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Original Article

The Unequal Burden of Self-Reported Musculoskeletal Pains Among South Korean and European Employees Based on Age, Gender, and Employment Status

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ABSTRACT

Background: The objective of this study was to elucidate the relationships musculoskeletal pains with combined vulnerability in terms of age, gender, and employment status

Methods: The fifth European Working Conditions Survey (EWCS) in 2010 (43,816 participants aged 15 years and over) analyzed for European employees and the third Korean Working Conditions Survey (KWCS) in 2011 (50,032 participants aged 15 years and older) analyzed for Korean employees. In this study, three well known vulnerable factors to musculoskeletal pains (older age, female gender, and precarious employment status) were combined and defined as combined vulnerability. Associations of musculoskeletal pains with combined vulnerability were assessed with prevalence ratios (PRs) and 95% confidence intervals (CIs) estimated by Poisson regression models with robust estimates of variance.

Results: The prevalences of musculoskeletal pains were lower but the absolute and relative differences between combined vulnerabilities were higher among Korean employees compared with the European employees. Furthermore, the increased risk of having musculoskeletal pains according to combined vulnerability was modestly explained by socioeconomic factors and exposure to ergonomic risk factors, especially in Republic of Korea.

Conclusions: The results of this study showed that the labor market may be more unfavorable for female and elderly workers in Republic of Korea. Any prevention strategies to ward off musculoskeletal pains, therefore, should be found and implemented to mitigate or buffer against the most vulnerable work population, older, female, and precarious employment status, in Republic of Korea.

1. Introduction

Musculoskeletal disorders, especially back and neck pain, are the second leading cause of years lost due to disability in a general population at a global level [1]. The global prevalence of low back pain in 2010 was estimated to be 9.4% with the prevalence being higher in Europe than Asia [2]. Globally, population attributable fraction for low back pain related with occupational exposure to ergonomic risk factors was 26% (13-43%) varied with age, gender, and region [3]. In a working population, musculoskeletal disorders were a major cause of absence from work and led to health-related, early retirement in Europe [4]. Musculoskeletal disorders represented 69.7% of the compensated occupational diseases in 2013 among workers in Republic of Korea [5].

Many prior studies showed health inequalities in musculoskeletal symptoms by age, gender, and employment status [6–13]. Older and female workers reported higher prevalence rates of musculoskeletal pains than their counterparts [14]. A longitudinal study conducted in France showed that musculoskeletal pain at multiple sites was more prevalent in blue-collar workers [15]. Socioeconomic inequalities in musculoskeletal pains were identified among the occupational class in a Norwegian study. Mehlum et al. [16] showed that socioeconomic gradients in musculoskeletal pains could be explained by physical risk factors and poor psychological working conditions.

Workers in temporary work showed significantly higher odds of wrist/hand symptoms compared with workers in permanent employment associated with significantly higher exposure to work-

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related ergonomic risk factors [17]. It is well known that older workers, women, and employees with precarious employment status are more vulnerable to musculoskeletal pains [6,7,9,10,13]. In this study, combinations of these three aspects of vulnerability (older age, female gender, and precarious employment status) were defined as combined vulnerability. However, several questions still remain. What happens when these vulnerabilities overlap? We can assume that the risk of musculoskeletal pains probably increases among individuals with multiple vulnerabilities, but to what extent? If the burden increases with combined vulnerability, which factors can explain the relationship of the burden with combined vulnerability? To answer these questions, we extended prior studies which elucidated the associations of musculoskeletal disorders with age, gender, and precarious employment and compared the associations among different countries.

The aims of this study were to compare the differential distributions of the musculoskeletal pains in accordance with the combined vulnerability of Korean and European employees and to identify factors which meaningfully explained the relationships of musculoskeletal pains with combined vulnerability and inter-country differences. Based on prior investigations, the hypotheses of this study are as follows. First, musculoskeletal pains are unequally distributed according to combinations of age, gender, and employment status. Second, patterns of association of musculoskeletal pains with combined vulnerability are different between Republic of Korea and Europe because different settings create different patterns of discrimination associated with age, gender, and employment status. Comparisons of musculoskeletal pain distributions and disparity patterns between Korean and European employees would provide insight into policy implications and specific recommendations to reduce musculoskeletal pains.

2. Materials and methods

2.1. Study population

Data were obtained from the fifth European Working Conditions Survey (EWCS) in 2010 and the third Korean Working Conditions Survey (KWCS) in 2011. The EWCS is conducted every five years since 1990 to monitor working conditions in Europe by the European Foundation for the Improvement of Living and Working Conditions. The fifth EWCS was carried out from January to August 2010 in 35 European countries with 43,816 participants using a multi-stage, stratified, random sampling method. In randomly drawn each primary sampling unit, a household was randomly sampled, and one person was selected for interview [18]. Eligible criteria were used for at least one hour in the reference week for pay aged 15 years and older (aged 16 years and older in Spain, the UK, and Norway). The survey was conducted with both computer aided personal interviewing (CAPI) and pen-and paper interviewing (PAPI) for 42 minutes on average. In fifth EWCS, the contact rate (CON2) was 0.763, the cooperation rate (COOP3) was 0.596, the refusal rate (REF2) was 0.299, and the response rate (RR3) was 0.442 defined by American Association for Public Opinion Research (AAPOR).

The KWCS was conducted since 2006 by the Occupational Safety and Health Research Institute (OSHRI) of the Korea Occupational Safety and Health Agency in Republic of Korea as a repeated cross-sectional study [19]. The KWCS is a national survey collecting information on occupational health indicators in working environments. The third KWCS was conducted from June to November 2011 [20]. The KWCS uses a two-stage, stratified, probability proportional to size systematic method based on the 2005 Population and Housing Census in Republic of Korea. The survey questionnaire in the third KWCS was designed based on the fifth EWCS. The survey was face-to-face PAPI by household visit. Eligible criteria of this survey was economically active population aged 15 years and older with paid work for at least one hour in reference week in 16 cities and provinces in Republic of Korea. The total survey participants were 50,032. In third KWCS, the CON2 was 0.566, the COOP3 was 0.662, the REF2 was 0.180, and the RR3 was 0.354 defined by AAPOR.

For the analyses, we used information from 27 European Union (EU) member countries (EU27). The study participants for this analysis were restricted to men and women aged 20–64 years who were employed for wages. A total of 56,182 participants (28,025 EWCS respondents and 28,157 KWCS respondents) were analyzed. The EWCS and KWCS provided a sample weight. We used a supranational weight for the EU27 which was applied when running the aggregate level analysis. All participants voluntarily agreed to participate and present their information to be used for research purposes in both surveys. Ethical approval for this study was waived because the data sets, both the EWCS and the KWCS, were publicly available and did not contain any personal information.

2.2. Outcome variables: musculoskeletal pains

Musculoskeletal pains including back, shoulders and neck and/or upper limbs, and lower limbs were assessed using a revised version of standardized the Nordic Musculoskeletal Questionnaire developed by support of the Nordic Council of Ministers for data collection [21]. Respondents were asked if they had suffered from any musculoskeletal symptoms over the last 12 months with two response categories: yes or no. Questions of musculoskeletal symptoms are the same in the EWCS and KWCS modeled on the EWCS.

2.3. Exposure variables

Age was classified into two categories (20~49 years and 50~64 years). Employment status was categorized into permanent (indefinite contract) and precarious (fixed-term or temporary contract). Based on age, gender, and employment status, we created a third variable with eight categories which represented combined vulnerability. This was carried out because we assumed that each factor (age, gender, and employment status) constituting combined vulnerability had their own vulnerability effect in work-related environments and when these factors were combined that the newly combined vulnerability might create synergistic effects on adverse health outcomes.

Combined vulnerability was categorized as follows: men aged younger than 50 years with permanent job; men aged younger than 50 years with precarious job; women aged younger than 50 years with permanent job; women aged younger than 50 years with precarious job; men aged 50 years or more with permanent job; men aged 50 years or more with precarious job; women aged 50 years or more with permanent job; women aged 50 years or more with precarious job.

We included variables to measure socioeconomic position as confounding factors. Educational level was asked seven categories between no education and postgraduate studies based on a modified version of Revised International Standard Classification on Education designed by United Nations Educational, Scientific and Cultural Organization [22] and reclassified as low secondary (0-9 years), high secondary (10-12 years), or tertiary (13+ years). Financial difficulty was assessed by asking “Thinking of your household's total monthly income, is your household able to make ends meet?”. Response categories were “very easily”, “easily”, “fairly easily”, “with some difficulty”, “with difficulty”, and “with great difficulty”. Participants replying “with great difficulty”, “with

difficulty", or "with some difficulty" were considered to be facing financial difficulty.

Occupational class was classified two categories: nonmanual (legislators, senior officials and managers, professionals, technicians and associate professionals, clerks, and service workers and shop and market sales workers) and manual (skilled agricultural and fishery workers, craft and related trades workers, plant and machine operators and assemblers, and elementary occupations) based on the 1988 version of the International Standard Classification of Occupations in EWCS [23] and the 6th revision of the Korean Standard Classification of Occupations [24]. Weekly working hours were categorized as 40 hours or less or 41 or more. Presenteeism was assessed by asking "Over the last 12 months, did you work when you were sick?". Responses to shift work and presenteeism were categorized as yes or no.

The psychosocial work environment was measured through the job demand–control model proposed by Karasek [25]. The KWCS and EWCS do not contain the original questionnaire of the job demand–control model. Thus, we used an approximate approach using variables of the KWCS and EWCS, as used in a prior study by Farioli et al. [9]. We combined the responses into summary scales of job demand and job control and then divided the scales into low and high categories by their median values in each region. The median value of job demand was 9.0 in the KWCS and 9.25 in the EWCS. The median value of job control was 12.0 in the KWCS and 14.5 in the EWCS. Finally, we created four categories of job demand–control: low strain (low demand and high control); active (high demand and high control); passive (low demand and low control); and high strain (high demand and low control).

To assess exposure to ergonomic risk factors, seven indicators were used: vibrations from hand tools, machinery, and so on; tiring or painful positions; lifting or moving people; carrying or moving heavy loads; standing; repetitive hand or arm movements; working with computers. Participants were asked the proportion of exposure time during the day to these ergonomic risk factors with seven answers from "all of the time" to "never" then regrouped to two responses; who reported working half of the time or more under these conditions were classified as the exposed or the not exposed who reported working less.

2.4. Statistical analysis

All statistical analyses were performed with SAS, version 9.4 (Cary, NC, USA). Categorical variables were presented as frequencies and percentages and were compared across Korean employees and EU27 employees using the chi-square tests with sample weights. Associations of musculoskeletal pains with combined vulnerability were examined with prevalence ratios (PRs) and 95% confidence intervals (CIs) estimated by Poisson regression models with robust estimates of variance. The robust Poisson method was performed with PROC GENMOD using the repeated statement [26].

To reduce the confounding effects of extraneous confounding factors, such as socioeconomic position, working hours, shift work, presenteeism, the psychosocial work environment, and exposure to ergonomic risk factors, statistical adjustment was made for the base line model (Model I) [27]. For example, to assess the association between musculoskeletal pains and combined vulnerability, we first ran a model with combined vulnerability only (Model I). In the second model, Model I was adjusted for education, financial difficulty, and occupational class (Model II). In the third model, we further included weekly working hours, shift work, and presenteeism (Model III). Next, we added psychosocial working conditions (Model IV). In the final model, exposure to ergonomic risk factors was combined (Model V). The same procedures were made for other exposure variables (i.e., age<50 vs. age≥50, men vs. women, and permanent vs. precarious) to estimate adjusted PRs for musculoskeletal pains. The interaction effects between confounding factors were not assessed. All models included country dummy variables when analyzing EU27 data. Separate analyses for Republic of Korea and EU27 were conducted. Sample weights were applied to maintain the representativeness of each population.

3. Results

The flowchart of selection steps of the study population was presented (Fig. 1). From EWCS, 28,025 employees (64.0%) were selected and 28,157 employees (56.3%) were selected from KWCS. All variables except exposures to vibration, carrying or moving heavy loads, and repetitive hand or arm movements showed

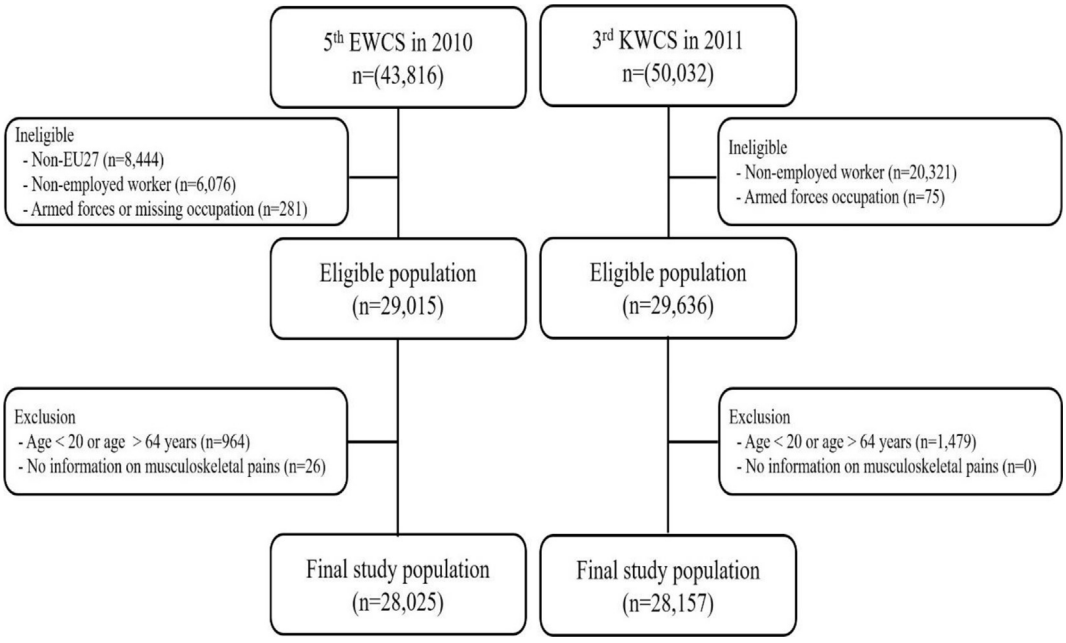

Fig. 1. Flowchart of selection steps of study population. EWCS, European Working Conditions Survey; KWCS, Korean Working Conditions Survey.

Table 1
Weighted numbers and percentages of study subjects in Korean and Europe (EU27) employees

	Korea (n=33,159)		EU27 (n=27,609)		p-value
	N	%	n	%	
Age					
20~49yrs	26,020	78.5	20,858	75.5	<.0001
50~64yrs	7,139	21.5	6,751	24.5	
Gender					
Male	19,525	58.9	14,578	52.8	<.0001
Female	13,634	41.1	13,031	47.2	
Employment status					
Permanent	25,380	76.5	24,068	87.2	<.0001
Precarious	7,779	23.5	3,541	12.8	
Combined vulnerability					
Age < 50/male/permanent	12,634	38.1	9,430	34.2	<.0001
Age < 50/male/precarious	2,525	7.6	1,455	5.3	
Age < 50/female/permanent	8,276	25.0	8,412	30.5	
Age < 50/female/precarious	2,584	7.8	1,561	5.7	
Age ≥ 50/male/permanent	2,992	9.0	3,443	12.5	
Age ≥ 50/male/precarious	1,373	4.1	251	0.9	
Age ≥ 50/female/permanent	1,478	4.5	2,783	10.1	
Age ≥ 50/female/precarious	1,296	3.9	275	1.0	
Socioeconomic factors					
Education					
Low secondary	2,830	8.5	8,395	30.5	<.0001
High secondary	18,508	55.8	10,849	39.4	
Tertiary	11,821	35.7	8,292	30.1	
Financial difficulty					
No	16,335	49.3	16,846	61.9	<.0001
Yes	16,824	50.7	10,387	38.1	
Occupational class					
Non-manual	21,928	66.1	18,606	67.4	0.0010
Manual	11,231	33.9	9,003	32.6	
Work environments					
Weekly working hours					
~40	13,502	40.7	22,030	80.8	<.0001
41~	19,657	59.3	5,223	19.2	
Shift work	3,088	9.3	5,469	20.0	<.0001
Presenteeism	6,949	21.0	9,659	35.8	<.0001
Job demand-control					
Low-strain	9,101	27.5	5,612	22.4	<.0001
Active	9,397	28.3	7,522	30.0	
Passive	7,078	21.3	6,616	26.4	
High strain	7,584	22.9	5,322	21.2	
Exposure to ergonomic risk factors					
Vibration	5,440	16.4	4,412	16.0	0.1736
Tiring or painful positions	9,797	29.6	8,783	31.9	<.0001
Lifting or moving people	1,699	5.1	1,751	6.4	<.0001
Carrying or moving heavy loads	5,850	17.6	5,009	18.2	0.0952
Standing	14,342	43.3	15,433	56.0	<.0001
Repetitive hand or arm movements	17,412	52.5	14,582	53.0	0.2579
Working with computers	13,032	39.3	11,879	43.1	<.0001

different distributions between Korean and EU27 employees (Table 1). Gender differences were noticed in the proportion of female employees between Republic of Korea and Europe, reflecting low labor market participation by women in Republic of Korea. Precarious employment was more prevalent among Korean employees (23.5%) than EU27 employees (12.8%). Accordingly, differences in the associated prevalence of combined vulnerability were substantial. In Europe, older male and female precarious workers accounted for only 0.9% and 1.0%, respectively, whereas in Republic of Korea those workers were 4.1% and 3.9%, respectively.

Korean employees showed a lower percentage of low secondary education (8.5%) and nonmanual occupation (66.1%) in comparison with the EU27 employees (30.5% and 67.4%, respectively). Korean employees showed a higher percentage of weekly working hours over 40 (59.3%) in comparison with the EU27 employees (19.2%). EU27 employees showed a higher percentage of shift work (20.0%) and presenteeism (35.8%) in comparison with Korean employees (9.3% and 21.0%, respectively). EU27 employees were exposed to higher levels of tiring or painful positions, lifting or moving people, standing, and working with computers in comparison with Korean employees (Table 1). More detailed distributions of socioeconomic factors, work environments, psychosocial working conditions, and exposure to ergonomic risk factors based on combined vulnerability are provided in Appendix Table A and B.

The prevalences of back pain, shoulders and neck and/or upper limbs pain, and lower limbs pain were substantially higher among employees aged 50 years or more than employees aged younger than 50 years in both regions (Fig. 2). However, the prevalence gaps between men and women and between permanent and precarious employees were less obvious in EU27 employees than Korean employees. Overall prevalences of back pain, shoulders and neck and/or upper limbs pain, and lower limbs pain were higher among EU27 employees in comparison with Korean employees (Appendix Table C). Prevalence of back pain ranged between 8.3% and 28.9% among Korean employees and ranged between 40.7% and 56.4% among EU27 employees based on combined vulnerability. In Republic of Korea, male employees aged younger than 50 years with a permanent job showed the lowest prevalence of back pain and female employees aged 50 years or more with a precarious job showed the highest prevalence. While, in the EU27, male employees aged younger than 50 years with a precarious job showed the lowest prevalence and male employees aged 50 years or more with a permanent job showed the highest prevalence of back pain (Fig. 2(a)).

Prevalence of shoulders and neck and/or upper limbs pain was higher than back pain and ranged between 24.4% (male employees aged younger than 50 years with a permanent job) and 55.1% (female employees aged 50 years or more with a precarious job) among Korean employees based on combined vulnerability (Appendix Table C). Among the EU27 employees, prevalence of shoulders and neck and/or upper limbs pain ranged between 38.6% (male employees aged younger than 50 years with a permanent job) and 57.4% (female employees aged 50 years or more with a precarious job; Fig. 2(b)). With regard to lower limbs pain in Republic of Korea, male employees aged younger than 50 years with a permanent job (13.9%) showed the lowest prevalence and female employees aged 50 years or more with a precarious job (41.2%) showed the highest prevalence based on combined vulnerability (Appendix Table C). In the EU27, female employees aged younger than 50 years with a permanent job (25.0%) showed the lowest prevalence and female employees aged 50 years or more with a precarious job (42.8%) showed the highest prevalence of lower limbs pain (Fig. 2(c)). Prevalences of back pain, shoulders and neck and/or upper limbs pain, and lower limbs pain showed increasing patterns with combined vulnerability of age, gender, and employment status in both Republic of Korea and the EU27 countries (Fig. 2).

Table 2 showed that PRs for musculoskeletal pains by age group and employment status considerably decreased after adjusting for socioeconomic factors among Korean employees. On the other hand, PRs for musculoskeletal pains by gender rarely changed even after additional adjustment. Table 2 also showed that the PRs of musculoskeletal pains varied among subgroups based on combined vulnerability in Republic of Korea. Female precarious employees aged 50 years or more had the highest PR of back pain (PR: 3.48, 95% CI: 3.01-4.03) and the PR decreased to 2.14 (95% CI: 1.82-2.51; Model II in Table 2) after adjusting for socioeconomic factors. Apart from socioeconomic factors, the PRs of back pain after adjusting for work environments, psychosocial working conditions, and exposure to ergonomic risk factors changed only modestly (PR: 1.96, 95% CI: 1.65-2.33; Model V in Table 2). The PRs of back pain after adjusting for socioeconomic position indicators, work environments, psychosocial working conditions, and exposure to ergonomic risk factors showed similar values to the PR when only

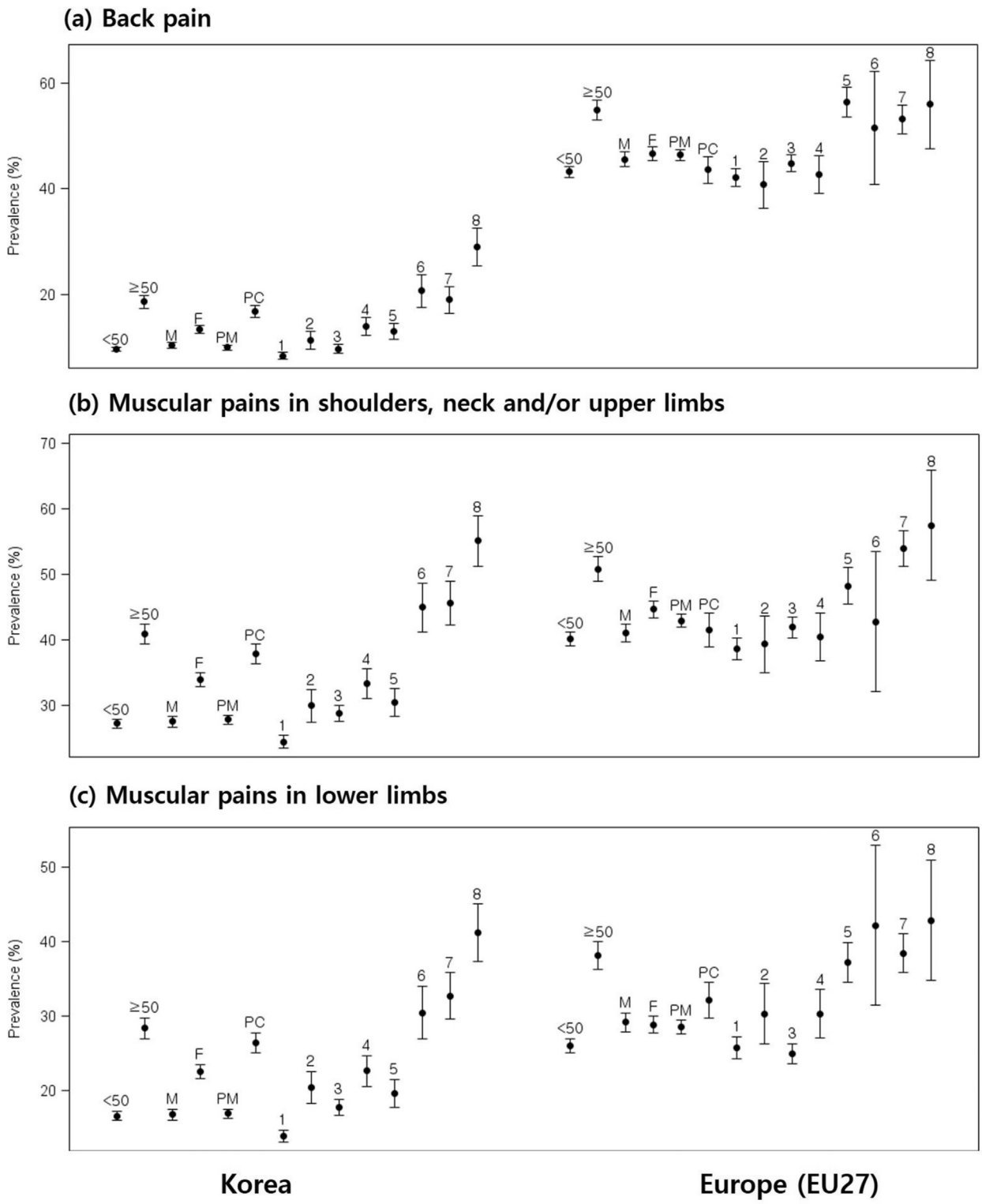

Fig. 2. (a) Prevalences and 95% confidence intervals (CIs) of back pain based on age group, gender, employment status, and combined vulnerability among Korean and Europe (EU27) employees with sample weights. (b) Prevalences and 95% CI of muscular pains in shoulders, neck and/or upper limbs. (c) Prevalences and 95% CI of muscular pains in lower limbs. [<50, age<50; ≥50, age≥50; M, male; F, female; PM, permanent; PC, precarious; 1, age < 50/male/permanent; 2, age < 50/male/precarious; 3, age < 50/female/permanent; 4, age < 50/female/precarious; 5, age ≥ 50/male/permanent; 6, age ≥ 50/male/precarious; 7, age ≥ 50/female/permanent; 8, age ≥ 50/female/precarious].

adjusting for socioeconomic factors and exposure to ergonomic risk factors (Model V in Appendix Table D). Similar patterns in PRs accounted for by the distribution of socioeconomic factors, and exposure to ergonomic risk factors were observed in shoulders and neck and/or upper limbs and lower limbs pain (Table 2).

In the EU27, employees aged 50 years or more showed generally higher PRs of musculoskeletal pains than their counterparts (Table 3). In contrast with Korean employees, than the EU27 employees, the PRs largely unchanged after adjusting for socioeconomic factors, work environments,

Table 2
Prevalence ratios (PRs) and 95% confidence intervals (CIs) of musculoskeletal pains among Korean employees

	Model I		Model II		Model III		Model IV		Model V	
	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI
Back pain										
Age ≥ 50 (Ref = age < 50)	1.94	1.79–2.11	1.30	1.18–1.43	1.29	1.18–1.42	1.30	1.18–1.43	1.25	1.13–1.37
Female (Ref = male)	1.30	1.20–1.40	1.47	1.36–1.59	1.50	1.39–1.63	1.51	1.39–1.64	1.39	1.28–1.52
Precarious (Ref = permanent)	1.68	1.55–1.83	1.19	1.09–1.30	1.19	1.09–1.30	1.19	1.09–1.30	1.11	1.02–1.21
Combined vulnerability										
Age < 50/male/permanent	Reference		Reference		Reference		Reference		Reference	
Age < 50/male/precarious	1.35	1.14–1.60	1.07	0.90–1.26	1.05	0.89–1.24	1.04	0.88–1.23	0.98	0.83–1.16
Age < 50/female/permanent	1.16	1.04–1.30	1.38	1.23–1.55	1.35	1.21–1.51	1.37	1.22–1.53	1.30	1.16–1.45
Age < 50/female/precarious	1.67	1.45–1.93	1.67	1.45–1.93	1.73	1.50–1.99	1.76	1.52–2.03	1.56	1.35–1.81
Age ≥ 50/male/permanent	1.56	1.36–1.80	1.26	1.09–1.45	1.24	1.07–1.43	1.25	1.09–1.45	1.24	1.08–1.43
Age < 50/male/precarious	2.48	2.09–2.94	1.38	1.15–1.66	1.30	1.08–1.56	1.35	1.12–1.62	1.27	1.05–1.52
Age ≥ 50/female/permanent	2.27	1.95–2.66	1.81	1.53–2.14	1.81	1.53–2.13	1.88	1.60–2.22	1.63	1.38–1.93
Age ≥ 50/female/precarious	3.48	3.01–4.03	2.14	1.82–2.51	2.26	1.92–2.67	2.28	1.92–2.70	1.96	1.65–2.33
Muscular pains in shoulders, neck and/or upper limbs										
Age ≥ 50 (Ref = age < 50)	1.50	1.43–1.57	1.17	1.11–1.23	1.18	1.12–1.24	1.20	1.14–1.26	1.17	1.11–1.23
Female (Ref = male)	1.23	1.18–1.29	1.34	1.29–1.40	1.35	1.29–1.41	1.24	1.19–1.30	1.31	1.25–1.37
Precarious (Ref = permanent)	1.36	1.30–1.43	1.10	1.05–1.15	1.10	1.05–1.15	1.09	1.04–1.15	1.05	1.00–1.10
Combined vulnerability										
Age < 50/male/permanent	Reference		Reference		Reference		Reference		Reference	
Age < 50/male/precarious	1.23	1.12–1.34	1.04	0.95–1.14	1.02	0.94–1.12	1.02	0.94–1.12	0.98	0.90–1.07
Age < 50/female/permanent	1.18	1.11–1.25	1.3	1.29–1.39	1.28	1.21–1.36	1.29	1.22–1.37	1.26	1.19–1.34
Age < 50/female/precarious	1.36	1.26–1.48	1.35	1.24–1.46	1.38	1.27–1.49	1.38	1.28–1.50	1.30	1.20–1.41
Age ≥ 50/male/permanent	1.25	1.15–1.35	1.09	1.00–1.18	1.10	1.01–1.19	1.11	1.03–1.21	1.11	1.03–1.20
Age < 50/male/precarious	1.84	1.68–2.02	1.26	1.14–1.38	1.23	1.12–1.35	1.24	1.13–1.37	1.18	1.07–1.31
Age ≥ 50/female/permanent	1.87	1.72–2.03	1.61	1.48–1.76	1.61	1.48–1.76	1.65	1.51–1.80	1.52	1.40–1.67
Age ≥ 50/female/precarious	2.26	2.08–2.45	1.66	1.52–1.81	1.72	1.58–1.88	1.74	1.58–1.91	1.63	1.49–1.80
Muscular pains in lower limbs										
Age ≥ 50 (Ref = age < 50)	1.71	1.60–1.81	1.21	1.13–1.30	1.22	1.13–1.30	1.24	1.16–1.33	1.20	1.12–1.28
Female (Ref = male)	1.34	1.27–1.42	1.49	1.41–1.58	1.51	1.42–1.60	1.52	1.43–1.61	1.42	1.34–1.52
Precarious (Ref = permanent)	1.56	1.47–1.66	1.16	1.09–1.24	1.16	1.09–1.24	1.16	1.09–1.24	1.06	0.99–1.13
Combined vulnerability										
Age < 50/male/permanent	Reference		Reference		Reference		Reference		Reference	
Age < 50/male/precarious	1.47	1.31–1.66	1.16	1.03–1.31	1.16	1.03–1.30	1.15	1.02–1.30	1.06	0.94–1.20
Age < 50/female/permanent	1.28	1.18–1.39	1.47	1.35–1.59	1.45	1.34–1.58	1.48	1.36–1.60	1.42	1.30–1.54
Age < 50/female/precarious	1.64	1.47–1.82	1.58	1.42–1.76	1.63	1.46–1.81	1.63	1.46–1.82	1.45	1.30–1.62
Age ≥ 50/male/permanent	1.42	1.27–1.58	1.16	1.04–1.30	1.16	1.04–1.30	1.19	1.07–1.33	1.20	1.07–1.34
Age < 50/male/precarious	2.20	1.93–2.50	1.31	1.14–1.50	1.28	1.12–1.47	1.35	1.18–1.55	1.22	1.07–1.40
Age ≥ 50/female/permanent	2.36	2.11–2.64	1.90	1.69–2.14	1.91	1.70–2.15	1.96	1.74–2.21	1.72	1.53–1.94
Age ≥ 50/female/precarious	2.97	2.66–3.31	1.94	1.73–2.18	2.03	1.80–2.28	2.09	1.84–2.36	1.82	1.60–2.07

reference group = Age < 50/male/permanent employees
Model I: Crude PR; Model II: adjusted for education, financial difficulty, and occupational class; Model III: adjusted for Model II covariates + weekly working hours, shift work, and presenteeism; Model IV: adjusted for Model III covariates + psychosocial working conditions; Model V: adjusted for Model IV covariates + exposure to ergonomic risk factors.

psychosocial working conditions, and exposure to ergonomic risk factors.

4. Discussion

This study showed that the prevalences of musculoskeletal pains were lower, but the absolute and relative differences between combined vulnerabilities were higher among Korean employees than with the EU27 employees. In addition, the increased risk of having musculoskeletal pains according to combined vulnerability was modestly explained by socioeconomic factors and exposure to ergonomic risk factors, especially in Republic of Korea. It is not clear why European employees reported more musculoskeletal pains, especially back pain, than Korean employees, even of the same age, gender, and employment status groups. One possible explanation is that the exposure to physical workloads such as tiring or painful positions, lifting or moving people, standing, or working with computers was relatively high among EU27 employees in comparison to Korean employees as shown in Table 1 of this study. A review of longitudinal studies found that heavy physical work (including excessive repetition, awkward postures, and heavy lifting) was the most commonly reported risk factor of work-related musculoskeletal disorders [28].

Several studies to date have suggested age, gender, and employment status differences in musculoskeletal pains [6,7,9,10,13]. Most of the studies investigating relationships between musculoskeletal pains and age, gender, and employment status have not been conducted with combinations, but separately. This study adds some weight of evidence in this area. In this study, risk estimates for musculoskeletal pains decreased after adjusting for exposure to ergonomic risk factors, especially among Korean employees. This might be explained by exposure to ergonomic risk factors being more frequent in vulnerable groups of Korean employees, while the imbalanced distribution was not clearly observed among EU27 employees (Appendix Table A and B). In Republic of Korea, most of ergonomic risk factors including tiring or painful positions, lifting or moving people, carrying or moving heavy loads, standing, and repetitive hand or arm movements followed a similar distribution which disproportionally favored age under 50, permanent, and/or male groups. While these particular distributions of ergonomic risk factors relative to age, gender, and employment status were not evident in EU27 employees, generally lower levels of exposure were observed in male employees aged 50 years or older than in male employees aged younger than 50 years (Appendix Table A and B).

Generally, similar results were found in several studies. A Finnish study showed that men were more commonly exposed to

Table 3
Prevalence ratios (PRs) and 95% confidence intervals (CIs) of musculoskeletal pains among Europe (EU27) employees

	Model I		Model II		Model III		Model IV		Model V	
	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI
Back pain										
Age ≥ 50 (Ref = age < 50)	1.27	1.21–1.32	1.25	1.20–1.30	1.25	1.20–1.31	1.27	1.22–1.33	1.27	1.21–1.32
Female (Ref = male)	1.03	0.99–1.07	1.11	1.06–1.15	1.10	1.06–1.15	1.11	1.06–1.17	1.07	1.02–1.12
Precarious (Ref = permanent)	0.93	0.88–1.00	0.96	0.90–1.02	0.96	0.90–1.02	0.97	0.91–1.04	0.96	0.90–1.03
Combined vulnerability										
Age < 50/male/permanent	Reference		Reference		Reference		Reference		Reference	
Age < 50/male/precarious	0.95	0.85–1.07	0.92	0.82–1.03	0.93	0.83–1.04	0.93	0.83–1.05	0.92	0.82–1.03
Age < 50/female/permanent	1.07	1.01–1.13	1.16	1.09–1.22	1.15	1.09–1.22	1.16	1.10–1.24	1.12	1.06–1.19
Age < 50/female/precarious	1.01	0.92–1.11	1.05	0.95–1.15	1.03	0.94–1.13	1.07	0.96–1.18	1.02	0.92–1.12
Age ≥ 50/male/permanent	1.33	1.25–1.41	1.32	1.24–1.41	1.32	1.24–1.41	1.35	1.26–1.45	1.36	1.28–1.46
Age < 50/male/precarious	1.25	1.02–1.54	1.15	0.95–1.39	1.16	0.97–1.40	1.21	1.01–1.46	1.19	0.99–1.43
Age ≥ 50/female/permanent	1.26	1.18–1.34	1.34	1.25–1.43	1.34	1.25–1.43	1.37	1.28–1.47	1.3	1.21–1.39
Age ≥ 50/female/precarious	1.33	1.15–1.54	1.29	1.12–1.49	1.33	1.15–1.53	1.31	1.12–1.54	1.31	1.11–1.55
Muscular pains in shoulders, neck and/or upper limbs										
Age ≥ 50 (Ref = age < 50)	1.25	1.20–1.31	1.23	1.18–1.29	1.23	1.18–1.29	1.25	1.19–1.31	1.25	1.19–1.31
Female (Ref = male)	1.09	1.05–1.14	1.19	1.14–1.25	1.19	1.14–1.25	1.20	1.14–1.26	1.15	1.09–1.21
Precarious (Ref = permanent)	0.96	0.90–1.03	0.99	0.93–1.06	1.00	0.94–1.07	0.98	0.91–1.05	0.97	0.91–1.04
Combined vulnerability										
Age < 50/male/permanent	Reference		Reference		Reference		Reference		Reference	
Age < 50/male/precarious	1.01	0.90–1.13	0.98	0.87–1.09	0.98	0.88–1.10	0.95	0.84–1.07	0.93	0.83–1.04
Age < 50/female/permanent	1.09	1.03–1.15	1.20	1.13–1.28	1.20	1.13–1.27	1.19	1.12–1.27	1.15	1.08–1.23
Age < 50/female/precarious	1.04	0.94–1.15	1.10	0.99–1.21	1.09	0.99–1.20	1.10	0.99–1.22	1.06	0.96–1.18
Age ≥ 50/male/permanent	1.23	1.15–1.33	1.23	1.15–1.32	1.23	1.14−−1.32	1.23	1.14–1.32	1.24	1.15–1.34
Age < 50/male/precarious	1.15	0.90–1.47	1.06	0.84–1.33	1.09	0.87–1.36	1.1	0.87–1.40	1.07	0.86–1.34
Age ≥ 50/female/permanent	1.38	1.29–1.48	1.47	1.37–1.57	1.47	1.38–1.58	1.51	1.41–1.63	1.44	1.34–1.55
Age ≥ 50/female/precarious	1.49	1.28–1.74	1.46	1.25–1.70	1.5	1.28–1.76	1.44	1.19–1.75	1.45	1.21–1.73
Muscular pains in lower limbs										
Age ≥ 50 (Ref = age < 50)	1.49	1.40–1.58	1.43	1.35–1.52	1.44	1.36–1.53	1.44	1.35–1.53	1.46	1.38–1.56
Female (Ref = male)	1.00	0.94–1.05	1.10	1.04–1.17	1.09	1.02–1.16	1.10	1.03–1.17	1.06	0.99–1.13
Precarious (Ref = permanent)	1.09	1.00–1.18	1.12	1.03–1.21	1.13	1.04–1.23	1.13	1.03–1.23	1.13	1.04–1.23
Combined vulnerability										
Age < 50/male/permanent	Reference		Reference		Reference		Reference		Reference	
Age < 50/male/precarious	1.13	0.97–1.30	1.04	0.90–1.21	1.05	0.91–1.21	1.04	0.89–1.21	1.03	0.89–1.19
Age < 50/female/permanent	0.98	0.91–1.06	1.10	1.02–1.19	1.08	1.00–1.18	1.09	1.00–1.19	1.07	0.98–1.16
Age < 50/female/precarious	1.14	1.01–1.28	1.20	1.06–1.35	1.18	1.05–1.34	1.23	1.08–1.40	1.18	1.04–1.34
Age ≥ 50/male/permanent	1.47	1.34–1.61	1.45	1.33–1.59	1.45	1.32–1.59	1.46	1.32–1.60	1.50	1.37–1.65
Age < 50/male/precarious	1.71	1.33–2.19	1.50	1.17–1.91	1.50	1.19–1.91	1.54	1.20–1.99	1.57	1.23–1.99
Age ≥ 50/female/permanent	1.52	1.39–1.66	1.59	1.45–1.74	1.58	1.44–1.73	1.61	1.46–1.77	1.55	1.41–1.72
Age ≥ 50/female/precarious	1.69	1.40–2.05	1.57	1.30–1.89	1.62	1.34–1.95	1.55	1.24–1.93	1.60	1.29–1.98

reference group=Age<50/male/permanent employees
All models include country dummy variables. Model I: Crude PR; Model II: adjusted for education, financial difficulty, and occupational class; Model III: adjusted for Model II covariates + weekly working hours, shift work, and presenteeism; Model IV: adjusted for Model III covariates + psychosocial working conditions; Model V: adjusted for Model IV covariates + exposure to ergonomic risk factors.

high physical work load than women; however, the peak physical exposure in men occurred age before 50s, whereas women experienced the peak physical exposure after 50s [29]. According to the fifth EWCS, posture-related risks, such as vibrations, tiring positions, lifting people, carrying heavy loads, standing, repetitive movements were declined with age in men [30]. Moreover, several studies presented that physical working conditions were important risk factors for occupational health inequalities [16,31–33]. Studies showed that the occupational class gradient in musculoskeletal pains was explained by physical workloads [32,34] and that socioeconomic inequalities in musculoskeletal pains could partly be attributed to inequalities in physical job demands and job autonomy [16]. A longitudinal study conducted in France showed similar results to the Korean employees in this study that physical strains performed a significant role rather than psychosocial factors in reducing occupational class disparities of low back pain [35].

In addition to different exposure to physical work load, the varying burden of musculoskeletal pains by combined vulnerability between Korean and EU27 employees could be explained by dissimilar distributions of socioeconomic factors. For example, a distinct difference for educational level distribution was found between the two regions. In Republic of Korea, the proportion of low secondary education group was very low (1.4-6.6%) among employees aged younger than 50 years. Among employees aged 50 years or more, the proportion of low secondary education is almost threefold higher in male precarious employees than male permanent employees, and female employees had a higher proportion of low secondary education than men, when employment status was the same. This uneven distribution of education in EU27 employees was less severe than in Korean employees. Occupational class also showed a dissimilar distribution between Korean and EU27 employees, particularly among employees aged 50 years or more. Added to this finding, financial difficulty was more prevalent among Korean precarious employment in the same age group and gender (Appendix Table A and B). Based on these findings, labor markets may be more unfavorable for female and/or older workers in Republic of Korea.

Over the last two decades, permanent employment based on full-time, secure work has decreased and has been largely substituted with precarious employment such as fixed-term or temporary work in Korean labor market as well as in Europe. These changes largely affected individuals with social and biological vulnerabilities, such as aging workers and/or female workers, especially in Republic of Korea. As shown in this study, in Republic of Korea, among employees aged 50 years and older, 37.4% of employees had precarious work, whereas 19.6% of employees aged younger than 50 years had precarious work. On the other hand, in Europe, among employees aged 50 years and older, only 7.8% of employees had precarious work and 14.5% of employees aged under 50 years had precarious work. In addition, it became worse when the vulnerabilities were combined. Among employees aged

50 years and older, 31.5 % (1,373/4,365) of men and 46.7% (1,296/2,774) of women were precarious employees in Republic of Korea, whereas 6.8% (251/3,694) of men and 9.0% (275/3,058) of women were precarious employees in Europe (Table 1).

To our knowledge, no study has been conducted to examine the effect of combined vulnerability of age, gender, and employment status on musculoskeletal pains. In addition, this study may be the first study to compare between Korean and EU27 employees regarding musculoskeletal pains, using a large representative sample.

However, this study also has limitations. First, the prevalence of musculoskeletal pains was assessed using a questionnaire, rather than a clinical diagnosis. In addition, all of the information on working conditions, including ergonomic exposure was based on self-report. Second, because this study is a cross-sectional design, we focused on associations between combined vulnerability and musculoskeletal pains. Employees with musculoskeletal pains might be more likely to have precarious employment status. Thus, we cannot rule out the possibility of reverse causation between combined vulnerability and musculoskeletal pains. Third, country level differences among European countries were not fully considered in our analysis, although country dummy variables were included in the analysis. The precarious employment was unequally distributed across the European labor force [36]. However, country level analysis will be needed in future studies to explain workers' health inequality through developing a conceptual framework for the relation of employment and working conditions and their health consequences [37]. In addition, this study did not apply multilevel analysis to compare differences between countries, especially in Europe. Therefore, the results of this study should be cautiously interpreted for comparison between countries, especially in EU27.

This study was conducted analyzing secondary data obtained from the large representative employees from Europe and Republic of Korea consisted of intensive individual information and showed that significantly higher risks on musculoskeletal pains according to combined vulnerability, especially in Republic of Korea. To improve the workers' working conditions, health status, and inequality, the findings from this study would be used as a basis to develop occupational health policies.

5. Conclusion

Despite these limitations, this study revealed that, in Republic of Korea, the risk of having musculoskeletal pains based on combined vulnerability was strongly involved with socioeconomic factors, such as education, financial difficulty, and occupational class and exposure to ergonomic risk factors. Although other factors, including weekly working hours, shift work, presenteeism, and psychosocial working conditions, brought relatively small changes in PRs, age, gender, and employment status create conditions conducive to expose a higher risk of musculoskeletal pains in Korean employees. Furthermore, labor markets may be more unfavorable for female and elderly workers in Republic of Korea. Any prevention strategies, therefore, should be found and implemented to mitigate or buffer against these combined vulnerabilities, if it is not possible to eliminate labor market separation.

Ethical approval and consent to participate

All participants agreed to participate and present their information to be used for research purposes in both surveys. Ethical approval for this study was waived because the data sets, both the EWCS and the KWCS, were publicly available and did not contain any personal information.

Availability of data and material

The data sets analyzed for this study are publicly opened. The URLs are https://www.eurofound.europa.eu/data/european-working-conditions-survey and http://oshri.kosha.or.kr/oshri/researchField/downWorkingEnvironmentSurvey.do#.

Authors' contributions

J.B. analyzed the data and created a draft of this manuscript. Y.H.K. critically revised this manuscript. S.L. designed this study and revised this manuscript. All authors read and approved the final manuscript.

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Conflicts of interest

The authors declare no actual or potential conflicts of interest.

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Appendix A. Supplementary data

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