Original article

Scand J Work Environ Health 2007;33(5):351-357

doi:10.5271/sjweh.1151

Influence of work-related factors and individual characteristics on work ability among Dutch construction workers

by Alavinia SM, van Duivenbooden C, Burdorf A

Affiliation: Department of Public Health, Erasmus MC, University Medical Center Rotterdam, PO Box 2040, NL-3000 CA Rotterdam, Netherlands.

Refers to the following texts of the Journal: 2002;28(2):85-93 2002;28(3):184-190 2006;32(1):75-84 1995;21(1):15-23 1997;23 suppl 1:66-71 1997;23 suppl 1:58-65 1997;23 suppl 1:49-57 1997;23 suppl 1:20-26

The following articles refer to this text: 2009;35(1):37-47; 2009;35(1):56-64; 2009;35(1):1-5; 2009;35(5):325-333; 2009;35(5):321-324; 2013;39(5):456-467

Key terms: construction worker; health; individual characteristic; lifestyle; Netherlands; work ability; work ability index; work-related factor

This article in PubMed: www.ncbi.nlm.nih.gov/pubmed/17973061

Print ISSN: 0355-3140 Electronic ISSN: 1795-990X Copyright (c) Scandinavian Journal of Work, Environment & Health

Original article

Scand J Work Environ Health 2007;33(5):351–357

Influence of work-related factors and individual characteristics on work ability among Dutch construction workers

by Seyed Mohammad Alavinia, MD,[1] Cor van Duivenbooden, MD,[2] Alex Burdorf, PhD[1]

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 Environment & Health* 2007;33(5):351–357.

Objectives The objective of this study was to evaluate the association of individual characteristics, health problems, lifestyle factors, and work-related factors with work ability among Dutch construction workers.
Methods In this cross-sectional survey, the study population consisted of 19 507 Dutch construction workers who had participated in a voluntary periodic medical examination in 2005 and for whom complete information on laboratory tests and spirometry was available. The main outcome of the study was work ability, measured by the work ability index. Independent variables consisted of physical and psychosocial work-related factors, individual characteristics, lifestyle factors, and some objective health indicators. Multiple linear and logistic regression models were used to determine the influence of different factors on work ability.
Results Physical workload and, to a less extent, psychosocial factors at work together explained 22% of the variability in work ability. Age, leisure-time physical activity, lung obstruction, and cardiovascular risk profile explained about 10% of the workers' ability to work, but, when adjusted for work-related risk factors, their effects became very small. Awkward back posture, static work postures, repetitive movements, and lack of support at work had the highest influence on work ability.
Conclusions In the construction industry, work-related risk factors were the most important in association with work ability. This finding suggests that interventions aimed at preventing construction workers from dropping out of the workforce should primarily focus on reducing physical and psychosocial load at work.

Key terms health; lifestyle; work ability index.

In order to prevent workers from quitting the workforce due to (work-related) disability, the concept of work ability has been developed as a valuable tool to tailor interventions at the individual level. The concept of work ability expresses the interrelation between the productive potential of a worker, the worker's individual characteristics, and work-related factors (1, 2). Thus the assessment of work ability should measure the ability of workers to perform their jobs, taking into account specific psychosocial and physical work-related factors, mental and physical capabilities, and health. On the basis of this concept, Finnish researchers have constructed the so-called work ability index, which is based on a questionnaire that combines subjective experiences of one's ability to cope with physical and mental requirements at work with information on disease and sick leave (3).

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 workplace (4). Because of the varying capacity of workers and the varying demands of worktasks, the same disease, injury, or limitation in functional capacity may have a different effect on work ability (5). It has been widely accepted that, in addition to work-related risk factors, lifestyle characteristics such as leisure-time physical activity can also affect work ability (6, 7). There is also a clear association between various diseases and poor work ability (8). Nevertheless, there are few studies that have estimated the relative contribution of different factors to the level of work ability, taking into account the broad array of relevant factors.

The aim of our study was to evaluate the associations between individual characteristics, health problems, lifestyle factors, and physical and psychosocial work-related factors on work ability among Dutch construction workers.

1 Department of Public Health, Erasmus MC, University Medical Center Rotterdam, Rotterdam, Netherlands.
2 Arbouw Foundation, Amsterdam, Netherlands.

Correspondence to: Dr A Burdorf, Department of Public Health, Erasmus MC, University Medical Center Rotterdam, PO Box 2040, NL-3000 CA Rotterdam, Netherlands. [Email: a.burdorf@erasmusmc.nl]

Study population and methods

Study population

The study population consisted of workers in the construction industry in the Netherlands who had participated in a voluntary periodic medical examination in 2005. Such a voluntary examination is offered to every construction worker every 4 years. It is estimated by the Arbouw Foundation, responsible for the organization and contracting, that the annual participation is about 60% of all construction workers invited to attend this examination. In the Netherlands, the periodic examination is offered by over 20 different occupational health services with local branches, and it consists of a questionnaire and physical examination. Information from questionnaires was available for 36 741 workers, but after the exclusion of incomplete data on laboratory and spirometry tests 19 507 (53.1%) workers were available for the analysis. Given the very small number of female workers, the analysis was limited to male construction workers.

Work ability

Work ability was measured by the work ability index. It consists of an assessment of the physical and mental demands of people in relation to their work, diagnosed diseases, limitations in work due to disease, sick leave, work ability prognosis, and psychological resources. The work ability index is constituted of seven dimensions, and the 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 (9).

Work-related factors

The work-related factors in this study consisted of items on psychosocial and physical work-related factors. Psychosocial work characteristics were assessed by means of an abbreviated Dutch version of Karasek's job content questionnaire (10), which included two yes–no questions on job demands and on job control. According to this model, the combination of high job demands and low job control is considered to be a job strain situation. In addition, dichotomized questions on supervisor and co-worker support and satisfaction with work were asked. The assessment of physical workload concerned dichotomous questions on regular exposure to the manual handling of material such as lifting and carrying heavy loads, awkward work postures with a bent or twisted back, static work postures, repetitive movements, and exposure to whole-body vibration. Those with positive answers were regarded as exposed. This crude assessment of aspects of physical load did not enable the presentation of information on duration or frequency of exposure (11).

Individual characteristics and lifestyle factors

Data on age, job type, height, and weight were collected by the questionnaire 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 persons as normal (BMI <25 kg/m^2), overweight (BMI 25–30 kg/m^2), or obese (BMI >30 kg/m^2). The lifestyle factors of interest concerned smoking, alcohol drinking, and normal and vigorous activity during leisure time. The participants were divided into current smokers and nonsmokers. An open question on the average number of alcoholic drinks per week was used to define problematic alcohol drinkers as those who consumed 15 units of alcohol or more per week (12). The participants were asked about their leisure-time physical activity in 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 frequency of strenuous physical activity leading to sweating. Those who reported physical activity for 30 minutes per day on at least 5 days a week were considered to be in agreement with the recommendation on moderate-intensity physical activity, and the participants with vigorous exercises at least 3 times a week were considered to be in agreement with the recommendation on vigorous-intensity physical activity (13).

Health

Total blood cholesterol and high-density lipoprotein (HDL) cholesterol were measured in venous blood samples. Spirometry was conducted to measure forced expiratory volume in 1 second (FEV1) and forced vital capacity (FVC). The FEV1 and FVC were expressed as percentages of the predicted values, based on reference equations, taking into account the age and height of each participant, recommended by the European Society of Respiratory Disease (14). On the basis of the spirometry findings, workers were divided into normal, obstructive, and restrictive lung diseases, categorized as mild, moderate, or severe, according to criteria of the American Thoracic Society (15).

The age, total blood cholesterol, high-density lipoprotein (HDL) cholesterol, smoking habits, and systolic blood pressure of each participant were used to calculate the Framingham Risk Score (FRS) for the 10-year risk of coronary heart disease events (coronary heart disease death and myocardial infarction) (16). The 10-year risk prediction was categorized into no risk (0–9%), low risk (10–15%), moderate risk (16–20%), and high risk (≥21%) of coronary heart death and myocardial infarction (17).

Statistical analysis

For the main variables, we generated descriptive statistics such as means and percentages. When the observed work ability indices were plotted against age, the resulting lines were irregular, in part because of a difference in the sample size per year of age (relatively few workers in the youngest and oldest groups). Due to these irregularities, a smoothing procedure was applied to the observed data to generate a smooth curve for the mean work ability index with a 3-year interval. For each year of age, the mean and the 5th and 95th percentiles were calculated.

Multiple linear regression models were used to explore the influence of different factors on the work ability index. In the first linear regression model, the influence of individual characteristics, lifestyle factors, and health parameters on the work ability index was evaluated. In the second linear regression model, associations between work-related factors and the work ability index were analyzed. Finally, in the third linear regression model, all of the factors from the first and second model were evaluated together for their association with the work ability index. In each model a backward selection approach was used with a P-value threshold of 0.10 for the initial selection of relevant variables, and only variables statistically significant at $P<0.05$ were retained in the model. In each model, age was included, regardless of its statistical significance. Since the distribution of the work ability index was slightly skewed towards the lower values, a separate analysis was performed without the participants with a work ability score below 28 (classified as poor) in order to evaluate whether these workers biased the results over the observed range of work ability scores. In the current analysis, the choice was made not to investigate the influence of depressive symptoms, musculoskeletal diseases, and job satisfaction, as these factors are partially included in the work ability index itself.

We also dichotomized the participants into those with a poor or moderate work ability versus those with an excellent or good work ability in order to explore the associations between different parameters and the occurrence of poor and moderate work ability in a multiple logistic regression analysis. All of the analyses were carried out with the statistical SAS package, version 8.2 (18).

Results

Table 1 shows the characteristics of the study population in the construction industry. The mean age of the workers was 44.1 years, ranging from 16 to 62 years. However, most of the workers were between the ages of 25 and 55 years, and those above 55 years were scarce. Most of the workers had a blue-collar job (77.6%). The mean BMI was 26.5, 49.2% of the participants was overweight, and 15.0% was categorized as obese. The mean work ability index was 40.9 (SD 5.1). The distribution of excellent, good, moderate, and poor work ability was 34.4%, 49.5%, 14.2%, and 1.9%, respectively. Figure 1 depicts the work

Table 1. Characteristics of the 19 507 Dutch construction workers who participated in a voluntary periodic medical examination in 2005. (BMI = body mass index, HDL = high-density lipoprotein, FEV1 = forced expiratory volume in 1 second, FVC = forced vital capacity)

Characteristic	N	Mean	SD	%
Age	19507	44.1	11.2	·
White-collar job (%)	4368			22.4
BMI (kg/m²)	19493	26.5	3.7	·
Blood pressure (mm Hg)				
Systolic	19396	133.2	16.5	·
Diastolic	19400	82.6	9.8	·
Cholesterol (mg/dl)				
Total	19456	212.5	40.8	·
HDL	19242	55.4	24.6	·
Spirometry				
FEV1% of predicted	19493	99.2	17.1	·
FVC % of predicted	19493	100.4	16.1	·
Lifestyle factors				
Smoker (%)	6185	·	·	31.7
Problematic alcohol drinker (%)	2965	·	·	15.2
Moderately intense activity (%)	12536	·	·	69.1
Vigorously intense activity (%)	3583	·	·	18.8
Work-related psychosocial load				
Low job control (%)	12570	·	·	64.4
High work demands (%)	11546	·	·	59.2
Job strain (%)	7486	·	·	38.4
Lack of support at work (%)	2452	·	·	12.8
Work-related physical load				
Manual materials handling (%)	8784	·	·	45.0
Awkward back postures (%)	4608	·	·	23.6
Static work postures (%)	7334	·	·	37.6
Repetitive movements (%)	4299	·	·	22.0
Whole-body vibration (%)	2709	·	·	14.0

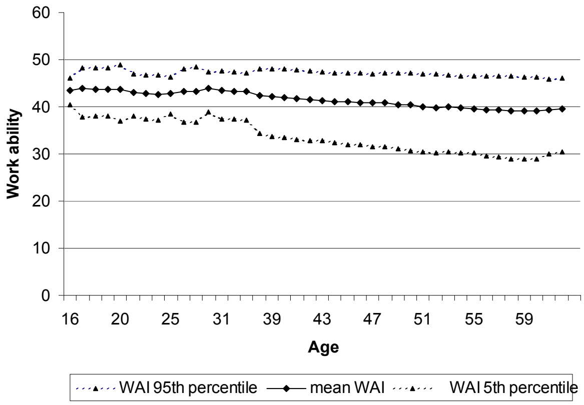

Figure 1. The work ability index (WAI) against age among 19 507 construction workers in the Netherlands in 2005.

ability against age, showing that the average work ability index was close to 43.5 for the workers at the age of 20 years and around 39.0 at the age of 60 years. Due to a larger proportion of workers with a moderate or poor work ability at a higher age, the lower 5th percentile of the work ability distribution per year of age decreased with older age.

Table 2 shows the influence of individual characteristics, lifestyle factors, and health parameters on the work ability index. Age and job type explained 9.4% of the variability in the work ability index. By adding body mass index, leisure-time physical activity, presence of pulmonary problems, and the 10-year risk for cardiovascular heart disease, the explained variability increased to 10.2%. Problematic alcohol consumption (beta = –0.008) was not statistically significant.

Table 3 shows the association between work-related factors and the work ability index. The presence of exposure to whole-body vibration was not statistically significant. The combined effect of physical load factors at work was responsible for about 13.8% of the variability, whereas psychosocial work-related factors explained about 4.3% of the variability in work ability among the workers. Awkward back postures, static work postures, and lack of support at work had the highest influence on the work ability index.

In the final multivariate model (table 4) age, obesity, lung obstruction, physical load, and psychosocial load were all associated with the work ability index. Problematic alcohol drinking, the cardiovascular heart disease profile, and whole-body vibration did not make a statistically significant contribution to the work ability index. Of all of the factors associated with the work ability index, the physical and psychosocial work-related factors were the most important. The large effect of a white-collar job in table 2 (1.83 points) decreased by 75% when adjusted for the work-related physical and psychosocial work factors. The analysis concerning the study population without the workers with a poor work ability showed very similar results.

Table 2. Results of the multivariate analysis [explained variance (R^2) = 0.10] of the associations of individual characteristics, lifestyle factors, and health measures with the work ability index among construction workers in the Netherlands in 2005.

	N	β	SE
Individual characteristic			
Age (years)	19507	–0.12	0.004 [a]
White-collar worker	4368	1.83	0.090 [a]
Lifestyle factor			
Normal weight	6987	Reference	.
Overweight	9596	–0.17	0.083
Obese	2924	–0.74	0.115 [a]
Moderately intense activity	12536	0.24	0.081 [a]
Vigorously intense activity	3583	0.35	0.095 [a]
Smoker	6185	–0.24	0.095 [a]
Health problem			
Normal lung function	17666	Reference	.
Mild lung obstruction	1274	–0.63	0.149 [a]
Moderate lung obstruction	340	–0.75	0.280 [a]
Severe lung obstruction	227	–0.86	0.334 [a]
Cardiovascular heart disease risk			
No risk	13504	Reference	.
Low risk	3299	–0.19	0.115 [b]
Moderate risk	1931	–0.11	0.147
High risk	773	–0.07	0.211

[a] P-value <0.05.
[b] P-value <0.10.

Table 3. Multivariate analysis [explained variance (R^2) = 0.22] of the associations of physical and psychosocial work-related factors with the work ability index, adjusted for age and job type, among construction workers in the Netherlands in 2005.

Work-related factors	β	SE
Work-related physical load		
Repetitive movements	–1.16	0.09 [a]
Static work postures	–1.42	0.08 [a]
Awkward back postures	–1.80	0.09 [a]
Manual materials handling	–0.42	0.08 [a]
Work-related psychosocial load		
Lack of support at work	–1.49	0.10 [a]
High work demands	–0.28	0.07 [a]
Low job control	–0.72	0.07 [a]

[a] P-value <0.05.

Table 4. Multivariate analysis [explained variability (R^2) = 0.23] of the associations of individual characteristics, lifestyle factors, health measures, and work-related factors with the work ability index among construction workers in the Netherlands in 2005.

	β	SE
Individual characteristics		
Age	–0.11	0.003 [a]
White-collar worker	0.45	0.096 [a]
Lifestyle factors		
Normal weight	Reference	.
Overweight	–0.17	0.077 [a]
Obese	–0.62	0.106 [a]
Moderately intense activity	0.23	0.076 [a]
Vigorously intense activity	0.59	0.089 [a]
Health problem		
Mild lung obstruction	–0.49	0.138 [a]
Moderate lung obstruction	–0.67	0.261 [a]
Severe lung obstruction	–0.75	0.311 [a]
Work-related factors		
Work-related physical load		
Repetitive movements	–1.16	0.097 [a]
Static work postures	–1.40	0.085 [a]
Awkward back postures	–1.84	0.097 [a]
Manual materials handling	–0.50	0.082 [a]
Work-related psychosocial load		
Lack of support at work	–1.46	0.104 [a]
High work demands	–0.29	0.073 [a]
Low job control	–0.70	0.073 [a]

[a] P-value <0.05.

Table 5 shows the factors associated with the occurrence of a poor or moderate work ability in the study population. The results of the logistic regression analysis were very similar to that of the linear regression model in that the same physical and psychosocial work-related factors were associated with a poor or moderate work ability.

Table 5. Multivariate analysis of the associations of individual characteristics, lifestyle factors, health measures, and work-related factors with the presence of poor or moderate work ability among construction workers in the Netherlands in 2005.

	OR	95% CI
Individual characteristics		
Age	1.05	1.04–1.06
White-collar worker	0.85	0.75–0.97
Lifestyle factors		
Normal weight	1	..
Overweight	1.08	0.98–1.06
Obese	1.37	1.22–1.55
Moderately intense activity	0.97	0.89–1.06
Vigorously intense activity	0.79	0.72–0.89
Health problem		
Normal lung function	1	..
Mild lung obstruction	1.24	1.06–1.46
Moderate lung obstruction	1.41	1.07–1.86
Severe lung obstruction	1.27	0.89–1.80
Work-related factors		
Work-related physical load		
Repetitive movements	1.56	1.41–1.72
Static work postures	1.91	1.73–2.10
Awkward back postures	2.05	1.86–2.27
Manual materials handling	1.21	1.01–1.34
Work-related psychosocial load		
Lack of support at work	1.73	1.55–1.92
High work demands	1.11	1.01–1.21
Low job control	1.35	1.24–1.46

Discussion

This study showed that the work ability index of Dutch construction workers was predominantly influenced by physical and psychosocial work-related factors. Individual and lifestyle characteristics and several physical health measures explained some of the variability of the workers' work ability, but their contribution was low.

Some limitations of this study must be taken into account. First of all, its cross-sectional design did not permit further exploration of causal relationships between these factors and work ability. Second, complete data on laboratory tests and pulmonary function tests were available only for 53% of the workers. One of the reasons for this low proportion of complete data was the lack of resources for conducting the required tests in small occupational health services. Since an analysis of the influence of work-related factors on the work ability index of all of the construction workers who filled out a questionnaire (N=36 741) showed results similar to those of the analysis presented in the current article on workers who filled out the questionnaire and also completed the physical examination (N=19 507), we think that the potential bias due to selective participation was limited. Third, the data were drawn from the voluntary medical examination of workers, and information on nonrespondents was not available. It was estimated that about 60% of the invited workers took part in the examination. Therefore, we do not know whether more unhealthy workers took part in the physical examination or not. Selective participation may have influenced the results of our study, but the potential effect of this source of differential bias is unknown. Finally, since many of the occupational health services were involved in the laboratory tests and spirometry and no interlaboratory quality assessments were conducted, it is expected that the interlaboratory differences would have contributed to a substantial measurement error.

Measuring work ability is a complex task. Good health and a good functional capacity form the basis for the work ability index, and they are highly dependent on professional skills, personal motivation, and organizational and ergonomic factors in the workplace (19). Strong intercorrelations have been found for work ability, health, lifestyle, and satisfaction with life (7). However, some of these reported associations must be interpreted with great care since the work ability index includes a number of diagnosed diseases and a question on job satisfaction. The health-related dimensions in the work ability index (ie, diagnosed diseases, functional limitations, and sickness absence) have a large influence on the work ability score. In this study population, many of the workers lost points because of the presence of diseases and subsequent consequences in terms of functional limitations or sickness absence. This finding implies that health is indeed a major factor in work ability. It has been shown that the work ability index is highly predictive of sickness absence and work disability, both among younger and older workers (20, 21). Therefore, recognition of the factors that affect work ability would help to prioritize preventive measures for high-risk workers. The result of our current study showed a large influence of work-related factors on workers' work ability. These findings may partly reflect the specific study population, but previous studies have also reported that poor work postures and repetitive movements were associated with an impaired ability to work (2, 22–24). Physical demands of work consistently explained both the variation and change in work ability (23). There are some indications that preventing the development of poor work ability depends on organizational and psychosocial factors (25), but our study could not corroborate these findings due to a lack of information on these potentially important factors.

Age has been acknowledged as an important factor with respect to impaired ability (2, 22). Among the construction workers in our study, the mean work ability index dropped by approximately 10% over a 40-year age span. Figure 1 demonstrates that, at a specific age, the variability in work ability is larger than the variability across age. This finding was also reflected in the modest contribution of age to the total explained variance in work ability, as presented in table 4. This result suggests that occupational health programs aimed at maintaining and promoting the employability of workers with generic measures for workers at a particular age will be less successful than individually tailored programs based on work ability.

Although in this study lifestyle factors had a limited influence on work ability, a study among aging industrial workers indicated that unhealthy lifestyles themselves are an important factor with respect to decreased work ability (26). Regular physical exercise at a moderate level has a positive effect on perceived work ability (27) and lowers the risk of several diseases including cardiovascular disease, type 2 diabetes, and musculoskeletal disease (28). Lack of physical exercise is also a risk factor for obesity and hypertension (28–30). Vigorous physical exercise during leisure time has been recommended with advancing age in order to prevent the decline in physical capacities, and for adopting other healthy lifestyles (31). On the other hand, because of the multifactorial nature of work ability, changes in the work ability index will not easily be obtained in due course by an exercise program, especially among workers with a high work ability index (32). Although the evidence for a causal effect of regular physical activity on improvement in work ability is still limited, there is sufficient evidence in general to advise a physically active lifestyle for workers.

When the health indicators for respiratory problems and cardiovascular risks were entered into the regression model, the explained variance increased only by 0.2%. When adjustment was made for work-related factors, the 10-year risk percentage profile for coronary heart disease was no longer statistically significantly associated with the work ability index. Pulmonary problems showed a negative association with work ability, and these associations were not influenced by work-related factors. Since the work ability index is self-reported, and the Framingham Risk Score has no obvious effect on worker's health, it may be expected that no association would be observed. However, the limited influence of respiratory problems and cardiovascular risks on work ability may also stem from the presence of a healthy worker effect because the study population did not include workers receiving long-term disability benefits or those who changed jobs because of health problems. This selection may have resulted in lower prevalences of these health indicators and, as a consequence, in a loss of power to detect meaningful associations.

It can be concluded that, in highly physically demanding jobs, such as those in the construction industry, psychosocial and physical work-related factors are the most important factors associated with work ability. This finding, although based on a cross-sectional analysis, suggests that, in workplaces with high physical loads, ergonomic interventions are of great importance for maintaining the work ability of workers.

Acknowledgments

Dr Seyed Mohammad Alavinia, a PhD student at the Netherlands Institute for Health Sciences (nihes) at Erasmus MC Rotterdam, was supported by a scholarship from the North Khorasan University of Medical Sciences, Bojnord, Iran.

References

1. Wegman D H. Older workers. Occup Med. 1999;14(3):537–57.
2. 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(3):209–17.
3. Ilmarinen J, Tuomi K, Eskelinen L, Nygård CH, Huuhtanen P, Klockars M. Background and objectives of the Finnish research project on aging workers in municipal occupations. Scand J Work Environ Health. 1991;17 Suppl 1:7–11.
4. Tuomi K, Huuhtanen P, Nykyri E, Ilmarinen J. Promotion of work ability, the quality of work and retirement. Occup Med (Lond). 2001;51(5):318–24.
5. Ilmarinen J, Tuomi K, Eskelinen L, Nygård CH, Huuhtanen P, Klockars M. Summary and recommendations of a project involving cross-sectional and follow-up studies on the aging worker in Finnish municipal occupations (1981–1985). Scand J Work Environ Health. 1991;17 Suppl 1:135–41.
6. Kaleta D, Makowiec-Dabrowska T, Jegier A. Leisure-time physical activity, cardiorespiratory fitness and work ability: a study in randomly selected residents of Lodz. Int J Occup Med Environ Health. 2004;17(4):457–64.
7. Seitsamo J, Ilmarinen J. Life-style, aging and work ability among active Finnish workers in 1981–1992. Scand J Work Environ Health. 1997;23 Suppl 1:20–6.
8. Tuomi K, Ilmarinen J, Eskelinen L, Järvinen E, Toikkanen J, Klockars M. Prevalence and incidence rates of diseases and work ability in different work categories of municipal occupations. Scand J Work Environ Health. 1991;17 Suppl 1:67–74.
9. Tuomi K, Ilmarinen J, Jahkola A, Katajarinne L, Tulkki A. Work ability index. 2nd ed. Helsinki: Finnish Institute of Occupational Health; 1998.
10. 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(4):322–55.

11. Burdorf A. Reducing random measurement errors in assessing postural load on the back in epidemiological surveys. Scand J Work Environ Health. 1995;21(1):15–23.
12. Health Council of the Netherlands. Guidelines for a healthy diet 2006. The Hague: Health Council of the Netherlands; 2006. Publication no 2006/21.
13. 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. JAMA. 1995;273(5):402–7.
14. 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(3):492–506.
15. 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(5):948–68.
16. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. 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(19):2486–97.
17. Greenland P, LaBree L, Azen S P, Doherty T M, Detrano R C. Coronary artery calcium score combined with Framingham score for risk prediction in asymptomatic individuals. JAMA. 2004;291(2):210–5.
18. SAS. SAS software version 8.2 1991–2001. Cary (NC): SAS institute; 2001.
19. Ilmarinen J, Tuomi K, Klockars M. Changes in the work ability of active employees over an 11-year period. Scand J Work Environ Health. 1997;23 Suppl 1:49–57.
20. 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(1):75–84.
21. 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 Ergon. 2000;25:477–81.
22. Tuomi K, Luostarinen T, Ilmarinen J, Klockars M. Work load and individual factors affecting work disability among aging municipal employees. Scand J Work Environ Health. 1991;17 Suppl 1:94–8.
23. 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.
24. 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(3):184–90.
25. Lindberg P, Josephson M, Alfredson L, Vingård E. Promoting excellent work ability and preventing poor work ability: the same determinants?: results from the Swedish HAKUL study. Occup Environ Med. 2006;63(2):113–20.
26. Tuomi K, Ilmarinen J, Seitsamo J, Huuhtanen P, Martikainen R, Nygård 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.
27. Nurminen E, Malmivaara A, Ilmarinen J, Ylöstalo 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(2):85–93.
28. Eyler AA, Brownson RC, Bacak SJ, Housemann RA. The epidemiology of walking for physical activity in the United States. Med Sci Sports Exerc. 2003;35(9):1529–36.
29. Lee IM, Paffenbarger Jr RS. Associations of light, moderate, and vigorous intensity physical activity with longevity: The Harvard Alumni Health Study. Am J Epidemiol. 2000;151(3):293–9.
30. Blair SN, Connelly JC. How much physical activity should we do?: the case for moderate amounts and intensities of physical activity. Res Q Exerc Sport. 1996;67(2):193–205. XX
31. Ilmarinen J, Rantanen J. Promotion of work ability during ageing. Am J Ind Med. 1999;suppl 1:21–3.
32. 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(9):906–10.

Received for publication: 19 February 2007