handling	1.11	0.95-1.30	-	
Awkward back postures	1.13*	1.01-1.26	-	
Static working postures	1.09*	1.01-1.18	-	
Repetitive movements	1.09*	1.01-1.17	-	
Bending or twisting upper body	0.94	0.87-1.02	-	

* P < 0.05.

the multivariate analysis. None of the physical work demands had a significant contribution in the multivariate model with ORs varying from 1.01 to 1.03.
Table 4 shows the joint effects of psychosocial work factors and work ability on productivity loss at work. For all three psychosocial factors and work ability the joined effect was stronger associated with productivity loss at work than the single effects of both variables. The RERI for job control was 0.63 (0.11-1.16), for skill-discretion 0.24 (-0.31-0.79), and for work demand -0.07 (-0.65-0.51). The interaction between decreased work ability and psychosocial factor was only statistically significant for lack of job control. So, the combined association of decreased work ability and lack of job control was significantly larger than the sum of the independent associations of decreased work ability and lack of job control. Within workers with a good work ability, the presence of lack of job control was associated with a 23% increase in likelihood of productivity loss at work. Within workers with a decreased work ability lack of job control had a 38% increase in occurrence of productivity loss at work.

Table 4 Interaction between work ability and work-related factors in the association with productivity loss at work among 10 542 workers.

	OR	95% CI	RERI $_a$	95% CI
Model 1: WAI and job control				
Good WAI and high job control	1.00		0.63*	0.11-1.16
Good WAI and lack of job control	1.23*	1.13-1.34		
Decreased WAI and high job control	2.25*	1.87-2.70		
Decreased WAI and lack of job control	3.11*	2.75-3.52		
Model 2: WAI and skill-discretion				
Good WAI and high skill-discretion	1.00		0.24	-0.31-0.79
Good WAI and poor skill-discretion	1.18*	1.07-1.30		
Decreased WAI and high skill-discretion	2.51*	2.02-3.14		
Decreased WAI and poor skill-discretion	2.93*	2.58-3.34		
Model 3: WAI and work demand				
Good WAI and low work demand	1.00		-0.07	-0.65-0.51
Good WAI and high work demand	1.22*	1.12-1.34		
Decreased WAI and low work demand	2.73*	2.29-3.26		
Decreased WAI and high work demand	2.89*	2.55-3.27		

*p<0.05, adjusted for age and sex, $_a$ Relative Excess Risk due to Interaction (RERI).

Discussion

Decreased work ability showed statistical significant associations with productivity loss at work, especially in combination with lack of job control. In other words, job control seems to act as a buffer in the association between decreased work ability and productivity loss at work.

Some limitations must be considered in this study. First of all, the cross-sectional design of the study does not permit further explanation of the causal relationship between determinants and productivity loss at work. The results of this study do not indicate whether productivity loss at work was a result of decreased work ability or decreased work ability was a result of lack of productivity.
Secondly, a subjective measure of productivity loss at work was used. Since objective measures of productivity at work are rarely available or difficult to access, self-reports

to estimate the decrease in productivity are more common [22, 23]. One study showed significant correlations between self-reported productivity and objective work output (r=0.48) among floor layers [6]. Nevertheless, the current study was done in a large array of different work settings and only used the quantity question of the QQ method. A measure of productivity loss at work concerning the last workday was used, because a longer time span may be influenced by self-reports. A disadvantage of a time span of one day is that it does not take into account the expected fluctuations in productivity loss within workers across workdays. This unknown daily fluctuation will have contributed to random measurement error and, thus attenuated the observed associations. Although participants were informed that all information would be handled completely anonymous, it also cannot be discarded that some information bias might have occurred, for example due to reluctance among participants to report reduced productivity at work due to fear of negative consequences.
Thirdly, a low response may also be associated with the presence of productivity loss at work. The response for the productivity item varied from 9% to 96% across companies. Within each company, it may be possible that workers with productivity loss at work have had less interest in participating in the study. The response level was lower in large companies, in commercial services companies, and among blue collar workers. However, using a cut-off of 80% response, no significant differences were found in productivity loss at work between companies with high and low response levels, and response level was also not statistically significant when included in the univariate analyses. Therefore, we think that this source of selection bias will not have influenced the results to a major extent.
Under the assumption of a causal relation between decreased work ability and productivity loss at work, we estimated that only 10% of productivity loss at work was attributable to a decreased work ability. A previous study also reported that 7% of productivity loss at work was attributable to impaired health, and that health impairments were stronger related to productivity loss at work than the number of diagnosed diseases [7]. This is not very surprising, given the fact that the measure of productivity loss at work used in this study estimates all productivity loss at work, not necessarily health related. There are various reasons for lost productivity which may have nothing to do with health including machine break-down, personal issues, and organisational problems. However, when workers are asked if their productivity loss is due to impaired health the percentage of health-related productivity loss at work will be much higher. For instance, in a group of workers with musculoskeletal complaints 75% of the subjects reported that productivity loss was due to their musculoskeletal disorders [4].

Associations between decreased work ability and productivity loss at work were most influenced by the dimensions 'general work ability', 'work ability in relation to physical and mental demands', and 'self-reported prognosis of work ability'. These dimensions primarily reflect individual capacities to cope with work demands. Several aspects may explain the importance of these 'capacity dimensions'. First of all, there are substantial differences in recall time among the seven work ability dimensions. For example, the first two dimensions are concerned with the current situation; dimension five relates to the past 12 months, dimension six alludes to the coming two years, whereas dimension seven refers to the current situation. Second, work ability dimensions are highly interrelated (Pearson correlations ranged from 0.13-0.57), and as a consequence only the dimensions with the strongest influence will be retained in the multivariate analysis.
The first two dimensions of the work ability index seem to reflect to some extent a productivity measure.

Our finding that productivity loss at work was associated with poor work factors corroborates previous studies [5, 7, 24]. A positive association between high work-load and productivity loss at work was for example also reported in a Finnish study showing that regular overtime increases sickness presenteeism [9]. When work tasks are perceived as highly demanding, a worker may experience problems complying with the work demands and, hence, perceive his productivity as below par. Perceived health limitations will only further increase the perception that required work output levels are not achieved and, therefore, result in increased productivity loss at work.
In agreement with Alavinia et al. [7] and Martimo et al. [5] high physical work demands seemed less important for productivity loss at work than psychosocial work characteristics. Different explanations could be a reason for this finding. First, job control and the related possibility to adjust work activities could act as a buffer in highly physical demanding professions in such way that a worker with musculoskeletal complaints can eliminate the high physical demanding task for that specific day or period. Alternatively, questions concerning psychosocial work factors could be more individual oriented, whereas physical work factors may reflect more objective working conditions. The finding could also be due to the cross-sectional design of the study, whereby it is not clear whether the lack of association between high physical work demands and productivity loss at work is due to a healthy-worker effect.

The association between decreased work ability and productivity loss at work differed for the absence or presence of poor psychosocial work factors. Especially job control

seems an important factor to remain productive when experiencing decreased work ability. Johansson and Lundberg [25] have proposed in their model 'illness flexibility' that employees with a high degree of control of their work tasks or adjustment latitude, are more likely to go to work because they can modify their work tasks in such a way as to be able to carry on despite impaired health. A comparable mechanism for productivity loss at work could be envisaged in the sense of having opportunities to change tasks in such a way that they can still be performed despite health impairments. Social support was not measured in the current study, but it was shown that among workers with impaired health due to early inflammatory joint conditions, low support from colleagues predicted a reduced productivity at work [2]. Likewise effort-reward imbalance and job dissatisfaction were not measured, but strong associations were found between both psychosocial factors with productivity loss at work in a population of office workers reporting work-related neck/shoulder or hand/arm symptoms during the past three months [8]. The importance of job control in continuing work or remaining active appears also from literature on return to work and sickness absence for specific diagnostic groups [26, 27].

In conclusion, this study confirmed that workers whose work ability was decreased reported more productivity loss at work. Job control buffered the loss of productivity at work among workers with decreased work ability. These results confirm that the relation between impaired health and decreased work output depends on autonomy of the worker. Hence, levels of productivity loss within specific diagnostic disease groups will not be equal for all workers. Job control can be increased by giving workers the opportunities to decide themselves for example on their working goal, working method, or working hours, taking into account existing quality norms.

References

[1] Schultz AB, Edington DW. Employee health and presenteeism: a systematic review. *J Occup Rehabil.* 2007;17:547-79.

[2] Geuskens GA, Hazes JM, Barendregt PJ, Burdorf A. Predictors of sick leave and reduced productivity at work among persons with early inflammatory joint conditions. *Scand J Work Environ Health.* 2008;34:420-9.

[3] Goetzel RZ, Long SR, Ozminkowski RJ, Hawkins K, Wang S, Lynch W. Health, absence, disability, and presenteeism cost estimates of certain physical and mental health conditions affecting U.S. employers. *J Occup Environ Med.* 2004;46:398-412.

[4] Lotters F, Meerding WJ, Burdorf A. Reduced productivity after sickness absence due to musculoskeletal disorders and its relation to health outcomes. *Scand J Work Environ Health.* 2005;31:367-74.

[5] Martimo KP, Shiri R, Miranda H, Ketola R, Varonen H, Viikari-Juntura E. Self-reported productivity loss among workers with upper extremity disorders. *Scand J Work Environ Health.* 2009;35:301-8.

[6] Meerding WJ, IJzelenberg W, Koopmanschap MA, Severens JL, Burdorf A. Health problems lead to considerable productivity loss at work among workers with high physical load jobs. *J Clin Epidemiol.* 2005;58:517-23.

[7] Alavinia SM, Molenaar D, Burdorf A. Productivity loss in the workforce: associations with health, work demands, and individual characteristics. *Am J Ind Med.* 2009;52:49-56.

[8] van den Heuvel SG, Ijmker S, Blatter BM, de Korte EM. Loss of productivity due to neck/shoulder symptoms and hand/arm symptoms: results from the PROMO-study. *J Occup Rehabil.* 2007;17:370-82.

[9] Bockerman P, Laukkanen E. What makes you work while you are sick? Evidence from a survey of workers. *Eur J Public Health.* 2010;20:43-6.

[10] Brouwer WB, Koopmanschap MA, Rutten FF. Productivity losses without absence: measurement validation and empirical evidence. *Health Policy.* 1999;48:13-27.

[11] Ilmarinen J. Work ability--a comprehensive concept for occupational health research and prevention. *Scand J Work Environ Health.* 2009;35:1-5.

[12] Tuomi K, Ilmarinen J, Jahkola A, Katajarinne L, Tulkki A. Work ability index. Helsinki: Finnish Institute of Occupational Health; 1998.

[13] Van den Berg TI, Elders LA, de Zwart BC, Burdorf A. The effects of work-related and individual factors on Work ability Index: a systematic review. *Occup Environ Med. 2009;*66: 211-20.

[14] Elders LA, Burdorf A. Interrelations of risk factors and low back pain in scaffolders. *Occup Environ Med.* 2001;58:597-603.

[15] Karasek R, Baker D, Marxer F, Ahlbom A, Theorell T. Job decision latitude, job demands, and cardiovascular disease: a prospective study of Swedish men. *Am J Public Health.* 1981;71:694-705.

[16] Karasek R, Brisson C, Kawakami N, Houtman I, Bongers P, Amick B. The Job Content Questionnaire (JCQ): an instrument for internationally comparative assessments of psychosocial job characteristics. *J Occup Health Psychol.* 1998;3:322-55.

[17] Pelfrene E, Vlerick P, Mak R, De Smet P, Kornitzer M, De Backer G. Scale reliability and validity of Karasek 'Job Demand-control-support' model in Belstress. *Work and Stress.* 2001;15:297-331.

[18] Hennekens C, Buring B, Mayrent S. Epidemiology in Medicine. Boston: Lippincott Williams&Wilkins 1987.

[19] Hosmer DW, Lemeshow S. Confidence interval estimation of interaction. *Epidemiology.* 1992;3:452-6.

[20] Andersson T, Alfredsson L, Kallberg H, Zdravkovic S, Ahlbom A. Calculating measures of biological interaction. *Eur J Epidemiol.* 2005;20:575-9.

[21] Statistical package for social sciences (SPSS). 15.0 ed. Chigago, IL 1999.

[22] Burdorf A. Economic evaluation in occupational health--its goals, challenges, and opportunities. *Scand J Work Environ Health.* 2007;33:161-4.

[23] Koopmanschap M, Burdorf A, Jacob K, Meerding WJ, Brouwer W, Severens H. Measuring productivity changes in economic evaluation: setting the research agenda. *Pharmacoeconomics.* 2005;23:47-54.

[24] Aronsson G, Gustafsson K. Sickness presenteeism: prevalence, attendance-pressure factors, and an outline of a model for research. *J Occup Environ Med.* 2005;47:958-66.

[25] Johansson G, Lundberg I. Adjustment latitude and attendance requirements as determinants of sickness absence or attendance. Empirical tests of the illness flexibility model. *Soc Sci Med.* 2004;58:1857-68.

[26] Duijts SF, Kant I, Swaen GM, van den Brandt PA, Zeegers MP. A meta-analysis of observational studies identifies predictors of sickness absence. *J Clin Epidemiol.* 2007;60:1105-15.

[27] Werner EL, Cote P. Low back pain and determinants of sickness absence. *Eur J Gen Pract.* 2009;15:74-9.

Chapter 8

General Discussion

8.1 Introduction

In this thesis, a series of studies is presented that focus on the importance of health in work ability and labour force participation. Due to ageing of the population, economic restraints and shortage of active workers, there is an increased interest in prolonging working life for older workers. Since ageing is accompanied with a decrease in workers' health, the role of ill health in exit from paid employment is of interest. However, health problems may lead to different limitations in different occupations and should therefore be considered in relation to the work demands. Work ability is a measure of the degree to which a worker, given his health, is physically and mentally able to cope with the demands at work. A decreased work ability may lead to quitting paid employment and can also have negative consequences for work performance. The relative contribution of individual and work related characteristics to workers' health and work ability are relatively unknown but could give important insights for interventions aimed at prolonging working careers.

Therefore, the primary objectives of this thesis were:

a. What is the relation between ill health and exit from paid employment among older workers?
b. Which individual characteristics, lifestyle factors and work-related risk factors are associated with work ability?
c. What are the consequences of a decreased work ability for sickness absence and productivity loss at work and are these consequences influenced by work related characteristics?

This chapter presents the main findings in the light of the objectives of this thesis, discusses methodological issues, and presents recommendations for practice and policies and future research.

8.2 Main findings

Objective 1 - *What is the relation between ill health and exit from paid employment among older workers?*

The longitudinal study with two-year follow-up among European workers aged 50-63 years (chapter 2) showed that poor self-perceived health was strongest associated

with exit from paid employment due to retirement, unemployment, or disability (ORs from 1.32 to 4.24). In order of decreasing importance chronic diseases, mobility problems, and instrumental limitations also influenced exit from paid employment, most notably through disability. The population attributable fractions of a less-than-good self-perceived health for transition into unemployment, retirement, and disability were 27%, 9%, and 61%, respectively. Because of the voluntary basis of exit through (early) retirement, additional analyses on this pathway of exit were conducted.

The literature study on determinants of early retirement (chapter 3) confirmed the importance of poor health. Odds ratios for the associations between poor health and early retirement reported in six studies varied between 1.16 and 3.36, of which 4 studies reported statistically significant associations. The importance of health for sustaining working careers was corroborated in the focus group interviews, wherein good health was mentioned as an important condition for continuing work.

The longitudinal European study (chapter 2) showed that lifestyle factors as well as work-related characteristics explained up to 19% of health related exit from paid employment. Significant odds ratios between ill health and exit from paid employment decreased by 0% to 10% after adjustment for lifestyle factors, 4% to 9% after adjustment for work factors, and 4% to 19% after adjustment for lifestyle factors and work characteristics simultaneously. The risk of ill health for exit through disability was least adjusted by lifestyle factors and work related characteristics. In the fully adjusted models for each of the four health measures obesity and problematic alcohol use remained significant in at least one of the models. Lack of job control and effort-reward imbalance at work remained significant after full adjustment in at least one of the four models. In the focus group interviews appreciative leadership style, social support at work, and healthy lifestyle were mentioned as factors of influence on early retirement decisions.

In conclusion, good health is an important condition for continuing working life among older workers. Lifestyle and work-related factors may partly counteract the negative impact of ill health on work participation. Additional insights emerging from focus group interviews among older workers were that shift work, unappreciative leadership style, and lack of support from colleagues have an impact on retirement intentions.

Objective 2 - *Which individual characteristics, lifestyle factors and work-related risk factors are associated with work ability?*

The literature review on the determinants of the work ability index (chapter 4) showed that individual characteristics, lifestyle, demands at work, and physical condition were associated with a poor work ability. More specific, older age, lack of leisure-time vigorous physical activity, poor musculoskeletal capacity, obesity, high mental work demands, lack of autonomy, poor physical work environment, and high physical work load were associated with a lower work ability score.

The cross-sectional study on the associations of psychosocial factors at work, life style, and stressful life events on work ability among white-collar workers with academic education (chapter 5) showed that worse teamwork, worse stress handling, lack of self-development, and, to a lesser extent, stressful life events, lack of physical activity, and obesity were associated with a lower work ability. Stratification analyses showed that the strength of association between lifestyle factors and work ability score was higher for older age groups.

In conclusion, the results show the multifactorial nature of work ability. A healthy lifestyle and good working conditions are important for a good work ability. There are some indications that these factors become increasingly important with ageing of the worker.

Objective 3 - *What are the consequences of a decreased work ability for sickness absence and productivity loss at work and are these consequences influenced by work related characteristics?*

The longitudinal study among a sample of Dutch construction workers (chapter 6) showed that less than excellent work ability was associated with sick leave less than 14 days, sick leave between 2 and 12 weeks, and above 12 weeks duration. The strength of association was higher for lower scores of work ability and for longer duration of sick leave. Population attributable fractions for long duration of sickness absence were 18%, 28%, and 2% for good, moderate, and poor work ability compared with excellent work ability (reference group). The two dimensions of the work ability index which were most predictive for moderate and long duration of sickness absence were 'presence of sickness absence in the past 12 months' (dimension 5), and 'subjective estimation of work impairment due to disease' (dimension 4). Among a sample of Dutch workers in different occupations (chapter 7) the odds ratios for the likelihood of productivity loss at work were 2.03, 3.50, and 5.55 for a good, moderate,

and poor work ability, compared with an excellent work ability (reference group). The population attributable fraction for productivity loss at work due to less than good work ability was 10%. Associations between reduced work ability and productivity loss were most influenced by the dimensions 'general work ability' (dimension 1), 'work ability in relation to physical and mental demands' (dimension 2), and 'prognosis of work ability' (dimension 6).

In the study in chapter 6 obesity, smoking, manual materials handling, and lack of job control remained important risk factors for sickness absence, after adjustment for the strong effects of work ability on sickness absence. There is some indication that the observed trend in risk ratio's for long term sickness absence became less steep after adjustment for lifestyle and work-related factors compared to shorter terms of sickness absence. Younger age, male worker and poor psychosocial work demands were associated with productivity loss at work (chapter 7). An analysis on the joint associations of poor psychosocial work factors and decreased work ability on productivity loss at work showed that the relative excess risk due to interaction (RERI) was 0.63 (0.11-1.16) for lack of job control. Thus, there was a significant departure from additivity for the joint association of lack of job control and decreased work ability. In other words, the combined influence of decreased work ability and lack of job control was significant larger than the sum of the independent influence of decreased work ability and lack of job control. Within good work ability, low job control accounted for a 23% increase in the odds ratio for productivity loss at work compared with workers with high job control. Among workers with decreased work ability the association for productivity loss at work was 38% higher for workers with low job control compared with workers with high job control. No significant interactions on an additive scale were found for the psychosocial factors lack of skill-discretion and high work demands.

In conclusion, a decreased work ability has considerable consequences for sickness absence and productivity loss at work. Job control in the sense of having a say in work deadlines, work tempo and work breaks, appeared an important factor to reduce negative consequences of a decreased work ability for sickness absence and productivity loss at work.

8.3 Methodological issues

For specific methodological concerns we refer to the methods and discussion section of the specific articles. This paragraph concerns general considerations, i.e. design issues.

8.3.1 General considerations regarding the role of ill health in exit from paid employment

The studies in chapter 2 and 3 concern some methodological issues; i.e. the conceptualisation of labour status, considerable differences in studied countries, and lack of insight in direct and indirect roles of important factors.

Definition of labour status

There are some methodological considerations concerning the operationalisation of labour status. In chapter 2 the outcome labour status was based on self-reported current economic status that best described the respondent's situation based on four mutually exclusive categories: paid work, retired, unemployed, disabled. The definition of being employed in SHARE encompasses all individuals who declared to have done any kind of formal paid work in the last four weeks, including self-employed work for family business. The use of this operationalisation of labour status does not discriminate between subjects receiving full social security benefit and subjects receiving part benefit and part income from paid employment or other types of social security benefit. There is no gold standard and large cohort studies have used different definitions. For example, in the European Community Household Panel (ECHP)[1] work status is defined using 12 mutually exclusive categories: paid employment (15+ hours/week), paid apprenticeship (15+ hours/week), training (15+ hours/week), self-employment (15+ hours/week), unpaid family (15+ hours/week), education/training, unemployed, retired, housework, community/military service, other economically inactive, and working less than 15 hours. In the British Household Panel Survey (BHPS) [2, 3] employment status was asked by 'did you do any paid work last week, either as an employee or self-employed?" Second, the use of labour status in chapter 2 was self-reported, wherefore it may differ from the official labour status. Respondent may have another interpretation of their status. Respondents, for example, may consider their unemployment as homework, when they are not actively looking for work. Another aspect on the operationalisation of labour status in chapter 2 is that the defined pathway of exit may not be the true pathway. For example, in older age groups early retirement may be used to avoid work disability, whereas among younger workers a work disability pension may prevent exit through unemployment. Besides above considerations, measuring the labour status 'early retirement' is hampered by the age-dependency of retirement. In order to distinguish between early retirement and legal retirement the population in chapter 2 was restricted to workers aged 50-63 years as it was assumed that workers normally retired when they became 65 years old at the end of follow-up. Among persons aged 65 years and over 4.3% was employed

in 2008 in EU-15 countries (17.6% in Portugal, 1.4% France), whereas the reason for inactivity was retirement for 84.4% [4]. The differences in definition of early retirement may vary among countries and, thus, influence the observed country-specific differences in chapter 2. In addition, the lack of a comparable definition may have contributed to the heterogeneity in the systematic review in chapter 3.

Lack of insight in the differences between European countries

The descriptive results of change in labour status (table 2 in chapter 2) showed considerable differences in prevalence of exit from paid employment and pathways of exit between countries. In the longitudinal analysis of the role of ill health on exit from paid employment in Europe country-specific or region-specific analyses were not feasible due to small numbers, hence, analyses were only country adjusted. Insight in differences per region was addressed by stratified analyses for the following regions; Scandinavian (Sweden, Denmark), Bismarckian (Austria, Belgium, France, Germany, Netherlands, Switzerland), and Southern Europe (Greece, Italy, Spain). Stratified analysis for these three regions showed that the conclusions drawn from the total population also accounted for each region, which is that the health measure most predictive for exit from paid employment was less than good perceived health, most notably through disability.

Lack of insight in direct and indirect effects of important factors on the relation between health and work participation

In order to minimize the negative effect of ill health on work participation, it is of interest to study factors that explain the relation between ill health and exit from paid employment. The associations of work-related factors and lifestyle on health were studied in chapter 2 (four measures of health) and chapter 5 (mental and physical health). However, in both studies the design was cross-sectional, wherefore a causal relationship could not be explored.

In chapter 2 analyses were conducted to gain insight in what proportion of the observed associations between ill health and future exit could be explained by work-related factors and lifestyle. In the multinominal analysis the role of ill health was adjusted for individual and work-related factors to calculate the percentage of change in odds ratio of ill health for exit from paid employment. This method can be used to estimate direct and indirect contributions of explanatory factors. However, the percentage of change can be similar for different absolute changes in odds ratios. The analyses are not sufficient to give an adequate insight in the pathways of the influence of lifestyle factors and work-related characteristics on exit from paid employment.

The results show that problematic alcohol consumption may have a direct effect on exit from paid employment independent of health status, for example through work output, difficulties with keeping up to work agreements, or cooperation [5]. An explanation for the increased risk of obesity for unemployment, irrespective of health status, may be stigmatisation or discrimination of obese workers [6]. A direct influence of poor work circumstances on premature exit may be most profound through early retirement. Research in the field of retirement intentions showed that effort-reward imbalance and low job control were independently associated with the intention to retire as early as possible [7].

8.3.2 General considerations determinants of work ability

The studies in chapter 4 and 5 concern some methodological issues; i.e. reporting bias, cross-sectional design, and external validity.

Reporting bias

In the systematic review (chapter 4) as well as the study among office workers (chapter 5) the majority of determinants was measured by self-reported questionnaires. Self-reported measures have the advantage that they are relatively easy to obtain. However, self-reported measures may result in different types of reporting bias. Respondents may be susceptible to social norms and fill in answers towards perceived socially desirable standards. Lifestyle factors such as smoking, alcohol consumption, and lack of physical activity during leisure time are well-known factors of health-declining behaviours, and therefore participants may have under-reported these behaviours [8, 9]. This bias due to social desirability would only have affected our results if this had occurred more in groups with excellent work ability than among workers with poor work ability. There is no indication that the work ability score will be of influence on the inclination to underestimate health risk behaviours. In the focus group interviews in chapter 3 workers with an excellent work ability expressed similar opinions about lifestyle than workers with a poor or moderate work ability. Another type of reporting bias that may have affected the results concerns the justification of a decreased work ability. A decreased work ability score could be justified by overestimating poor working conditions. Reporting more unhealthy lifestyles could also be used as justification but seems less obvious as lifestyle is an individual behaviour and would therefore make the subject itself responsible for the decreased work ability. The reporting bias would overestimate the effect of work circumstances on the work ability score. Because work ability and determinants were measured at the same time, subjects were not aware of their total score on the work ability index, and, thus, justification may have had limited effect on our results.

Cross-sectional design

The majority of studies included in the systematic review (chapter 4), as well as the study in chapter 5 had a cross-sectional design, i.e. the measurement of potential determinants and work ability index took place at the same moment in time. Therefore, it was not possible to investigate the causality of the relationship between determinants and outcome, or whether decreased work ability results from the determinant or that the determinant is a result of a decreased work ability. It could be that decreased work ability also limits the ability for physical activity in leisure-time. Also, perceived work pressure may increase when a worker is less able to fulfil work demands caused by health complaints. However, a comparison between cross-sectional and longitudinal results in the review showed comparable influences of lifestyle factors and work-related characteristics.

Another methodological issue that cannot be tackled with a cross-sectional design, is the so-called 'lag time' between exposure to unhealthy lifestyle and poor working conditions and a subsequent decreased work ability. The stratification by age in chapter 5 gives some insight in exposure durations, assuming that older workers had a longer exposure, but a clear insight in exposure durations and latency periods is lacking. Not taking exposure duration into account may have underestimated the contribution of determinants to a decreased work ability.

External validity of results

Studies included in the systematic review (chapter 4) were dominated by Finnish studies (70%) with emphasis on research among municipal workers. Therefore, some caution is needed in the generalisability of the study results to other occupational populations in other countries. However, Dutch study results among white-collar workers (chapter 5) and construction workers [10] showed quite comparable results, so generalisability seems reasonable. Research concerning the work ability index has mainly been carried out among older workers. Therefore, it is not clear if the same determinants play an equally important role in younger populations. The average age of the study population in chapter 5 was 35.7 years old, which was quite young. Therefore, the number of subjects with poor or moderate work ability was slightly lower than in the general working population. Stratification by age showed that the age of the worker is of influence on the strength of the association between determinant and work ability score, whereby the association between the determinant and decreased work ability score was stronger among older workers. Associations between the studied factors and WAI in chapter 5 may therefore be slightly higher for the general working population. Dutch research on work ability until now was mainly

focused on physically demanding occupations (e.g. construction workers). The population in chapter 5 was characterized by mentally demanding professions, wherefore generalisability of study results to a population with more physically demanding professions may be doubtful. Comparison with a study among Dutch construction workers [10] showed the work-related factors that were present in both occupational groups had a similar importance, and also comparable associations for age and lack of vigorous physical activity were observed. Therefore, translation of results to other occupations may be legitimate concerning type of determinant, and every so often even for the strength of association.

8.3.3 General considerations consequences of a decreased work ability

The studies in chapter 5 and 6 concern some methodological issues; i.e. self-reported (subjective) measurement of productivity loss at work, selective response due to voluntary participation, overlap in definition of the predictor and the outcome, and calculation of interaction from additivity using the Relative Excess Risk due to Interaction (RERI).

Self-reported measure of productivity loss at work

The outcome measure productivity loss at work (chapter 7) was measured with a self-reported questionnaire and, thus, response and/or recall bias could have occurred. Recall bias was minimized by focusing on the last working day of the worker. Response bias may have occurred due to a social desirability not to report productivity loss at work, although subjects were assured that data were handled completely anonymously. It is not known whether there is a difference in responding social desirable between workers with or without decreased work ability. It could be that workers with a decreased work ability may be more focused on their working abilities and may be more aware of their daily performance. As a consequence, they may have been more likely to report productivity loss at work.

In a former study the Quantity and Quality (QQ) instrument was validated with objective information on daily work output from 19 work site observations. Among floor layers, actual production output, measured as square meters made, was significantly correlated with the mean self-reported productivity of the team (correlation coefficient r=0.48). Due to the very low variation in actual production output in road pavers (coefficient of variation 9.5%), no correlation was found with self-reported productivity [11]. An objective measure of work productivity will have the advantage of minimising response and recall bias, but is also associated with considerable restrictions in generalisability and is burdensome to implement in

practice. For example, for most jobs quantifying performance is challenging, productivity has also a quality aspect which may even be more difficult to measure objectively, and many jobs involve teamwork as a result of what individual productivity is difficult to ascertain [12].

Selective response voluntary participation

Data in chapters 6 and 7 were drawn from voluntary (medical) examination of workers, wherefore selective response may have occurred. Information on non-respondents was not available in the study on sickness absence. There were no differences in level of productivity loss between companies with high and low response, so there seems not to be a selective response between companies with high and low response. Within companies selective response between individual subjects could have occurred. This may have influenced the results when workers with sickness absence or productivity loss at work were more or less declined to participate in the study. It is unknown whether this has occurred and has lead to an over- or underestimation of the effects.

Overlap in definition of the predictor and the outcome

The consequence of decreased work ability for sickness absence (chapter 6) may be obvious as there is some overlap between the predictor work ability and outcome sickness absence. Most profound, the work ability index contains one question on sickness absence (dimension 5; sickness absence during the past year). On the one hand only 9.5% of the total work ability score is determined by dimension 5. On the other hand the strong effect of WAI on sick leave was primarily due to two dimensions, including sickness absence in the past 12 months.

There may be some overlap between productivity loss at work and the first two dimensions of the WAI. However, the WAI is health-oriented, whereas the measure of productivity loss at work concerns also loss which was not health-based.

Measuring interaction

In chapter 7 we were interested in the joint associations of decreased work ability and poor working conditions on the presence of productivity loss. There are several methods to assess the statistical significance of interactions on risk for specific events. The most common procedure is to test departure from the multiplicative model of interaction, but we have chosen to measure additive interaction. The scale of interaction (additive or multiplicative) is in essence determined by the statistical model that fits best [13, 14]. However, under certain simple biologic models the joint

effects of two factors appear to follow an additive pattern, implied by terms such as synergism and antagonism [14-16]. The fit with the sufficient-component concept of causality is also an important argument for using the additive scale [14]. One of the disadvantages of additive interaction is that the additive scale does not indicate a particular disease mechanism [14]. In chapter 7 we reported individual effects of decreased work ability and poor working conditions and their joint effect, so that readers who prefer multiplicative interaction can also interpret the findings on a multiplicative scale.

The Relative Excess Risk due to Interaction (RERI) was estimated as measure for interaction with confidence levels based on covariates in line with the delta method of Hosmer and Lemeshow [17]. The use of RERI assumes that the odds ratios could be used as a fair approximation of relative risks. One of the disadvantages of this method is that it handles only two covariates, otherwise data in each stratum become too sparse [18]. Calculation of the confidence interval using Hosmer and Lemshow proposed Wald type interval estimates [17] is subject of debate and different alternatives have been proposed, for example bootstrapping [19] and likelihood-based confidence intervals [20]. However, also these methods have their limitations.

8.4 Interpretation of the findings

This thesis provides valuable indications of the importance of health for work participation, the influence of lifestyle and work circumstances on work ability, and the consequences of decreased work ability for work performance. We will compare our results to evidence from other studies following the three objectives.

8.4.1 Role of ill health in exit from paid employment

The finding that ill health is related to an increased risk of exit from paid employment is not new itself [6, 21-33]. Our results, but also studies on work participation among diagnostic groups such as rheumatoid arthritis, diabetes, depression, and asthma, clearly show that getting a chronic disease has a major consequence for future work participation [34-37]. Yet, our findings showed that self-perceived health was most predictive for future work status. The importance of self-perceived health compared to being diagnosed with a chronic disease was in line with a systematic literature study among employees with a chronic somatic disease which showed that perceived health was a prognostic factor for work disability [38].

Additional analyses in the SHARE database illustrate that the potential impact of prevention of ill health on labour force participation, in theory, could increase the average age of quitting paid employment from 60.4 to 61.5 years (13.2 months) among men and from 59.2 to 60.5 years (16.2 months) among women [39]. Besides prolonging working life, prevention of ill health will have additional effects for work participation among subjects out of the labour force, which were not taken into account in these analyses.

Our results show the consequence of ill health at baseline on work participation during two year follow-up. Medical history or how long the ill health status was already present at baseline was unknown and, thus, the relevant time windows for the effect of ill health on exit from work could not be established. In the field of health economics it is more common to measure actual change in health status, for example by health shocks that are defined as deteriorations in relative health status. Some insight in time effects may be obtained from this field of research, although these measurements are not intended to give insight in time effects, but an attempt to minimize justification bias whereby subjects systematically overestimate their poor health in order to justify their position outside the workforce. For example, Disney et al. (2006)[40] showed that lagged health as well as acute health deterioration were associated with exit from economic activity.

An European study [41] also confirmed the relationship between acute health shocks and the retirement decision, with higher hazard ratios for acute deteriorations than for a more gradual decline in health status.

It is of interest to known which role work ability plays in the relation between health and exit. Finnish studies have shown that among the working-age population self-rated health was strongly related to the person's estimate of work ability. Those who regarded their health to be average estimated their work ability to be limited six times more often than those who believed that they were in good health [42]. However, perceived work ability and perceived health are not the same thing. The Finnish survey showed that a poor perceived health not automatically resulted in a poor work ability or vice versa. Although a limited work ability was much more prevalent among the chronically ill than among healthy persons, problems with work ability became more common with age even among healthy persons [42].

Lifestyle and work explained 19% of the health-related exit in Europe (chapter 2). The results of the systematic review in chapter 3 support the influence of work-related characteristics and lifestyle on early retirement with strong evidence for the influence of lack of job satisfaction [43]

The negative effects of unhealthy lifestyle were also reported with respect to work disability [24, 44]. and unemployment [6, 45]. In contrast to our results, considerable evidence consists for the risk of smoking for exit through unemployment [5, 45, 46] and work disability [47-49].

Regarding work related characteristics the evidence is less clear due to the broad range of definitions that has been used in work and health literature. High physical work demands have been reported as risk factors for work disability [47, 48, 50-52] and unemployment [49, 53]. Some psychosocial risk factors for exit from paid employment described in literature were lack of job control [54], poor possibilities for self-development [48, 49], lack of job satisfaction [50], temporary employment [55], and lack of social support [50].

Factors which may also explain health-related exit are national economic circumstances and regulations governing the legal age of retirement and mechanisms for leaving employment. For example, the average retirement age in the Netherlands increased from 61 years old in 2006 to 62 years old in 2007, primarily due to abolition of different regulations [56]. Among Dutch workers financial incentives were important for the decision to stop working [57]. An European study showed that a decline in health status had a smaller impact on the likelihood of retirement in countries that have a stronger financial incentive to retire early [41]. Another European study showed that the level of social protection was of influence on the relation between health and unemployment [58]. Also, on individual level a previous period without paid employment increases the negative influence of ill health on participation [57, 59]. The relation between health and work participation may further be influenced by gender [59], older age [60], and educational level [32].

In conclusion, poor health is one of the most important factors for sustaining employability. However, knowledge is lacking on the direct and indirect influences of individual and work-related factors and governmental regulations.

8.4.2 Determinants of work ability

There is consistent evidence for the decrease of work ability by ageing. However, this influence is only moderate when compared to other determinants. Due to the large heterogeneity of study characteristics, no conclusions could be drawn regarding the relative importance of each determinant from the literature study. However, the cross-sectional analysis among Dutch commercial service workers showed that the effect of work-related characteristics was much higher than for demographic factors and lifestyle. Other studies have reported contradictory findings, with one study describing

a stronger influence of work-related factors than individual factors [61], other studies reporting no systematic differences in strength of associations [62-65] and one study observing a stronger effect of individual factors than work-related factors [66].

Stratification analysis in chapter 5 showed that the strength of association between several factors and work ability increased for older age groups, most profoundly for unhealthy lifestyle. The importance of physical activity for older workers was also found in different Finnish studies[61], wherein an increase in physical activity was also related to an increase in WAI [62], and a decrease in physical activity to a decline in WAI [63].
Other studies have carried out stratified analyses by gender [64-67] but no clear pattern could be distinguished. The results in the systematic review (chapter 4) did not show evidence for gender as an important determinant of WAI.

The systematic review in chapter 4 showed a broad range of determinants of work ability. Evidence on effective interventions to increase or maintain work ability is scarce. Some intervention studies have been published of which two main categories can be distinguished. First, interventions aimed at health promotion had at best a moderate influence on work ability. WAI scores in the intervention group increased stronger compared to the control group but no significant effects were reported [68-72]. Second, interventions on work related determinants showed slightly more convincing results [73-76]. Two studies found a significant stronger increase in work ability scores in the intervention group [73, 74].

A recent Finnish study attempted to develop trajectories of work ability among managers. Five different trajectories of change in work ability during 10-year follow-up were distinguished, showing that workers in favourable trajectories (remaining excellent or slightly decreasing) were more often younger workers and in upper-management as compared to other groups. Workers in less favourable trajectories rated their job control, organizational climate, and organizational commitment lower. The older managers and lower-level managers were at risk of having their work ability develop in an unfavourable direction [77].
In conclusion, there is consistent evidence that older age and unhealthy lifestyles are of influence for decreased work ability. The influence of unhealthy work circumstances is less extensively studied, but our results indicate an important role of work-related factors for maintaining or sustaining work ability.

8.4.3 Consequences of a decreased work ability

Decreased work ability was associated with increased risks for sickness absence (chapter 6) and productivity loss at work (chapter 7), also shown by others [78, 79]. The consequences of a decreased work ability are broader than solely work performance, but also have an influence on exit from paid employment, most notably due to work disability. Studies among construction workers aged above 40 years showed that Dutch construction workers with a poor work ability had a 20 fold increased risk to become disabled in the following two years [80] and that Finnish workers with a poor work ability had a 10 fold increased risk to become disabled in the following four years [81].
Finnish studies also showed that workers with a limited work ability more often became unemployment and unemployment persons with a better work ability were more likely to gain paid employment [42]. The consequences of decreased work ability for (early) retirement are less consistent. Among Finnish food industry employees the proportion of poor and moderate work ability was 25% among normal retirees, while 57% among early retirees (before age 65 years) [82]. In a Finnish cohort the majority of those who were about to retire still had an adequate work ability. According to own work ability assessments, approximately one third of all 63- to 67-years-old were able to work. This not automatically implicates that retirement is only justified when a worker perceives poor work ability but illustrates the potential to lengthen working careers [42].

Chapter 6 presented associations of psychosocial work factors with sickness absence which were in line with findings of a meta-analysis on determinants of sickness absence due to psychosocial health complaints [83]. In our study the associations with high physical work demands were somewhat weaker compared to psychosocial factors, which was also reported in a Swedish literature review [84]. Our findings regarding the influence of obesity and overweight on sickness absence were in line with Neovius et al. [85]. Other studies have shown the importance of organizational justice for sickness absence, either indirectly through impaired mental health [86], or directly for distributive justice [87] or for both procedural and relational justice [88, 89]. Due to a majority of male workers, gender differences could not be addressed in our study, but another studie showed a higher risk for sickness absences among female workers, mainly explained by more short absences spells and higher physical work demands [90].
Our finding that productivity loss at work was associated with lack of job control, poor skill-discretion, and high work-demands corroborates previous studies [78, 91, 92].

Organizational and personality factors were not examined in our study but according to other studies productivity loss at work was associated with workers' replacement practices [91], regular overtime [93], mismatch between desired working and actual working hours [94], attendance-pressure factors [91], personal sickness absence attitudes and overcommitment, and job insecurity [95, 96].

Older age was associated with a decreased risk for short term sickness absence and productivity loss at work. This finding is in line with earlier studies on sickness absence [97] and productivity loss at work [91]. A few determinants were analysed both for sickness absence as well as productivity loss at work. Comparison of the results showed that lack of job control had positive associations for both outcome measures. High work-demands seem more important for productivity loss at work than for sickness absence.

Productivity loss at work due to health impairments and sickness absence may be more or less substitutes of each other. Few studies have examined if employees substitute presenteeism for sickness absence and which factors are of influence to choose to continue working while sick or being absent from work. A recent study showed there is a trade-off between both categories; regular overtime decreases sickness absence, but increases being present while sick [93]. An explanation could be that workers without sickness absence have enough energy or better coping strategies that will facilitate their ability to work despite their health complaints.

In view of the current thesis it would be of interest to know whether a decreased work ability would have a stronger effect on sickness absence than on productivity loss at work. Our analyses showed that the range of rate ratios for each WAI category for sickness absence in chapter 6 and the odds ratios for productivity loss at work in chapter 7 were quite comparable.

The results in chapter 7 show that job control is an important factor to remain productive when perceiving decreased work ability. The importance of job control for staying healthy at work has been described in the Job Demand Control theory [98]. In our study we considered job control as flexible working times, have a say in work pace, deadlines, working method etcetera. The illness flexibility model [99] seems to act in a comparable way in preventing sickness absence as such that those who are able to adapt their pace of work have a higher threshold to decide to stay sick at home. A systematic review on organisational-level interventions aimed to increase job control found some evidence for health benefits [100]. According to another study a match between desired and actual working hours is an important factor to remain productive when perceiving impaired health [94].

In conclusion, a decreased work ability has considerable consequences for sickness absence and productivity loss at work. Lack of job control seems an important factor for workers with a decreased work ability to remain productive at work.

8.5 Recommendations for policy and practice

Increasing work participation of older workers

This research leads to the following recommendations for increasing work participation of older workers;

- The results in part one of this thesis indicate strong evidence for an increased risk for premature exit from paid employment for older workers with impaired health. It illustrates a considerable potential for increase in work participation by health promotion programmes. It is therefore advised to include health promotion among the workforce as an important target in policies aiming at increasing work participation.
- The findings in part three of this thesis showed that the negative effect of a decreased work ability on work performance may be partly counterbalanced by increased job control. Possibilities to adjust working tasks, working speed, and order of tasks seem to enable workers to modify their job aspects in such a way that they can remain productive despite their decreased work ability. This suggests that company policies for workers with chronic diseases and a decreased work ability should give a high priority to enlargement of possibilities to plan and pace their own activities at work.

Maintaining or increasing work ability

This research leads to the following recommendations for maintaining or increasing work ability;

- The literature study in chapter 4 showed that research on determinants of work ability was mainly focused on individual factors. However, the study in chapter 5 showed that the associations between work-related factors and decreased work ability were stronger. Health promotion programs aimed at maintaining or increasing work ability should therefore not be restricted to interventions on lifestyle improvement only, but also include workplace reorganisations for example to increase job control, teamwork and possibilities for self-development.
- The Work Ability Index is an useful tool to easily and quickly gain a first insight

into workers' health-related ability to work. The work ability score is especially of interest for its predictive value of future problems in work participation and work performance at group level. However, additional diagnostic procedures are necessary because the index is not aimed at providing detailed information on the specific causes and determinants of the individual problems with work ability. Therefore, companies should systematically investigate the causes of reduced work ability at individual level and evaluate whether socio-medical supervision is addressing these causes adequately. Second, companies should regular monitor the work ability of their employees with respect to individual trajectories and changes over time instead of using a single measurement as basis for company policies.

8.6 Recommendations for future research

This research leads to the following recommendations for future research;

- More insight in the time sequence of the role of poor health or chronic diseases in exit from paid employment is needed to develop accurate policies and interventions. In order to show the time lag between the onset of poor health and exit, longitudinal study designs with long follow-up periods and repeated measurements, and preferably person-oriented trajectories, are needed.
- The findings in the systematic review (chapter 4) showed that there is considerable knowledge on the association of individual factors and lifestyle on the work ability index. Study results on the association between work-related factors and WAI were less available, wherefore the role of physical and psychosocial work demands on WAI is less clear. Future research should give a clear insight in the role of these work demands on WAI, but also of additional factors such as work organization, organizational culture, and Human Resource-policies.
- Given the societal attention for employability, it is an intriguing observation that intervention studies on employability are almost completely lacking. Evaluative research is needed to determine the effectiveness of the proposed interventions on actual retirement behaviour, work ability, productivity loss at work, and sickness absence.

References

[1] Eurostat. European Community Household Panel, Users' Database Manual (version of november 1999). Luxembourg 1999.

[2] Institute for social and economic research. Available from: http://www.iser.essex.ac.uk/survey/bhps/documentation [cited 15-12-2009].

[3] Taylor M. British household panel study user manual: introduction, technical reports and appendices. Colchester: 1998: ESRC Research Centre on Micro-social Change, University of Essex 1998.

[4] Eurostat. Available from: http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&language=en&pcode=tsiem010&tableSelection=1&footnotes=yes&labeling=labels&plugin=1. [cited 15-12-2009].

[5] Leino-Arjas P, Liira J, Mutanen P, Malmivaara A, Matikainen E. Predictors and consequences of unemployment among construction workers: prospective cohort study. *BMJ*. 1999;319:600-5.

[6] Jusot F, Khlat M, Rochereau T, Serme C. Job loss from poor health, smoking and obesity: a national prospective survey in France. *J Epidemiol Community Health*. 2008;62:332-7.

[7] Siegrist J, Wahrendorf M, von dem Knesebeck O, Jurges H, Borsch-Supan A. Quality of work, well-being, and intended early retirement of older employees: baseline results from the SHARE Study. *Eur J Public Health*. 2007;17:62-8.

[8] Fisher MA, Taylor GW, Shelton BJ, Debanne SM. Sociodemographic characteristics and diabetes predict invalid self-reported non-smoking in a population-based study of U.S. adults. *BMC Public Health*. 2007;7:33.

[9] Jago R, Baranowski T, Baranowski JC, Cullen KW, Thompson DI. Social desirability is associated with some physical activity, psychosocial variables and sedentary behavior but not self-reported physical activity among adolescent males. *Health Educ Res*. 2007;22:438-49.

[10] Alavinia SM, van Duivenbooden C, Burdorf A. Influence of work-related factors and individual characteristics on work ability among Dutch construction workers. *Scand J Work Environ Health*. 2007;33:351-7.

[11] Meerding WJ, IJzelenberg W, Koopmanschap MA, Severens JL, Burdorf A. Health problems lead to considerable productivity loss at work among workers with high physical load jobs. *J Clin Epidemiol*. 2005;58:517-23.

[12] Prasad M, Wahlqvist P, Shikiar R, Shih YC. A review of self-report instruments measuring health-related work productivity: a patient-reported outcomes perspective. *PharmacoEconomics*. 2004;22:225-44.

[13] Andersson T, Alfredsson L, Kallberg H, Zdravkovic S, Ahlbom A. Calculating measures of biological interaction. *Eur J Epidemiol*. 2005;20:575-9.

[14] Knol MJ, Egger M, Scott P, Geerlings MI, Vandenbroucke JP. When one depends on the other: reporting of interaction in case-control and cohort studies. *Epidemiology*. 2009;20:161-6.

[15] Ahlbom A, Alfredsson L. Interaction: A word with two meanings creates confusion. *Eur J Epidemiol*. 2005;20:563-4.

[16] Li R, Chambless L. Test for additive interaction in proportional hazards models. *Ann Epidemiol*. 2007;17:227-36.

[17] Hosmer DW, Lemeshow S. Confidence interval estimation of interaction. *Epidemiology*. 1992;3:452-6.

[18] Skrondal A. Interaction as departure from additivity in case-control studies: a cautionary note. *Am J Epidemiol*. 2003;158:251-8.

[19] Assmann SF, Hosmer DW, Lemeshow S, Mundt KA. Confidence intervals for measures of interaction. *Epidemiology*.1996;7:286-90.
[20] Richardson DB, Kaufman JS. Estimation of the relative excess risk due to interaction and associated confidence bounds. *Am J Epidemiol*. 2009;169:756-60.
[21] Alavinia SM, Burdorf A. Unemployment and retirement and ill-health: a cross-sectional analysis across European countries. *Int Arch Occup Environ Health*. 2008;82:39-45.
[22] Arrow JO. Estimating the influence of health as a risk factor on unemployment: a survival analysis of employment durations for workers surveyed in the German Socio-Economic Panel (1984-1990). *Soc Sci Med*. 1996;42:1651-9.
[23] Bartley M. Unemployment and ill health: understanding the relationship. *J Epidemiol Community Health*. 1994;48:333-7.
[24] Biering-Sorensen F, Lund J, Hoydalsmo OJ, Darre EM, Deis A, Kryger P, et al. Risk indicators of disability pension. A 15 year follow-up study. *Dan Med Bull*. 1999;46:258-62.
[25] Borsch-Supan A, Jurges H, Mackenbach J, Siegrist J, Weber G. Health, Ageing and Retirement in Europe. First results from the survey of Healht, Ageing and Retirement in Europe. First results from the survey of Health, Ageing and Retirement in Europe. . Mannheim: Mannheim Research Institute for the Economic of Ageing (MEA); 2005.
[26] Cai L, Kalb G. Health status and labour force participation: evidence from Australia. *Health Econ*. 2006;15:241-61.
[27] Dwyer DS, Mitchell OS. Health problems as determinants of retirement: are self-rated measures endogenous? *J Health Econ*. 1999;18:173-93.
[28] Friis K, Ekholm O, Hundrup YA, Obel EB, Gronbiek M. Influence of health, lifestyle, working conditions, and sociodemography on early retirement among nurses: The Danish Nurse Cohort Study. *Scand J Public Health*. 2007;35:23-30.
[29] Karpansalo M, Manninen P, Kauhanen J, Lakka TA, Salonen JT. Perceived health as a predictor of early retirement. *Scand J Work Environ Health*. 2004;30:287-92.
[30] McDonough P, Amick BC, 3rd. The social context of health selection: a longitudinal study of health and employment. *Soc Sci Med*. 2001;53:135-45.
[31] Schofield DJ, Shrestha RN, Passey ME, Earnest A, Fletcher SL. Chronic disease and labour force participation among older Australians. *Medical J Aust*. 2008;189:447-50.
[32] Schuring M, Burdorf L, Kunst A, Mackenbach J. The effects of ill health on entering and maintaining paid employment: evidence in European countries. *J Epidemiol Community Health*. 2007;61:597-604.
[33] Stattin M. Retirement on grounds of ill health. *Occup Environ Med*. 2005;62:135-40.
[34] Geuskens GA, Burdorf A, Hazes JM. Consequences of rheumatoid arthritis for performance of social roles--a literature review. *J Rheumatol*. 2007;34:1248-60.
[35] Lagerveld SE, Bultmann U, Franche RL, van Dijk FJ, Vlasveld MC, van der Feltz-Cornelis CM, et al. Factors Associated with Work Participation and Work Functioning in Depressed Workers: A Systematic Review. *J Occup Rehabil*. 2010 [epub ahead of print].
[36] Larbanois A, Jamart J, Delwiche JP, Vandenplas O. Socioeconomic outcome of subjects experiencing asthma symptoms at work. *Eur Respir J*. 2002;19:1107-13.
[37] Von Korff M, Katon W, Lin EH, Simon G, Ciechanowski P, Ludman E, et al. Work disability among individuals with diabetes. *Diabetes care*. 2005;28:1326-32.
[38] Detaille SI, Heerkens YF, Engels JA, van der Gulden JW, van Dijk FJ. Common prognostic factors of work disability among employees with a chronic somatic disease: a systematic review of cohort studies. *Scand J Work Environ Health*. 2009;35:261-81.

[39] Burdorf A, van den Berg T, Avendano M, Kunst A, Mackenbach J. The effects of ill health on displacement from the labour market and potential impact of prevention. In: Borsch-Supan A, ed. *Health, Ageing and Retirement in Europe (2004-2007) Starting the longitudinal dimension*. Mannheim: SHARE 2008:135-40.
[40] Disney R, Emmerson C, Wakefield M. Ill health and retirement in Britain: a panel data-based analysis. *J Health Econ*. 2006;25:621-49.
[41] Hagan R, Jones AM, Rice N. Health and retirement in Europe. *Int J Environ Res Public* Health. 2009;6:2676-95.
[42] Gould R, Ilmarinen J, Järvikoski A, Järvisalo J, Koskinen S, Martelin T, et al. Dimensions of work ability. Results of the Health 2000 survey. Helsinki: Finnish centre for pensions (ETK)
The Social insurance institution (Kela) National public health institute (KTL) Finnish Institute of Occupational Health (FIOH) 2008.
[43] Mein G, Martikainen P, Stansfeld SA, Brunner EJ, Fuhrer R, Marmot MG. Predictors of early retirement in British civil servants. *Age and ageing*. 2000;29:529-36.
[44] Rissanen A, Heliovaara M, Knekt P, Reunanen A, Aromaa A, Maatela J. Risk of disability and mortality due to overweight in a Finnish population. *BMJ* 1990;301:835-7.
[45] Liira J, Leino-Arjas P. Predictors and consequences of unemployment in construction and forest work during a 5-year follow-up. *Scand J Work Environ Health*. 1999;25:42-9.
[46] Whooley MA, Kiefe CI, Chesney MA, Markovitz JH, Matthews K, Hulley SB. Depressive symptoms, unemployment, and loss of income: The CARDIA Study. *Arch Intern Med*. 2002;162:2614-20.
[47] Eriksen W, Natvig B, Rutle O, Bruusgaard D. Smoking as a predictor of long-term work disability in physically active and inactive people. *Occup Med* (Oxford, England). 1998;48:315-20.
[48] Lund T, Csonka A. Risk factors in health, work environment, smoking status, and organizational context for work disability. *Am J Ind Med*. 2003;44:492-501.
[49] Lund T, Iversen L, Poulsen KB. Work environment factors, health, lifestyle and marital status as predictors of job change and early retirement in physically heavy occupations. *Am J Ind Med*. 2001;40:161-9.
[50] Haahr JP, Frost P, Andersen JH. Predictors of health related job loss: a two-year follow-up study in a general working population. *J Occup Rehabil*. 2007;17:581-92.
[51] Karpansalo M, Manninen P, Lakka TA, Kauhanen J, Rauramaa R, Salonen JT. Physical workload and risk of early retirement: prospective population-based study among middle-aged men. *J Occup Environ Med*. 2002;44:930-9.
[52] Solomon C, Poole J, Palmer KT, Coggon D. Health-related job loss: findings from a community-based survey. *Occup Environ Med*. 2007;64:144-9.
[53] Lindholm C, Burstrom B, Diderichsen F. Class differences in the social consequences of illness? *J Epidemiol Community Health*. 2002;56:188-92.
[54] Blekesaune M, Solem PE. Working conditions and early retirement - A prospective study of retirement behavior. *Research on Aging*. 2005;27:3-30.
[55] Bildt C, Michelsen H. Occupational conditions exceed the importance of non-occupational conditions and ill health in explaining future unemployment among women and men. *Arch Womens Ment Health*. 2003;6:115-26.
[56] CBS. Werknemers op hogere leeftijd met pensioen; 2010 Persbericht PB010-023 26 maart 2010.
[57] Lindeboom M, Kerkhofs M. Health and work of the elderly: subjective health measures, reporting errors and endogeneity in the relationship between health and work. *J Appl Econ*. 2009;24:1024-46.
[58] Bambra C, Eikemo TA. Welfare state regimes, unemployment and health: a comparative study of the relationship between unemployment and self-reported health in 23 European countries. *J Epidemiol Community Health*. 2009;63:92-8.

[59] Gannon B. A dynamic analysis of disability and labour force participation in Ireland 1995-2000. Health economics. 2005 Sep;14(9):925-38.
[60] Zhang X, Zhao X, Harris A. Chronic diseases and labour force participation in Australia. *J Health Econ*. 2009 Jan;28(1):91-108.
[61] Tuomi K, Huuhtanen P, Nykyri E, Ilmarinen J. Promotion of work ability, the quality of work and retirement. *Occup Med (Lond)*. 2001;51:318-24.
[62] Tuomi K, Vanhala S, Nykyri E, Janhonen M. Organizational practices, work demands and the well-being of employees: a follow-up study in the metal industry and retail trade. *Occup Med (Lond)*. 2004;54:115-21.
[63] Tuomi K, Ilmarinen J, Martikainen R, Aalto L, Klockars M. Aging, work, life-style and work ability among Finnish municipal workers in 1981-1992. *Scand J Work Environ Health*. 1997;23 Suppl 1:58-65.
[64] Aittomaki A, Lahelma E, Roos E. Work conditions and socioeconomic inequalities in work ability. *Scand J Work Environ Health*. 2003;29:159-65.
[65] Eskelinen L, Kohvakka A, Merisalo T, Hurri H, Wagar G. Relationship between the self-assessment and clinical assessment of health status and work ability. *Scand J Work Environ Health*. 1991;17 Suppl 1:40-7.
[66] Kaleta D, Makowiec-Dabrowska T, Jegier A. Lifestyle index and work ability. *Int J Occup Med Environ Health*. 2006;19:170-7.
[67] Laitinen J, Nayha S, Kujala V. Body mass index and weight change from adolescence into adulthood, waist-to-hip ratio and perceived work ability among young adults. *Int J Obesity* (2005). 2005;29:697-702.
[68] Blangsted AK, Sogaard K, Hansen EA, Hannerz H, Sjogaard G. One-year randomized controlled trial with different physical-activity programs to reduce musculoskeletal symptoms in the neck and shoulders among office workers. *Scand J Work Environ Health*. 2008;34:55-65.
[69] Karazman R, Kloimuller I, Geissler H, Karazman-Morawetz I. Effects of ergonomic and health training on work interest, work ability and health in elderly public urban transport drivers. *Int J Ind Erg*. 2000;25:503-11.
[70] Nurminen E, Malmivaara A, Ilmarinen J, Ylostalo P, Mutanen P, Ahonen G, et al. Effectiveness of a worksite exercise program with respect to perceived work ability and sick leaves among women with physical work. *Scand J Work Environ Health*. 2002;28:85-93.
[71] Pohjonen T, Ranta R. Effects of worksite physical exercise intervention on physical fitness, perceived health status, and work ability among home care workers: five-year follow-up. *Prev Med*. 2001;32:465-75.
[72] Smolander J, Blair SN, Kohl HW, 3rd. Work ability, physical activity, and cardiorespiratory fitness: 2-year results from Project Active. *J Occup Environl Med*. 2000;42:906-10.
[73] de Boer AG, Burdorf A, van Duivenbooden C, Frings-Dresen MH. The effect of individual counselling and education on work ability and disability pension: a prospective intervention study in the construction industry. *Occup Environ Med*. 2007; 64:792-797.
[74] de Boer AG, van Beek JC, Durinck J, Verbeek JH, van Dijk FJ. An occupational health intervention programme for workers at risk for early retirement; a randomised controlled trial. *Occup Environ Med*. 2004;61:924-9.
[75] Larsson A, Karlqvist L, Gard G. Effects of work ability and health promoting interventions for women with musculoskeletal symptoms: a 9-month prospective study. *BMC musculoskeletal disorders*. 2008;9:105.
[76] Nevala-Puranen N. Effects of occupationally-oriented rehabilitation on farmers' work techniques, musculoskeletal symptoms, and work ability. *J Occup Rehab*. 1996;6:191-200.

[77] Feldt T, Hyvonen K, Makikangas A, Kinnunen U, Kokko K. Development trajectories of Finnish managers' work ability over a 10-year follow-up period. *Scand J Work Environ Health*. 2009;35:37-47.
[78] Alavinia SM, Molenaar D, Burdorf A. Productivity loss in the workforce: associations with health, work demands, and individual characteristics. *Am J Ind Med*. 2009;52:49-56.
[79] Kujala V, Tammelin T, Remes J, Vammavaara E, Ek E, Laitinen J. Work ability index of young employees and their sickness absence during the following year. *Scand J Work Environ Health*. 2006;32:75-84.
[80] Alavinia SM, de Boer AG, van Duivenbooden JC, Frings-Dresen MH, Burdorf A. Determinants of work ability and its predictive value for disability. *Occup Med* (Lond). 2009;59:32-7.
[81] Liira J, Matikainen E, Leino-Arjas P, Malmivaara A, Mutanen P, Rytkönen H, et al. Work ability of middle-aged Finnish construction workers - a follow-up study in 1991-1995. *Int J Ind Erg*. 2000;25:477-81.
[82] Salonen P, Arola H, Nygard CH, Huhtala H, Koivisto AM. Factors associated with premature departure from working life among ageing food industry employees. *Occup Med* (Lond). 2003;53:65-8.
[83] Duijts SF, Kant I, Swaen GM, van den Brandt PA, Zeegers MP. A meta-analysis of observational studies identifies predictors of sickness absence. *J Clin Epidemiol*. 2007;60:1105-15.
[84] Allebeck P, Mastekaasa A. Swedish Council on Technology Assessment in Health Care (SBU). Chapter 5. Risk factors for sick leave - general studies. *Scand J Public Health* Suppl. 2004;63:49-108.
[85] Neovius K, Johansson K, Kark M, Neovius M. Obesity status and sick leave: a systematic review. *Obes Rev*. 2009;10:17-27.
[86] De Boer AG, Bakker AB, Syroit JE, Schaufeli WB. Unfairness at work as a predictor of absenteeism. *Journal of Organizational Behavior*. 2002;23:181-97.
[87] Ybema JF, Bos KV. Effects of organizational justice on depressive symptoms and sickness absence: A longitudinal perspective. *Soc Sci Med*. 2010;70:1609-17.
[88] Elovainio M, Kivimaki M, Vahtera J, Virtanen M, Keltikangas-Järvinen L. Personality as a moderator in the relations between perceptions of organizational justice and sickness absence. *Journal of Vocational Behavior*. 2003;63:379-95.
[89] Elovainio M, van den Bos K, Linna A, Kivimaki M, Ala-Mursula L, Pentti J, et al. Combined effects of uncertainty and organizational justice on employee health: testing the uncertainty management model of fairness judgments among Finnish public sector employees. *Soc Sci Med*. 2005;61:2501-12.
[90] Laaksonen M, Martikainen P, Rahkonen O, Lahelma E. Explanations for gender differences in sickness absence: evidence from middle-aged municipal employees from Finland. *Occup Environ Med*. 2008;65:325-30.
[91] Aronsson G, Gustafsson K. Sickness presenteeism: prevalence, attendance-pressure factors, and an outline of a model for research. *J Occup Environ Med*. 2005;47:958-66.
[92] Martimo KP, Shiri R, Miranda H, Ketola R, Varonen H, Viikari-Juntura E. Self-reported productivity loss among workers with upper extremity disorders. *Scand J Work Environ Health*. 2009;35:301-8.
[93] Bockerman P, Laukkanen E. What makes you work while you are sick? Evidence from a survey of workers. *Eur J Public Health*. 2010;20:43-6.
[94] Bockerman P, Laukkanen E. Predictors of sickness absence and presenteeism: does the pattern differ by a respondent's health? *J Occup Environ Med*. 2010;52:332-5.
[95] Caverley N, Cunningham JB, MacGregor JN. Sickness presenteeism, sickness absenteeism, and health following restructuring in a public service organization. *Journal of Management Studies*. 2007;44:304-19.

[96] Hansen CD, Andersen JH. Going ill to work--what personal circumstances, attitudes and work-related factors are associated with sickness presenteeism? *Soc Sci Med*. 2008;67:956-64.
[97] Marmot M, Feeney A, Shipley M, North F, Syme SL. Sickness absence as a measure of health status and functioning: from the UK Whitehall II study. *J Epidemiol Community Health*. 1995;49:124-30.
[98] Karasek R, Baker D, Marxer F, Ahlbom A, Theorell T. Job decision latitude, job demands, and cardiovascular disease: a prospective study of Swedish men. *Am J Public Health*. 1981;71:694-705.
[99] Johansson G, Lundberg I. Adjustment latitude and attendance requirements as determinants of sickness absence or attendance. Empirical tests of the illness flexibility model. *Soc Sci Med*. 2004;58:1857-68.
[100] Egan M, Bambra C, Thomas S, Petticrew M, Whitehead M, Thomson H. The psychosocial and health effects of workplace reorganisation. 1. A systematic review of organisational-level interventions that aim to increase employee control. *J Epidemiol Community Health*. 2007;61:945-54.

Summary

Samenvatting

Summary

This thesis aimed to contribute to the understanding of the role of ill health on work participation and work performance of older workers. The primary objectives were (1) What is the relation between ill health and exit from paid employment among older workers?
(2) Which individual characteristics, lifestyle factors and work-related risk factors are associated with work ability?, and, (3) What are the consequences of a decreased work ability for sickness absence and productivity loss at work and are these consequences influenced by work related characteristics?
The first objective was addressed in chapter 2 and 3, the second objective in chapter 4 and 5, and the third objective in chapter 6 and 7.
Chapter 2 described a longitudinal study on the role of four different health measures on exit from paid employment through work disability, unemployment, or retirement among workers aged 50 to 63 years old in 11 European countries. During the two-year follow-up period, 17% of employed workers quitted paid employment, primarily due to early retirement. Controlling for individual and work related characteristics, poor self-perceived health was strongly associated with exit from paid employment due to retirement, unemployment, or disability (ORs from 1.32 to 4.37). Adjustment by work related factors and lifestyle reduced the significant associations between ill health and exit from paid employment by 0 to 18.7%. Low education, obesity, low job control, and effort-reward imbalance were associated with measures of ill health, but also risk factors for exit from paid employment after adjustment for ill health.
Chapter 3 presented the results of a study on the influence of health and work on early retirement and incentives for longer working. A systematic review was conducted of longitudinal studies on factors for nondisability early retirement. Eight longitudinal studies showed that important factors for early retirement were poor health, being single, high physical work demands, high work pressure, low job satisfaction, and lack of physical activity in leisure time. In addition, in the printing industry seven focus group interviews (n=32) were conducted about reasons for planning retirement early and incentives to stay longer in work among workers with poor and excellent work ability. The focus group participants reported shift work, social support, and appreciative leadership style also as factors. It was concluded that poor health and poor work circumstances are important in decisions to retire early. Social support and appreciative leadership style may be buffers in this process.
Chapter 4 presented a literature review, which aimed to gain insight in the effects of individual and work-related factors on the Work Ability Index (WAI). Factors associated

with poor work ability identified in 20 studies, were lack of leisure-time vigorous physical activity, poor musculoskeletal capacity, older age, obesity, high mental work demands, lack of autonomy, poor physical work environment, and high physical work load. It was concluded that the multifactorial nature of work ability should be taken into account in health promotion programmes aimed at maintaining and promoting the participation of the labour force and improvement of the performance at work.

Chapter 5 described a cross-sectional study on the associations of psychosocial factors at work, life style, and stressful life events on health and work ability among white-collar workers (n=1141). Work ability of white-collar workers in the commercial services industry was strongly associated with psychosocial factors at work, such as teamwork, stress handling, and self-development and, to a lesser extent, with stressful life events, lack of physical activity, and obesity. With respect to work ability, the influence of unhealthy life style seems more important for older workers, than for their younger colleagues. The strong associations between psychosocial factors at work and mental health and work ability suggest that in this study population health promotion should address working conditions rather than individual life style factors.

Chapter 6 evaluated the relative contribution of individual characteristics, lifestyle factors, work related risk factors, and work ability on the occurrence of short (<2 weeks), moderate (2-12 weeks), and long (>12 weeks) durations of sickness absence during 12 months follow-up among 5867 Dutch construction workers. Predictors for sick leave lasting 2-12 weeks and >12 weeks were: older age, obesity, smoking, manual materials handling, lack of job control, lung restriction, and less-than-excellent work ability. For most predictors higher relative risk (RR) values were observed with a longer duration of sickness absence. The highest population attributable fractions were observed for age over 50 years (18%), manual materials handling (20%), and good (18%), moderate (28%), and poor (2%) work ability.

Chapter 7 examined the role of work-related characteristics on the negative consequences of decreased work ability for productivity loss at work among 10,542 workers in 49 different Dutch companies. Additive interactions between work-related factors and decreased work ability were evaluated by the Relative Excess Risk due to Interaction (RERI).

The odds ratios and 95% confidence intervals (CI) for the likelihood of productivity loss were 2.03 (1.85-2.22), 3.50 (3.10-3.95), and 5.54 (4.37-7.03) for a good, moderate, and poor work ability, compared with an excellent work ability (reference group).

Productivity loss at work was associated with lack of job control, poor skill discretion, and high work demands. There was a significant interaction between reduced work

ability and lack of job control (RERI = 0.63 95% CI 0.11-1.16) with productivity loss at work. It was concluded that the negative effects on work performance of reduced work ability may be partly counterbalanced by enlarging workers' possibilities to plan and pace their own activities at work.

Chapter 8, the general discussion, started with presenting the main findings in the light of the study objectives, followed by methodological issues that should be acknowledged when interpreting the findings. New insights were described on the role of poor health and exit from paid employment, the associations between individual, lifestyle and work related factors with decreased work ability, and the consequences of decreased work ability for sickness absence and productivity loss at work. Finally, recommendations for policy and practice and future research were presented.

Samenvatting

In dit proefschrift onderzoeken wij de rol van verminderde gezondheid en verminderd werkvermogen op de arbeidsparticipatie en werkprestaties van oudere werknemers. De volgende doelstellingen staan centraal in dit proefschrift: (1) Wat is de relatie tussen verminderde gezondheid en uitval uit betaalde arbeid onder oudere werknemers? (2) Welke individuele kenmerken, leefstijlfactoren en werkgerelateerde risicofactoren zijn geassocieerd met werkvermogen? En (3) Wat zijn de gevolgen van een verminder werkvermogen voor ziekteverzuim en productiviteitsverlies op het werk en worden deze gevolgen beïnvloed door werkgerelateerde kenmerken?

De eerste doelstelling wordt onderzocht in de hoofdstukken 2 en 3, de tweede doelstelling in de hoofdstukken 4 en 5 en de derde doelstelling in de hoofdstukken 6 en 7.

Hoofdstuk 2 beschrijft een longitudinale studie naar de rol van vier verschillende gezondheidsmaten op uitval uit betaalde arbeid door middel van arbeidsongeschiktheid, werkloosheid, of pensionering onder werknemers in de leeftijd van 50 tot 63 jaar in 11 Europese landen. Tijdens de 2-jarige follow-up periode, verliet 17% van de werkenden betaalde arbeid, voornamelijk vanwege vroegpensioen. Verminderde ervaren gezondheid was sterk geassocieerd met verlies van betaald werk als gevolg van pensioen, werkloosheid, of arbeidsongeschiktheid (ORs van 1.32 tot 4.37), gecontroleerd voor individuele en werkgerelateerde kenmerken.

Controle voor werkgerelateerde factoren en leefstijl verlaagt de significante associaties tussen verminderde gezondheid en uitval uit betaald werk met 0 tot 18.7%. Laag opleidingsniveau, obesitas, gebrek aan regelmogelijkheden en onbalans tussen investering en beloning waren geassocieerd met de gezondheidsmaten, maar ook risicofactoren voor uitval uit betaalde arbeid na controle voor verminderde gezondheid.

Hoofdstuk 3 beschrijft de resultaten van een studie naar de invloed van gezondheid en werk op vroegpensioen en voornemens om langer te blijven werken. Een systematische literatuurstudie was uitgevoerd naar longitudinale studies over factoren voor niet gezondheidsgerelateerd vroegpensioen. Acht longitudinale studies tonen dat belangrijke factoren voor vroegpensioen verminderde gezondheid, alleenstaand, hoge fysieke werkeisen, hoge werkdruk, lage werktevredenheid, en gebrek aan fysieke activiteit in de vrije tijd waren. Aanvullend werden in de grafische industrie zeven focus groep interviews (n=32) gehouden naar de redenen voor het plannen van vroegpensioen en voornemens om langer te blijven werken onder werknemers met een uitstekend en verminderd werkvermogen. De deelnemers aan

de focusgroepen gaven ploegendienst, sociale steun en een stimulerende leiderschapsstijl aan als aanvullende factoren. Er werd geconcludeerd dat verminderde gezondheid en slechte arbeidsomstandigheden belangrijk zijn voor de beslissing om met vroegpensioen te gaan. Sociale steun en een stimulerende leiderschapstijl kunnen buffers zijn in dit proces.

Hoofdstuk 4 presenteert een literatuurstudie naar de effecten van individuele en werkgerelateerde factoren op de Work Ability Index (WAI). De 20 bestudeerde studies toonden dat gebrek aan fysieke inspanning in de vrije tijd, slechte spiercapaciteit, oudere leeftijd, obesitas, hoge mentale taakeisen, gebrek aan autonomie, slechte fysische werkomstandigheden en hoge fysieke taakeisen waren geassocieerd met verminderd werkvermogen. Er werd geconcludeerd dat de multifactoriele aard van werkvermogen mee moet worden genomen in gezondheidsbevorderende programma's gericht op het behouden en verbeteren van arbeidsparticipatie en verbetering van werkprestaties.

Hoofdstuk 5 beschrijft een dwarsdoorsnede studie naar de associaties van psychosociale factoren op het werk, leefstijl en stressvolle levensgebeurtenissen op gezondheid en werkvermogen onder kantoorpersoneel (n=1141). Werkvermogen van kantoorpersoneel in de commerciële dienstverlening was sterk geassocieerd met psychosociale factoren op het werk, zoals teamwork, omgaan met stress en zelfontwikkeling, en in mindere mate met stressvolle levensgebeurtenissen, gebrek aan fysieke inspanning en obesitas. Met betrekking tot werkvermogen blijkt de invloed van ongezonde leefstijlfactoren belangrijker voor oudere werknemers dan voor hun jongere collega's. De sterke associaties tussen psychosociale factoren op het werk en mentale gezondheid en werkvermogen suggereren dat gezondheidsbevordering in deze populatie zich eerder zou moeten richten op werkomstandigheden dan individuele leefstijlfactoren.

Hoofdstuk 6 evalueert de relatieve bijdrage van individuele kenmerken, leefstijl factoren, werkgerelateerde risicofactoren en werkvermogen op het optreden van kort (<2 weken), gemiddeld (2-12 weken) en langdurig (>12 weken) ziekteverzuim gedurende 12 maanden follow-up onder 5867 Nederlandse bouwvakkers. Voorspellers van gemiddeld en langdurig ziekteverzuim waren: oudere leeftijd, obesitas, roken, handmatig tillen, gebrek aan regelmogelijkheden, beperkt longvolume en een minder-dan-uitstekend werkvermogen. Voor de meeste voorspellers werden hogere relatieve ratio's geobserveerd voor langere perioden van ziekteverzuim. De hoogste populatie attributieve fractie werd geobserveerd voor leeftijd ouder dan 50 jaar (18%), handmatig tillen (20%) en goed (18%), matig (28%) en slecht (2%) werkvermogen.

Hoodstuk 7 bestudeert de rol van werkgerelateerde kenmerken op de negatieve gevolgen van verminderd werkvermogen voor productiviteitsverlies op het werk onder 10,542 werknemers in 49 verschillende Nederlandse bedrijven. Additieve interacties tussen werkgerelateerde factoren en verminderd werkvermogen werden geëvalueerd door het Relatieve Excedent Risico als gevolg van Interactie (RERI). De odds ratios en de 95% betrouwbaarheidsintervallen (BI) voor een goed, matig en slecht werkvermogen, werden vergeleken met een uitstekend werkvermogen (referentiegroep).

Productiviteitsverlies op het werk was geassocieerd met gebrek aan regelmogelijkheden, gebrek aan afwisseling en hoge taakeisen. Er was een significante interactie tussen verminderd werkvermogen en gebrek aan regelmogelijkheden (RERI = 0.63 95% BI 0.11-1.16) met productiviteitsverlies op het werk. Er werd geconcludeerd dat het negatieve effect van verminderd werkvermogen op werkprestatie gedeeltelijk kan worden gecompenseerd door het vergroten van de invloed van de werknemer op de werkvolgorde en werksnelheid.

Hoofdstuk 8, de algemene discussie, begint met het presenteren van de belangrijkste bevindingen in het licht van de onderzoeksvragen, gevolgd door methodologische beperkingen die van belang zijn bij de interpretatie van de bevindingen. Nieuwe inzichten in de rol van verminderde gezondheid en uitval uit betaalde arbeid, de associaties van individuele kenmerken, leefstijl en werkgerelateerde kenmerken met verminderd werkvermogen en de gevolgen van verminderd werkvermogen voor ziekteverzuim en productiviteitsverlies op het werk worden beschreven. Hoofdstuk 8 eindigt met aanbevelingen voor beleid, praktijk en toekomstig onderzoek.

Dankwoord

Zo ben je als student er nog van overtuigd dat je nooit 'in zo'n hokje gaat zitten', maar na wat ervaring in het bedrijfsleven wordt academische diepgang toch wel interessant en zit je uiteindelijk wat jaartjes later het dankwoord van je proefschrift te schrijven. Een aantal mensen hebben er zeker aan bijgedragen dat ik geen spijt heb gehad van mijn keuze om alsnog te promoveren.

Ten eerste wil ik mijn promotor Lex Burdorf bedanken. Fantastisch dat het gelukt is om benoemd te worden tot hoogleraar en jij nu inderdaad de promotor in plaats van co-promotor bent. Onvermoeibaar probeerde jij mij te prikkelen tot toch weer een niveau hoger door 'krachtiger te formuleren' en niet zo snel tevreden te zijn met bestaande stukken maar deze juist bij te schaven. Ik waardeer het enorm dat ik het gevoel kreeg dat er altijd tijd voor mij was en er een sfeer was, waar alles gezegd kon worden.
Daarnaast wil ik Leo Elders bedanken, zonder wie het project waarop ik werd aangenomen nooit had bestaan. Je zit altijd vol met creatieve ideeën en tomeloze energie. Je voelde goed aan dat ik ook wel behoefte had aan contact met de praktijk en onze uitstapjes naar bedrijven en gezellige telefoongesprekken maakten het promotietraject zeker aangenamer.

Voor een aantal artikelen in dit proefschrift kreeg ik de beschikking over een kant-en-klare dataset. Dennis Lindeboom, Folef Bredt, Jan Plat en Duco Molenaar hartelijk dank voor het gebruik van jullie gegevens. Op deze wijze kunnen wetenschap en praktijk prima voordeel van elkaar hebben.

Werknemers van diverse organisaties, slechts 40+, maar in onderzoekstermen al als oud te kwalificeren, wil ik van harte bedanken voor het invullen van toch behoorlijk dikke vragenlijsten en de openheid in persoonlijk kwesties en soms gevoelige onderwerpen tijdens de groepsinterviews.
Ria en Ineke van het kenniscentrum GOC wil ik graag bedanken voor het coördineren van het project in de grafimedia.

Tijdens mijn promotietijd had ik het geluk dat er in het veld een grote interesse ontstond voor de Work Ability Index. Blik op Werk heeft enorm bijgedragen aan de bekendheid van de vragenlijst en kennis omtrent de praktische toepasbaarheid. Sietske van Rossum bedankt dat ik via jullie platform mijn onderzoeksresultaten kon

verspreiden onder de professionals die er uiteindelijk mee aan de slag moeten. Hierdoor werd ik geprikkeld meer na te denken over de betekenis van de resultaten voor de praktijk en bleef het onderzoek niet puur academisch.

Research can be individualistic. Therefore it was very pleasant that you, Mohammad, shared the same research topic. Although you sometimes struggled with statistical analyses and Dutch bureaucracy you kept motivated to finish your PhD in time and also inspired me to keep on going and to realise how well organised the work situation of Dutch researchers is.

Uit vele onderzoeken op het gebied van arbeid en gezondheid blijkt het belang van sociale steun; deze was op de afdeling ruimschoots aanwezig.
Suzan, het was heerlijk klagen over P&O dames, maar nog leuker was het om te discussiëren over de waslijst aan vakantiebestemmingen (en welk congres daar nou eens bij zou passen). Merel en Goedele, jullie waren al wat verder en erg behulpzaam in het geven van onderzoekstips en –trucs, maar het was bovenal erg gezellig om even bij jullie binnen te wippen. Nicole en Karien bedankt voor de gezellige treinritjes terug naar Brabant! Daarnaast nog alle andere collega's die zorgden voor gezelligheid tijdens lunchwandelingen, theepauzes en warme maaltijden in Dijkers waaronder onder meer Quirine, Lenneke, Liddy, Nicolien, Noortje, Jan, Bart, Marie-Louise, Carlijn, Rick, Hilde, Hester etc. etc.
Als onderzoeker moet je van allerlei markten thuis zijn (het plakken van adresstickers is af en toe een erg belangrijke 'competentie'), maar daarbij was het fijn dat er hulp beschikbaar was in de vorm van ondersteunend personeel waarvan ik Sonja, Sanne, Kees, Roel en Mona even wil noemen.
Collega's van de Raad voor Werk en Inkomen wil ik graag bedanken voor jullie interesse en medeleven tijdens de laatste loodjes.

Wat fijn om twee paranimfen te hebben waarbij je een vertrouwd gevoel hebt. Elin, wat is er in die kamer van ons een hoop thee gedronken, maar nog veel meer gekletst; de deuren van nabij gelegen kamers gingen er soms dicht van. Toch ook wel werkinhoudelijk, maar zeker nog meer over eten, onze mannen, vakanties, loopbaanplannen en allerhande vrouwenzaken. Gelukkig vonden we beiden dat we het met elkaar hadden getroffen als kamergenoten en zijn we al goed bezig om het contact ook buiten MGZ te onderhouden.
Kirsten, bedankt voor alle adviezen als ervaringsdeskundige, maar meer nog voor de gezellige avondjes. Ik vind het heel fijn dat wij elkaars nuchterheid zo kunnen

waarderen. We wisselen nu even van plek, maar hopelijk wordt het resultaat net zo goed.

Om de kleine zorgen om artikelen, analyses en kritische reviewers van je af te zetten, was er genoeg afleiding; Inez, Femke, Marjanka, Anke, Marieke, Debora, eetclub, leesclub, waterpoloteam en tennismaatjes. Bedankt voor jullie luisterend oor, medeleven en interesse in de proefschrift vorderingen.

Lieve pap en mam, Brenda en Adrie, mijn promotieonderzoek en het stadium waarin het zich bevond was soms misschien wat abstract. Bedankt voor de fijne en onbezorgde jeugd waarin heel veel mocht en kon, maar grenzen ook duidelijk waren. De Groningse 'nait soezen' mentaliteit kwam in dit promotietraject uitstekend van pas!

Liefste Bas, tijdens de eindfase van een promotietraject moeten er heel wat keuzes worden gemaakt, daarin was het fijn om samen de knopen door te hakken. Onze banen zijn zo totaal verschillend, maar zolang we elkaar blijven verbazen, leren we nog steeds van elkaar. Niet alleen op het gebied van werk, maar ook daarbuiten.

About the author

Curriculum Vitae

List of publications

PhD portfolio Summary

Curriculum Vitae

Tilja Ilona Jessica van den Berg was born on July 24 1980, in t'Zandt, the Netherlands. She obtained her secondary school education at Ommelander College Appingedam. Thereafter, she started studying Health Sciences at University Maastricht. In 2003 she completed a Master of Science in Health Sciences with a major in 'Human Movement Sciences' and 'Work and Health'. Thereafter she worked as a researcher at the Department of Health Organization, Policy and Economics at University Maastricht and as a consultant in quality, environment and health at BMD in Barendrecht. In April 2006 she was employed as a researcher at the Department of Public Health of the Erasmus MC in Rotterdam, where she carried out the research presented in this thesis. She is currently employed as a research consultant at the Council for Work and Income (Raad voor Werk en Inkomen (RWI)) in The Hague.

Tilja Ilona Jessica van den Berg werd geboren op 24 juli 1980 in t'Zandt, Nederland. In 1998 behaalde ze haar atheneumdiploma aan het Ommelander College te Appingedam. Vervolgens startte zij met de studie Gezondheidswetenschappen aan de Universiteit Maastricht. In 2003 behaalde zij haar doctoraal Gezondheidswetenschappen, met als afstudeerrichting 'Bewegingswetenschappen' en 'Arbeid- en organisatiekunde'. Na haar afstuderen werkte zij als onderzoeker aan de vakgroep Beleid, Economie en Organisatie van de Zorg van de Universiteit Maastricht en daarna als adviseur kwaliteit, arbo en milieu bij adviesbureau BMD te Barendrecht. Vanaf april 2006 was zij als onderzoeker verbonden aan de afdeling Maatschappelijke Gezondheidszorg van het Erasmus MC in Rotterdam en voerde het promotie-onderzoek uit dat resulteerde in dit proefschrift. Op dit moment is zij werkzaam als adviseur Onderzoek en Analyse bij de Raad voor Werk en Inkomen (RWI) in Den Haag.

List of publications

2010

Van den Berg TI, Elders LAM, Burdorf A. The influence of health and work on early retirement. Accepted *J Occup Environ Med* 2010;52:576-83.

Van den Berg TI, Schuring M, Avendano M, Mackenbach J, Burdorf A. The impact of ill health on exit from paid employment in Europe. Accepted *Occup Environ Med*.

Robroek SJW, van den Berg TIJ, Plat JF, Burdorf A. The role of obesity and lifestyle behaviors in a productive workforce. Accepted *Occup Environ Med*.

2009

Van den Berg TI, Elders LA, de Zwart BC, Burdorf A. The effects of work-related and individual factors on the Work Ability Index: a systematic review. *Occup Environ Med*. 2009;66:211-20.

Alavinia SM, van den Berg TI, van Duivenbooden C, Elders LA, Burdorf A. Impact of work-related factors, lifestyle, and work ability on sickness absence among Dutch Construction workers. *Scand J Work Environ Health*. 2009;35:325-33.

Bredt FJ, van den Berg TI, Elders LAM, Burdorf A. Determinanten van werkvermogen bij hoger opgeleide professionals. *Tijdschrift voor Bedrijfs- en Verzekeringsgeneeskunde* 2009;17:104-110.

Van den Berg TI, Elders LA, Burdorf A. Het effect van een schouderbeschermer op schouderklachten en productiviteit van steigerbouwers. *Tijdschrift voor Ergonomie* 2009;34:4-10.

Van den Berg TIJ, Schuring M, Avendano M, Mackenbach JP, Burdorf A. De invloed van gezondheid op vervroegde uittreding uit het arbeidsproces in elf Europese landen. *Tijdschrift voor Bedrijfs- en Verzekeringsgeneeskunde* 2009;17: 279-285.

2008

Burdorf A, van den Berg T, Avendano M, Kunst A, Mackenbach J. *The effects of ill health on displacement from the labour market and potential impact of prevention*. 2008 In: A. Börsch-Supan et al. Health, Ageing and Retirement in Europe (2004-2007) – Starting the longitudinal dimension, 135-140. Mannheim: MEA.

Van den Berg TI, Alavinia SM, Bredt FJ, Lindeboom D, Elders LA, Burdorf A. The influence of psychosocial factors at work and life style on health and work ability among professional workers. *Int Arch Occup Environ Health* 2008;81:1029-36.

Van den Berg TI, Vrijhoef HJ, Tummers G, Landeweerd JA, van Merode GG. The work setting of diabetes nursing specialists in the Netherlands: a questionnaire survey. *Int J Nurs Stud* 2008;45: 1422-32.

2006

Van den Berg TI, Landeweerd JA, Tummers GE, van Merode GG. A comparactive study of organisational characteristics, work characteristics and nurses' psychological work reactions in a hospital and nursing home setting. *Int J Nurs Stud* 2006;43:491-505.

Submitted

Van den Berg TIJ, Robroek SJW, Plat JF, Koopmanschap MA, Burdorf A. The importance of job control for workers with decreased work ability to remain productive at work. (submitted to *Int Arch Occup Environ Health*)

PhD portfolio Summary

Summary of PhD training and teaching activities

Name PhD student: Tilja van den Berg

PhD period: April 2006-April 2010

Erasmus MC Department: Public Health

Promotor: Prof.dr.ir. A. Burdorf

	Year	Workload (hours/ECTS)
1. PhD training		
Research skills		
Erasmus Summer programme, Erasmus MC, Rotterdam	2008	
Topics in Meta-analysis		20 hours / 0.7 ETCS
Erasmus Winter programme, Erasmus MC, Rotterdam	2009	
Biostatistics for Clinicians		20 hours / 1.0 ECTS
Regression Analysis for Clinicians		40 hours / 1.9 ECTS
Survival Analysis for Clinicians		40 hours / 1.9 ECTS
Erasmus Summer programme, Erasmus MC, Rotterdam		
Demography of Ageing	2009	20 hours / 0.7 ECTS
Topics in Health and Diseases in the Elderly	2009	20 hours / 0.7 ECTS
General academic skills		
Scientific English Writing for PhD students, Erasmus MC, Rotterdam	2009	112 hours / 4.0 ECTS
Scientific Presentations		
3th International Symposium on Work Ability, Hanoi, Vietnam - *Oral: The effects of work-related and individual factors on work ability: A systematic review* - *Oral: Individual and work related determinants of work ability in white-collar workers*	2007	60 hours / 2.1 ECTS
Bedrijfsgeneeskundige dagen, NVAB, Zeist *- Poster: Langer gezond werken en de rol van werkvermogen*	2007	16 hours / 0.6 ECTS
Research meeting, Department of Public Health, Rotterdam *Health, work ability and labour force participation*	2008	16 hours / 0.6 ECTS

Dutch Congress for Public Health, NCVGZ, Groningen - *Oral: De invloed van psychosociale factoren op het werk en leefstijl op de gezondheid en het werkvermogen in verschillende leeftijdsgroepen* - *Poster: Welke factoren bepalen werkvermogen? Een systematisch overzicht.*	2008	32 hours / 1.1 ECTS
1st Case-study workshop on demographic changes, ageing workers and working life patterns, Finse, Norway - *Oral: Consequences on reduced work ability for productivity loss* - *Oral: The influence of health and work on early retirement in older workers; a quantitative and qualitative analysis*	2009	60 hours / 2.1 ECTS
Annual epidemiology conference WEON - Poster: *De effecten van slechte gezondheid op uitval uit de arbeidsmarkt in 11 Europese landen: de SHARE studie*	2009	32 hours / 1.1 ECTS
Bedrijfsgeneeskunde dagen, NVAB, Zeist - *Poster: Het effect van een schouderbeschermer op schouderklachten en productiviteit van steigerbouwers*	2009	16 hours / 0.6 ECTS
Scientific meeting Work ability index, Erasmus MC, Rotterdam - *Oral: Where to focus on when intervening on continuing work of older workers*	2010	16 hours / 0.6 ECTS
Presentations practical implication		
Beroepsvereniging Arbeid- en organisatiedeskundigen, regio Zuid - *Onderzoek met de Work ability index, achtergrond en resultaten*	2008	10 hours / 0.4 ECTS
Bedrijfsgeneeskundige dagen, NVAB, Zeist - *Workshop: De Work Ability Index: impact van kennis voor de praktijk*	2009	16 hours / 0.6 ECTS
Symposium Nederlandse Vereniging voor Arbeidshygiëne (NVvA) - *Workshop: Duurzame inzetbaarheid en werkvermogen*	2009	16 hours / 0.6 ECTS
Symposium Vitaal naar de toekomst, Viazorg, Goes - *Oral: De gevolgen van een verminderd werkvermogen voor duurzame inzetbaarheid*	2009	16 hours / 0.6 ECTS

Information meetings on Work Ability Index - Bedrijfsartsen in de zorg (BAZ), Utrecht - Marketconcern, Utrecht - Blik op Werk (4x) - FNV Bondgenoten - Essent, Business Unit Projects & Production - Kenniscentrum GOC, Veenendaal	2008-2010	80 hours / 2.9 ECTS
Co-moderator Scientific knowledge and Work Ability, Blik op Werk	2008-2010	80 hours / 2.9 ECTS
International conferences		
3rd International Symposium on Work Ability, Hanoi, Vietnam	2007	24 hours / 0.9 ECTS
1st Case-study workshop on demographic changes, ageing workers and working life patterns, Finse, Norway	2009	24 hours / 0.9 ECTS
Seminars and workshops		
Attending seminars of the Department of Public Health	2006-2010	100 hours / 3.6 ECTS
Attending seminar *De rol van de bedrijfsarts voor oudere werknemers*, UMC Radboud, Nijmegen	2006	8 hours / 0.3 ECTS
Attending conference *De kracht van werkvermogen*, Maarssen	2010	8 hours / 0.3 ECTS
2. Teaching activities		
Supervising Study group Work and Health Curriculum medical students, 4th year, Erasmus MC Rotterdam Thema 4.2: *De populatie als patiënt* Supervising Bachelor thesis	2009	40 hours / 1.4 ECTS 20 hours / 0.7 ECTS
Total		962 hours / 35.8 ECTS