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To what extent do education and physical work load factors explain occupational differences in disability retirement due to knee OA? A nationwide register-based study in Finland

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ABSTRACT

Objectives To examine the association of education and physical work load factors on the occupational differences in disability retirement due to knee osteoarthritis (OA).

Design Longitudinal study.

Setting Linkage of several nationwide registers and a job exposure matrix in Finland.

Participants A total of 1 135 654 Finns aged 30–60 years in gainful employment were followed from 2005 to 2013 for full disability retirement due to knee OA.

Primary and secondary outcome measures We calculated age-adjusted incidence rates and examined the association of occupation, education and physical work load factors with disability retirement using competing risk regression model. Disability retirement due to other causes than knee OA, old-age retirement and death were treated as competing risk.

Results A total of 6117 persons had disability retirement due to knee OA. Women had a higher age-adjusted incidence rate than men (72 vs 60 per 100 000 person-years, respectively). In men, a very high risk of disability retirement was found among construction workers, electricians and plumbers (HR 16.6, 95% CI 12.5 to 22.2), service workers (HR 12.7, 95% CI 9.2 to 17.4) and in women among building caretakers, cleaners, assistant nurses and kitchen workers (HR 15.5, 95% CI 11.7 to 20.6), as compared with professionals. The observed occupational differences were largely explained by educational level and noticeably mediated by physical work load factors in both genders.

Conclusion Our observational study suggests that the risk of disability retirement among manual workers is strongly attributed to the physically heavy work.

Strengths and limitations of this study

- This is one of the few population-based studies and among the largest on occupational differences in disability retirement due to knee osteoarthritis that includes both men and women and information on physical work load factors assessed by a job exposure matrix.
- We used longitudinal population-based register data with very good statistical power and without missing information or loss to follow-up.
- We applied a competing risk model to estimate the occupation-specific risk of disability retirement due to knee OA.
- We estimated the mediating effect of physical load factors on the association between the occupation and disability retirement due to knee OA.
- Using register-based data, the residual confounding due to lifestyle factors that affect decisions regarding disability retirement cannot be ruled out.

INTRODUCTION

Population ageing confronts most of the high-income countries with a rapid decline in the proportion of people participating in labour force. The proportion of people aged >60 years is predicted by 2050 to represent 37% of the population in Europe and 22% of the population worldwide.[1] Prolongation of work careers and increasing participation in work are set as national goals in the Nordic countries as well as many other Western countries.

Osteoarthritis (OA) is the most common chronic joint disorder, rapidly increasing with ageing population.[2 3] The knee joint is most often affected by OA, especially among women.[2] The Global Burden of Disease Study 2015 ranked OA as the 13th (overall) and 8th (among those above 50 years of age) highest contributor to global disability.[4] Although OA is traditionally considered as an age-related disorder, the earlier stage of the disease starts at an age when people are still working.[5]

Epidemiological studies provide consistent evidence linking occupational physical

activities with OA of the knee.[5–7] On the other hand, knee OA was found to be associated with reduced work participation, loss of work productivity, work loss[5 8–10] and withdrawal from the labour force due to work disability retirement as well as premature age-based retirement.[11]

Occupations may differ regarding possibilities for people with OA to perform job tasks. Earlier studies have reported a considerable occupational variation in all-cause disability retirement.[12–14] Differences in work-related exposure levels between occupations are well recognised[15]; however, a review by Allebeck and Mastekaasa[16] found only limited scientific evidence for the impact of physically demanding work on disability retirement. Education, as one of the indicators of socioeconomic status, has consistently been associated with disability retirement.[17–19] People with low education are more likely working in manual occupations with physically demanding tasks.[20] Previous studies[14 16 21] suggest that working conditions and health behaviours contribute to the socioeconomic differences in disability retirement, but the magnitudes of the effects have generally been moderate. Knowledge on occupational inequalities in cause-specific disability retirement is limited. A recent study observed a particularly high risk of disability retirement due to knee OA among women working in cleaning and men in metal work.[22]

The aim of this study was to identify occupations with a high risk of disability retirement due to knee OA in the Finnish population and to examine the impact of work-related factors on occupational differences in disability retirement. We expected that the effects of occupation on disability retirement are mediated through physical working conditions. Educational level, however, often predetermines the selection of occupation, and may therefore operate as a confounder for occupational differences in disability retirement.

MATERIALS AND METHODS

Setting and data sources

This was a population-based study, using register data from a 70% random sample of the Finnish population aged 18–70 years living in Finland on 31 December 2004 (~2.5 million). Persons aged 30–60 years (as of December 2004), who were in gainful employment on 1 January 2005, were eligible to the study. We excluded persons who did not have an occupational title or those who started to receive any retirement-related benefit (full disability retirement, partial or full old-age retirement, unemployment retirement) before 1 January 2005. Our cohort consisted of 1 135 654 persons (574 617 men and 561 037 women).

National register of the Finnish Centre for Pensions

Information on employee pensions, earning periods and unemployment related unsalaried periods was obtained from the register held by the Finnish Centre for Pensions. The register covers everyone who is a Finnish citizen or permanent resident of Finland. In Finland, people with a chronic illness, disability or injury that has been verified by a physician with a medical certificate and evaluated as causing considerable and long-lasting (about 1 year) decreased work ability are entitled to disability pension.[23 24]

If there is a possibility to restore the employee's work ability through rehabilitation or treatment, a temporary pension for a fixed period can be granted by the pension provider. Temporary disability pension can often be continued after the initial period; however, a decision regarding permanent disability pension is made within 2 years.

Disability retirement due to knee OA

The register provides information on all disability retirement events with their primary and secondary diagnoses, which are classified according to The International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10, Finnish version of ICD-classification 1996). The outcome of this study was full-time disability retirement (either temporary or permanent) due to knee OA (M17) during the period from 1 January 2005 to 31 December 2013.

Occupation

Information on the persons' occupation held on the 31 December 2004 was obtained from the Finnish Longitudinal Employer-Employee Data (FLEED) of Statistics Finland. The FLEED provide information by region on, for example, the population's sociodemographic factors, living conditions, economic activity and employment. Around 40 nationwide administrative registers, annually updated, serve as the source of information. The database includes all permanent residents in the country on the last day of the year. The occupations were classified up to 4-digit level according to the Classification of Occupations 2001 by Statistics Finland, which is based on the International Standard Classification of Occupations (ISCO-88). For the analysis, the occupations were aggregated to the 2-digit level (see online supplementary table S1).

Physical work load factors

Heavy physical work (eg, involving lifting and carrying heavy loads, excavating, shovelling or hammering), kneeling or squatting at work (for at least 1 hour a day), manual handling of heavy loads (lifting, carrying or pushing items heavier than 20 kg at least 10 times every day), sitting at work (on average at least 5 hours per day) and standing or moving at work (on average at least 5 hours per day) were estimated with a gender-specific job exposure matrix (JEM) developed earlier in a large population survey.[25] The JEM includes exposure information for >401 occupations, coded according to the Classification of Occupations 2001 by Statistics Finland.

Education

Information on the persons' education achieved by 31 December 2004 was obtained from FLEED of Statistics

Finland. Education was categorised as 0) unknown, 1) primary, 2) secondary, 3) lower tertiary and 4) higher tertiary.

Statistical analysis

We calculated age-adjusted (age groups 30–39, 40–49, 50–59 and 60 or more years) incidence rates (per 100 000 person-years) of disability retirement due to knee OA by occupational group and estimated 95% CIs using a Poisson distribution. Calculation of the CI for the incidence rate of a disease is typically done by computing the CI from a sample of observations drawn at random from a Poisson distribution.[26] The persons were followed from 1 January 2005 until 31 December 2013 for the first occurrence of temporary or permanent full disability retirement due to knee OA.

Our primary aim was to examine, whether the effect of occupation on disability retirement due to knee OA is mediated by physical work load factors. As a secondary aim, we explored to which extent the association between occupation and disability retirement is affected by the level of education.

We assumed that education predetermines the selection of occupation, which in turn predetermines physical load factors at work, which may cause knee OA and result in disability retirement. We also assumed that education may be associated with disability retirement directly or indirectly via another pathway than that mentioned above (eg, lifestyle factors).

First, we explored the association between individual physical work load factors and disability retirement controlling for age. After this, we included all physical work load factors simultaneously into the age-adjusted model. Finally, we did further adjustment for education. The mediating effect of physical work load was tested after the association between occupation and disability retirement was controlled for education. For that, the contribution of education and physical work-related factors to the association between occupation and disability retirement was examined by consecutively including education (model 2) and physical work-related factors (model 3) into the age-adjusted model (model 1).

We used competing risk regression model (stcrreg, STATA V.14) to estimate HRs and their 95% CI and to test for the association between occupation, physical work load factors, education and full disability retirement. We accounted for the effect on the outcome of the following competing risks: full disability retirement due to other causes than knee OA, old-age retirement and death. In analyses of occupational differences, the reference group consisted of professionals.

To estimate the contribution of the explanatory factors to the observed statistically significant associations, we calculated the percentage of attenuation of HR for all occupations (with professionals as reference) after adjustment, using the formula[27]: $(HR_{Model\_i}\text{-}HR_{Model\_i+1})/(HR_{Model\_i}\text{-}1)\times 100\%$, i=1, 2.

We also examined separately the contribution of each physical work load factor to the excess risk of disability retirement. For that we compared the HRs adjusted for age, education and physical work load factor in question with HRs adjusted for age and education.

The analyses were made separately for men and women.

Patient and public involvement

No patients or public were involved in the study and there are no plans to disseminate the results of the research to these parties.

RESULTS

Description of sample

In total, 1 135 654 persons (49.4% women) met the inclusion criteria. At baseline, women were slightly older (45.3±8.4 vs 44.6±8.3 years), had more frequently attained tertiary education (30.5% vs 16.7%) and were more often employed in the public sector (46.2% vs 17.1%) than men. Men most likely worked in manual occupations and women in lower-level non-manual occupations (table 1).

A notable gender difference in education was observed within occupational groups. In particular, female environmental officers and nurses, office clerks, agricultural and fishery workers, professional drivers as well as construction workers, electricians and plumbers were more educated than males in the corresponding occupations. In contrast, male physical and engineering science technicians, customer services clerks, service workers and metal and machinery workers had attained higher education as compared with females in the corresponding occupations (table 1).

Incidence rate of full disability retirement due to knee OA

From 1 January 2005 until 31 December 2013, a total of 6117 persons (2836 men and 3281 women) had full disability retirement due to knee OA. Overall age-adjusted incidence rate of disability retirement was 60 and 72 per 100 000 person-years for men and women, respectively (table 2). Among men, construction workers, electricians and plumbers showed the highest incidence rates, while among women, building caretakers, cleaners, assistant nurses and kitchen workers had the highest incidence rate. Other occupations with higher incidence rate than the population average included agricultural and fishery workers (both genders), metal and machinery workers (men), wood and metal processing workers (both genders), unskilled transport, construction and manufacturing workers (women), as well as service workers (women).

Physical work-related factors and disability retirement

The distribution of physical work load factors by occupational group and by education are presented in online supplementary table S2 and S3, respectively. In the age-adjusted models, all physical load factors

Table 1 Baseline characteristics of those aged 30–60 years (A) men (n=574 617) and (B) women (n=561 037)

ISCO-88 code	Occupational group	Education (%)						Sector of employment (%)		
		%	Age	Primary	Secondary	Lower tertiary	Higher tertiary	Private	Public	Self-employed
(A) Men										
	Upper-level non-manual occupations									
11, 12, 13	Managers	5.8	46.3	6.7	17.2	26.4	49.7	79.7	19.0	1.4
21, 22, 24	Professionals	13.5	43.9	4.1	15.9	18.5	61.5	66.6	26.2	7.2
23	Teaching professionals	4.0	45.2	3.6	15.2	22.3	58.9	16.8	79.0	4.2
	Lower-level non-manual occupations									
31	Physical and engineering science technicians	8.3	44.4	8.3	26.4	42.3	23.0	76.4	15.3	8.3
32	Environmental officers and nurses	1.0	43.4	5.2	17.2	59.1	18.5	39.1	48.3	12.7
33, 34	Finance and sales associate professionals and administrative secretaries	8.7	44.6	16.1	33.2	36.3	14.4	59.2	15.4	25.5
41	Office clerks	3.2	44.7	29.3	41.8	21.6	7.3	76.0	21.4	2.6
42	Customer services clerks	0.3	41.7	13.3	36.2	40.6	9.9	83.9	7.3	8.8
51	Service workers	3.9	42.4	19.2	64.9	13.1	2.8	41.7	40.2	18.1
52	Shop workers	2.3	42.8	30.4	45.1	22.0	2.5	93.0	0.2	6.9
	Manual occupations									
61, 92	Agricultural and fishery workers	6.0	46.8	32.7	56.0	8.6	2.7	8.4	7.3	84.4
71	Construction workers, electricians and plumbers	8.3	44.7	31.19	64.0	3.8	1.0	69.7	6.3	24.1
72	Metal and machinery workers	10.8	45.0	17.1	77.2	4.4	1.3	79.9	6.7	13.4
73, 74	Craft workers	2.0	44.7	26.2	60.8	10.6	2.4	73.7	3.5	22.8
81	Chemical, wood and metal processing workers	3.3	44.6	30.8	62.7	5.3	1.2	94.1	3.6	2.3
82	Machine operators and assemblers	4.6	43.4	32.8	59.8	6.0	1.4	94.7	0.5	4.8
83	Professional drivers	8.0	45.1	43.4	51.8	4.1	0.7	69.9	7.6	22.6
91	Building caretakers, cleaners, assistant nurses and kitchen workers	2.9	45.2	35.0	57.4	5.8	1.8	57.4	38.9	3.7
93	Unskilled transport, construction and manufacturing workers	3.2	44.1	39.0	53.8	6.2	1.0	88.9	10.0	1.1
(B) Women										
	Upper-level non-manual occupations									
11, 12, 13	Managers	2.8	46.2	3.9	15.9	42.1	38.1	56.9	42.2	0.9
21, 22, 24	Professionals	10.2	44.2	3.1	12.6	31.1	53.2	41.4	51.7	6.9
23	Teaching professionals	8.3	44.0	1.6	8.1	36.2	54.1	10.3	87.1	2.6
	Lower-level non-manual occupations									
31	Physical and engineering science technicians	1.9	43.4	11.1	37.6	31.0	20.3	70.3	24.5	5.3
32	Environmental officers and nurses	7.6	44.0	1.5	7.9	77.0	13.6	22.3	73.5	4.2

Continued

Table 1 Continued

ISCO-88 code	Occupational group	Education (%)						Sector of employment (%)		
		%	Age	Primary	Secondary	Lower tertiary	Higher tertiary	Private	Public	Self-employed
33, 34	Finance and sales associate professionals and administrative secretaries	12.6	45.1	13.3	30.1	48.5	8.1	54.5	33.7	11.8
41	Office clerks	10.6	46.0	19.4	31.9	45.7	3.0	56.8	42.0	1.2
42	Customer services clerks	3.2	46.7	19.9	38.6	39.9	1.6	82.3	16.6	1.2
51	Service workers	18.7	45.5	14.6	74.4	9.3	1.7	25.5	62.4	12.2
52	Shop workers	5.0	43.8	32.4	46.7	19.7	1.2	98.5	0.4	1.1
	Manual occupations									
61, 92	Agricultural and fishery workers	3.2	46.2	23.5	57.4	16.2	2.9	8.2	10.9	80.9
71	Construction workers, electricians and plumbers	0.4	45.9	33.4	51.2	13.8	1.6	62.3	2.4	35.3
72	Metal and machinery workers	1.1	45.5	31.8	54.2	11.6	2.4	79.6	5.8	14.6
73, 74	Craft workers	1.2	46.0	24.7	59.5	14.2	1.6	67.3	4.1	28.7
81	Chemical, wood and metal processing workers	0.8	45.6	39.0	52.1	7.6	1.3	97.8	1.0	1.1
82	Machine operators and assemblers	3.2	45.6	39.3	52.5	7.3	0.9	93.7	3.4	2.9
83	Professional drivers	0.5	45.9	36.1	49.9	13.2	0.8	54.6	9.2	36.3
91	Building caretakers, cleaners, assistant nurses and kitchen workers	7.8	47.5	35.3	59.7	4.4	0.6	39.0	59.6	1.4
93	Unskilled transport, construction and manufacturing workers	1.2	45.7	43.5	48.2	7.6	0.7	93.0	6.1	1.0

ISCO, International Standard Classification of Occupations.

were statistically significantly associated with disability retirement due to knee OA in both genders (table 3). Four out of five physical load factors increased the risk of disability retirement, whereas sitting reduced the risk. With all physical load factors in the model, the associations of heavy lifting with disability retirement (both genders) lost their statistical significance. Further adjustment for education attenuated the risk estimates, especially among women.

Risk of disability retirement due to knee OA by occupation

Among men, the age-adjusted risk of disability retirement due to knee OA was increased in all occupations except managers and teaching professionals as compared with the professionals (table 4). Construction workers, electricians and plumbers had the highest (OR 16.6, 95% CI 12.5. to 22.2), and service workers, as well as unskilled transport, construction and manufacturing workers had the second highest risk. Among women, the age-adjusted risk of disability retirement was increased in all occupations as compared with the professionals, building caretakers, cleaners, assistant nurses and kitchen workers having the highest risk (HR 15.5, 95% CI 11.7 to 20.6).

In both genders, adjustment for education considerably attenuated the occupational differences in disability retirement due to knee OA (table 4). Among men, the reduction in the risk varied between 52.7% (physical and engineering science technicians) and 75.2% (shop workers). Among women, the reduction in risk of disability retirement was highest for customer services clerks and second highest for physical and engineering science technicians. However, adjustment for education somewhat increased the risk for disability retirement for female teaching professionals, suggesting negative confounding.

Influence of physical work load factors on occupational differences in disability retirement due to knee OA

The combined contribution of physical work load factors to the risk of disability retirement due to knee OA varied between 14.2% and 85.2% among men and 16.7% and 120.7% among women (table 4). Among men, the largest influence of the physical work load

Table 2 Age-adjusted incidence rate (IR per 100 000 person-years) and 95% CI of full-time disability retirement due to knee osteoarthritis during 2005–2013 among men and women by occupational group

	Men		Women	
Occupational group	IR	95% CI	IR	95% CI
Managers	10	6 to 21	20	10 to 46
Professionals	8	5 to 13	10	6 to 18
Teaching professionals	12	6 to 23	16	10 to 25
Physical and engineering science technicians	34	25 to 50	20	10 to 45
Environmental officers and nurses	22	7 to 75	33	23 to 50
Finance and sales associate professionals and administrative secretaries	32	23 to 46	30	22 to 42
Office clerks	56	37 to 37	32	23 to 44
Customer services clerks	21	5 to 108	25	13 to 50
Service workers	81	59 to 117	118	104 to 134
Shop workers	30	15 to 69	86	66 to 117
Agricultural and fishery workers	92	72 to 120	199	157 to 257
Construction workers, electricians and plumbers	142	120 to 170	87	34 to 247
Metal and machinery workers	102	87 to 122	56	24 to 144
Craft workers	66	40 to 118	78	46 to 141
Chemical, wood and metal processing workers	98	71 to 140	132	79 to 235
Machine operators and assemblers	64	46 to 90	101	75 to 142
Professional drivers	70	55 to 91	141	77 to 261
Building caretakers, cleaners, assistant nurses and kitchen workers	112	82 to 157	246	216 to 282
Unskilled transport, construction and manufacturing workers	104	76 to 148	133	84 to 230
All	60	56 to 65	72	67 to 77

factors on occupational differences in disability retirement was found among construction workers, electricians and plumbers. Agricultural and fishery workers had the second highest contribution of work load factors to the risk (77.7%). With physical load factors in the model the risk of disability retirement lost its statistical significance for shop workers as well as agricultural and fishery workers and remained statistically significant for most of the other occupations.

Table 3 Associations between physical work load factors and disability retirement due to knee osteoarthritis among men and women

	HR*	95% CI	HR†	95% CI	HR‡	95% CI
Men						
Heavy physical work	2.38	2.21 to 2.57	1.39	1.23 to 1.59	1.26	1.12 to 1.43
Kneeling/squatting ≥1 hour/day	2.40	2.22 to 2.58	1.35	1.20 to 1.51	1.26	1.13 to 1.41
Heavy lifting ≥20 kg, ≥10 times/day	2.09	1.93 to 2.26	0.97	0.86 to 1.09	0.98	0.87 to 1.10
Sitting ≥5 hours/day	0.28	0.25 to 0.32	0.44	0.38 to 0.51	0.68	0.59 to 0.79
Standing or moving ≥5 hours/day	2.52	2.32 to 2.73	1.28	1.14 to 1.44	1.11	0.99 to 1.24
Women						
Heavy physical work	2.75	2.57 to 2.95	1.92	1.76 to 2.10	1.49	1.36 to 1.63
Kneeling/squatting ≥1 hour/day	1.94	1.75 to 2.15	1.34	1.20 to 1.49	1.12	1.01 to 1.24
Heavy lifting ≥20 kg, ≥10 times/day	2.13	1.94 to 2.35	1.04	0.92 to 1.16	1.01	0.90 to 1.14
Sitting ≥5 hours/day	0.23	0.20 to 0.26	0.33	0.29 to 0.38	0.36	0.31 to 0.41
Standing or moving ≥5 hours/day	2.09	1.95 to 2.24	1.20	1.11 to 1.29	1.13	1.05 to 1.22

*Adjusted for age.
†Adjusted for age and mutually (for all variables in the table).
‡Adjusted for age, education and mutually.

Table 4 HRs and 95% CIs of full-time disability retirement due to knee OA in 2005–2013 among men and women by occupational group (reference group—professionals)

Occupational group	Men								Women							
	Model 1		Model 2			Model 3			Model 1		Model 2			Model 3		
	HR	95% CI	HR	95% CI	PRE*	HR	95% CI	PRE†	HR	95% CI	HR	95% CI	PRE	HR	95% CI	PRE
Managers	1.07	0.71 to 1.74	0.95	0.61 to 1.50	NA	0.90	0.57 to 1.41	NA	1.62	1.01 to 2.58	1.47	0.92 to 2.35	24.2	1.59	0.99 to 2.54	NA
Professionals	1.00		1.00			1.00			1.00		1.00			1.00		
Teaching professionals	1.34	0.82 to 2.19	1.36	0.82 to 2.22	NA	1.26	0.76 to 2.01	NA	1.51	1.04 to 2.18	1.72	1.19 to 2.49	–41.2‡	1.25	0.85 to 1.83	65.3
Physical and engineering science technicians	4.13	2.99 to 5.69	2.48	1.78 to 3.45	52.7	2.20	1.55 to 3.11	18.9	2.05	1.20 to 3.51	1.12	0.66 to 1.93	88.6	1.04	0.60 to 1.78	NA
Environmental officers and nurses	2.98	1.51 to 5.88	1.87	0.94 to 3.71	56.1	1.60	0.79 to 3.23	NA	3.33	2.40 to 4.61	2.79	2.00 to 3.90	23.2	1.81	1.27 to 2.56	54.7
Finance and sales associate professionals and administrative secretaries	3.89	2.81 to 5.36	2.06	1.47 to 2.87	63.3	1.91	1.35 to 2.69	14.2	2.59	1.90 to 3.53	1.48	1.07 to 2.03	69.8	1.40	1.02 to 1.93	16.7
Office clerks	6.64	4.68 to 9.40	2.97	2.06 to 4.27	65.1	2.62	1.80 to 3.81	17.8	2.51	1.83 to 3.45	1.32	0.95 to 1.82	78.8	1.42	1.02 to 1.97	NA
Customer services clerks	3.76	1.17 to 12.1	1.95	0.61 to 6.27	65.6	2.01	0.62 to 6.49	NA	1.93	1.27 to 2.94	0.96	0.63 to 1.47	104.3	1.38	0.89 to 2.14	NA
Service workers	12.7	9.19 to 17.4	5.32	3.80 to 7.44	63.1	3.84	2.61 to 5.66	34.3	9.68	7.31 to 12.8	4.27	3.18 to 5.74	62.3	2.00	1.44 to 2.77	69.4
Shop workers	4.26	2.75 to 6.60	1.81	1.15 to 2.84	75.2	1.41	0.84 to 2.37	49.4	7.35	5.39 to 10.0	3.15	2.28 to 4.34	66.1	1.88	1.33 to 2.64	59.1
Agricultural and fishery workers	8.75	6.48 to 11.8	3.56	2.28 to 4.89	67.0	1.57	0.97 to 2.56	77.7	14.4	10.7 to 19.5	6.44	4.72 to 8.80	59.4	2.56	1.77 to 3.71	71.3
Construction workers, electricians and plumbers	16.6	12.5 to 22.2	6.55	4.82 to 8.92	64.4	1.82	1.06 to 3.13	85.2	6.52	3.60 to 11.8	2.04	1.56 to 5.17	81.2	0.80	0.41 to 1.54	119.2
Metal and machinery workers	11.7	8.79 to 15.6	4.71	3.46 to 6.41	65.3	1.88	1.19 to 2.97	76.3	4.35	2.36 to 7.99	1.87	1.01 to 3.45	74.0	0.82	0.43 to 1.57	120.7
Craft workers	7.83	5.41 to 11.4	3.28	2.22 to 4.83	66.6	2.10	1.38 to 3.20	51.8	5.87	3.09 to 8.86	2.58	1.69 to 3.93	67.6	1.87	1.22 to 2.86	44.9
Chemical, wood and metal processing workers	11.7	8.31 to 15.7	4.52	3.22 to 6.33	67.1	3.41	2.30 to 5.06	31.5	10.1	6.73 to 15.2	4.17	2.75 to 6.31	65.2	2.51	1.62 to 3.88	52.4
Machine operators and assemblers	8.36	6.05 to 11.5	3.31	2.36 to 4.66	68.6	2.41	1.62 to 3.59	39.0	7.85	5.70 to 10.8	3.23	2.31 to 4.51	67.4	2.02	1.41 to 2.88	54.3
Professional drivers	7.72	5.72 to 10.4	3.01	2.18 to 4.15	70.1	2.44	1.70 to 3.50	28.4	10.8	6.86 to 16.9	4.61	2.91 to 7.30	63.2	3.68	2.29 to 5.92	25.8
Building caretakers, cleaners, assistant nurses and kitchen workers	12.2	8.85 to 16.7	4.86	3.47 to 6.81	65.5	2.83	1.88 to 4.27	52.6	15.5	11.7 to 20.6	6.46	4.79 to 8.70	62.3	2.61	1.86 to 3.66	70.5

Continued

Table 4 Continued

Occupational group	Men								Women							
	Model 1		Model 2			Model 3			Model 1		Model 2			Model 3		
	HR	95% CI	HR	95% CI	PRE*	HR	95% CI	PRE†	HR	95% CI	HR	95% CI	PRE	HR	95% CI	PRE
Unskilled transport, construction and manufacturing workers	12.7	9.21 to 17.4	4.98	3.56 to 6.96	66.0	2.96	1.93 to 4.54	50.8	9.99	6.93 to 14.4	4.09	2.80 to 5.95	65.6	1.74	1.15 to 2.63	76.1

Model 1: adjusted for age, model 2: adjusted for age and education, model 3: adjusted for age, education and physical work load factors.
*PRE: proportion explained by education (%)—the percentage of attenuation of HR (with professionals as reference) after adjustment for education: $(HR_{Model\,2}-HR_{Model\,1})/(HR_{Model\,1}-1)\times100\%$.
†PRE: proportion explained by physical work load factors (%)—the percentage of attenuation of HR (with professionals as reference) after adjustment for physical work load factors: $(HR_{Model\,3}-HR_{Model\,2})/(HR_{Model\,2}-1)\times100\%$.
‡Negative value indicates an increase in HR after adjustment.
NA, not applicable.

The physical work load factors completely mediated the effect on disability retirement due to knee OA among female construction workers, electricians and plumbers as well as metal and machinery workers and teaching professionals (table 4). In general, the contribution of physical work load factors to occupational differences in disability retirement was larger among women than among men in manual occupations. Among female managers and office clerks, adjustment for physical work load factors increased the risk of disability retirement, suggesting that occupational factors do not play a role in the increased risk for these occupations.

The physical load that explained the highest contribution to the excess risk among men was kneeling and squatting (table 5). The proportion of the risk explained was especially high for the construction workers, electricians and plumbers (84.3%), metal and machinery workers (75.5%) and agricultural and fishery workers (75.4%). However, among women heavy physical work contributed most to the excess risk within construction workers, electricians and plumbers (96.2%), unskilled transport, construction and manufacturing workers (70.2%), metal and machinery workers (80.5%) and agricultural and fishery workers (66.5%).

DISCUSSION

This is one of the few population-based studies and among the largest on occupational differences in disability retirement due to knee OA that includes both men and women and information on physical work load factors assessed by a job exposure matrix. We observed considerable occupational differences in the 9-year incidence rate of disability retirement due to knee OA in both genders. The overall incidence rate was significantly higher in women than men, with the largest gender difference among building caretakers, cleaners, assistant nurses and kitchen workers as well as agricultural and fishery workers. The observed occupational differences in disability retirement were considerably attenuated after controlling for education. Physical work load factors noticeably mediated the effect of occupation on disability retirement in both genders.

Comparison with previous studies

The majority of previous studies on the association between occupation and knee OA have used either case-control or cross-sectional design, have been based on a selected set of occupations or examined the association among men only. We estimated the risk of disability retirement due to knee OA across a wide range of occupations (including all non-manual and manual occupations held by Finns in 2005). Our results on an excessive risk of disability retirement among male construction workers, electricians and plumbers as well as metal and machinery workers; female building caretakers, cleaners, assistant nurses and kitchen workers as well as agricultural and fishery workers and chemical,

Table 5 The contribution of separate physical work load factors on the occupational differences in disability retirement due to knee OA among men and women (reference group—professionals)

	Proportion (%) of risk of disability retirement due to knee OA explained*									
	Men					Women				
Occupational group	HPW	K	HL	Sit	Stand	HPW	K	HL	Sit	Stand
Managers	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Professionals										
Teaching professionals	NA	NA	NA	NA	NA	–6.93†	11.1	0.0	66.7	18.1
Physical and engineering science technicians	9.5	16.9	10.8	20.3	4.1	NA	NA	NA	NA	NA
Environmental officers and nurses	NA	NA	NA	NA	NA	39.7	10.1	4.5	34.1	10.6
Finance and sales associate professionals and administrative secretaries	10.4	13.2	6.6	12.3	3.8	14.6	6.3	2.1	4.2	–6.3
Office clerks	20.8	10.7	8.1	13.7	2.5	NA	NA	NA	NA	NA
Customer services clerks	0.0	–2.1	2.1	–11.6	0.0	NA	NA	NA	NA	NA
Service workers	23.6	27.5	10.4	24.5	5.6	44.6	21.1	2.8	35.2	15.3
Shop workers	34.6	44.4	37.0	53.1	13.6	35.8	11.6	3.3	30.7	22.8
Agricultural and fishery workers	53.5	75.4	44.5	34.8	10.5	66.5	24.8	8.8	37.9	–3.9
Construction workers, electricians and plumbers	47.4	84.3	32.6	31.0	8.8	96.2	21.2	–53.8	10.6	–72.1
Metal and machinery workers	30.7	75.5	18.1	30.7	8.1	80.5	54.0	9.2	49.4	28.7
Craft workers	27.2	46.9	18.0	24.6	4.4	35.4	8.9	2.5	22.2	0.0
Chemical, wood and metal processing workers	24.7	28.4	21.9	22.7	6.0	50.2	4.4	3.5	19.9	11.0
Machine operators and assemblers	27.3	35.9	24.2	26.0	6.5	54.3	2.2	2.7	12.6	11.7
Professional drivers	32.8	18.9	28.4	17.4	0.5	47.9	6.1	6.9	–2.5	–0.6
Building caretakers, cleaners, assistant nurses and kitchen workers	29.8	46.6	13.0	29.3	6.2	48.0	19.0	2.7	37.2	14.1
Unskilled transport, construction and manufacturing workers	38.2	46.5	29.9	27.9	7.3	70.2	13.9	6.5	29.4	19.4

*The percentage of attenuation of HR (with professionals as reference) after adjustment: $(HR_{Model\ 3}–HR_{Model\ 2})/(HR_{Model\ 2}–1)\times100\%$, model 2 adjusted for age and education, model 3 adjusted for age, education and physical work load factor.
†Negative value indicates an increase in HR after adjustment for the physical work load factor in question.
HL, heavy lifting; HPW, heavy physical work; K, kneeling or squatting; NA, not applicable; Sit, sitting; Stand, standing or moving.

wood and metal processing workers of both genders are in line with the previous studies reporting an association of occupation with OA.[22 28–30]

There is growing evidence on the detrimental effect of significant and recurrent squatting, bending, kneeling and loading of the knee on the development of knee OA.[7] It has been suggested that social and occupational differences in disability retirement could be due to unfavourable physical working conditions that vary across occupations. Indeed, it has been estimated that about 5% of knee OA might result from occupations involving repetitive knee use.[31 32] Our findings suggest that at least 50% of disability retirement due to knee OA among individuals in most manual occupations could be attributed to physical work load factors. In fact, our results suggest that the excess risk of disability retirement among male shop workers as well as agricultural and fishery workers, and female construction workers, electricians and plumbers could be eliminated if the physical work load factors would be at the level of those among professionals. The contribution of physical load factors to disability risk among professional drivers was modest.

It is well documented that women have higher incidence rates of knee OA than men, especially after the age of 50 years.[7] However, gender-specific occupational differences in OA are largely unknown. We observed a clear gender difference in the incidence rate of disability retirement due to knee OA among Finns aged 30–60 years. In particular, female agricultural and fishery workers and women working as building caretakers, cleaners, assistant nurses and kitchen workers had a twofold incidence rate of disability retirement as compared with men in those occupations.

The level of education has been well documented to be one of the strongest determinants of social inequality

in health and disability retirement in particular.[17–19] Previous studies have suggested that occupational class and working conditions are the major contributors to these associations.[14 16 17 21] In our study, even after taking into account occupational differences in education and physical work load, the increased risk of disability retirement due to knee OA remained in most of the occupations. The remained risk of disability retirement was more than threefold among male service workers and male chemical, wood and metal processing workers (particularly, papermaking plant operators) and female professional drivers as compared with professionals. The findings suggest that these occupations may involve clustering of other risk factors (eg, obesity, smoking, psychosocial work-related factors) for disability due to knee OA that were not examined in our study. Indeed, a higher prevalence of obesity and smoking among fire-fighters, police workers[33 34] as well as professional drivers than in the general population[35 36] has been reported. However, the remained elevated risk of disability retirement for some occupations may still be due to physical load factors that were not captured by the JEM. Despite assessment of the physical work load factors by a gender-specific JEM, there may have been a non-differential misclassification of the exposures, particularly in occupations with larger within-occupation differences in the physical work load factors.

Strengths and limitations

The strength of the current study is that a large nationally representative sample of the Finnish working population was followed over a relatively long period of time. Information on physical work exposures for each occupation, classified based on the ISCO, was obtained from a gender-specific job exposure matrix and therefore the observed associations were not affected by recall bias. Furthermore, there was no selection and attrition bias, since the study was solely based on register data. There is strong epidemiological evidence suggesting an increased risk of disability retirement, earlier old-age retirement and mortality among workers with physically demanding work.[37–40] To minimise an overestimation of HRs and to control for the potential effect of competing risks on disability retirement due to knee OA, we conducted a competing risk analysis.

A major limitation of register-based studies, in general, is that they typically provide only a limited number of background characteristics of the participants and other potential confounders. Economic incentives may affect the propensity of persons to apply for disability pension. Those with higher socioeconomic status may want to stay at work, as their loss in income will be larger in absolute terms. On the other hand, those with lower socioeconomic status may also want to stay at work, as their income from disability pension may not be sufficient for their basic needs. However, persons in upper non-manual jobs may be able to stay at work despite knee problems, while for persons in manual occupations, working conditions may limit their work participation. Therefore, residual confounding due to lifestyle factors or other factors that affect decisions regarding disability retirement cannot be ruled out.

In conclusion, while there is sufficient evidence for occupation as a risk factor for knee OA among men, studies on occupational differences in knee OA and its consequences among women are scarce. The recent study provides comprehensive information on occupational differences in disability retirement due to knee OA in both genders and across a broad range of occupations. We observed an exceptionally high risk of disability retirement among male construction workers, electricians and plumbers, service workers, unskilled transport, construction and manufacturing workers as well as female building caretakers, cleaners, assistant nurses and kitchen workers. Our observational study suggests that the risk of disability retirement among manual workers is strongly attributed to the physically heavy work. Prevention measures should focus on the reduction of physically heavy tasks, kneeling or squatting activities and lifting and carrying of loads. More intervention studies on the effectiveness of aids and working methods for reducing knee straining activities are needed.

Contributors EV-J obtained the data. All authors were involved in study conception and design, interpretation of results. SS conducted the statistical analyses. TK wrote the first drafts of the article. All authors discussed the drafts, revised them critically and prepared the final version to be submitted for publication. SS has full access to all data in the study and takes responsibility of the integrity of the data and the accuracy of the data analysis.

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Ethics approval The researchers used fully anonymous register data for which ethics committee approval is not needed according to Finnish legislation. Statistics Finland linked its data to those of the Social Insurance Institution of Finland and the Finnish Centre for Pensions, after which the data were anonymised and stored by Statistics Finland. The researchers analysed the anonymous data using a remote access system. All output extracted from the system was approved by Statistics Finland to ensure compliance with data protection regulations. The data can only be accessed by individual researchers who have obtained permission from each of the administrative sources providing the data.

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Data sharing statement Due to data protection regulations of the administrative sources providing the register data, the authors do not have the permission to share the data. Permissions to use the register data can be applied from the Social Insurance Institution of Finland (http://www.kela.fi/web/en/research-data-requests), the Finnish Centre for Pensions (http://www.etk.fi/en/statistics-2/statistics/producer-of-statistics/) and Statistics Finland (http://www.stat.fi/meta/tietosuoja/kayttolupa_en.html).

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