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Original research

Precarious employment, strenuous working conditions and the long-term risk of diagnosed chronic musculoskeletal disorders

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► Additional supplemental material is published online only. To view, please visit the journal online (https://doi.org/10.1136/oemed-2024-109867).

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Received 19 September 2024
Accepted 4 December 2024
Published Online First
23 December 2024

ABSTRACT

Objectives To investigate the effect of precarious employment (PE) on the risk of diagnosed chronic musculoskeletal disorders (MSDs) among Swedish workers in occupations with strenuous working conditions.

Methods This nationwide register-based cohort study included workers registered as living in Sweden in 2005, aged 21–60 at the 2010 baseline. Three samples were included: workers with high biomechanical workload (n=680 841), repetitive work (n=659 422) or low job control (n=703 645). PE was evaluated using the SWE-ROPE (2.0) construct, which includes: contractual insecurity, temporariness, multiple jobs, income and collective bargaining agreement from 2010. Three exposure groups were created: PE, substandard and standard employment (SE). MSD data were obtained from outpatient registers (2011–2020). Cox proportional-hazards models estimated crude and adjusted sex-specific HRs with 95% CIs. Various outcomes were investigated for the different samples.

Results Among workers with heavy biomechanical workload, results suggest increased risks of back MSDs in PE compared with those in SE. No association was found between PE and tendonitis in repetitive work, but PE was associated with an increased Carpal Tunnel Syndrome risk among men. Among workers with low job control, PE was associated with increased risks of soft tissue disorders among men and fibromyalgia among women.

Conclusions PE was associated with an increased risk of MSDs among workers with strenuous working conditions, with variations depending on disorder and sex. The findings suggest a differential exposure to biomechanical workload within occupations. Targeted interventions and strengthened workplace safety regulations are needed to protect the musculoskeletal health of workers in PE.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ It is increasingly suggested that the nature of one's employment relationship can significantly influence working conditions and health. Precarious employment (PE) has been linked to strenuous working conditions and adverse health outcomes, but its longitudinal association with musculoskeletal disorders (MSDs) is less understood.

WHAT THIS STUDY ADDS

⇒ To the best of our knowledge, this is the first longitudinal study to show a link between PE and an increased risk of diagnosed MSDs. By investigating a sample of workers in strenuous occupations, we were able to infer that the increased risk of MSDs is likely driven by either differential exposure to hazardous working conditions between precarious and standard employees within the same job roles or a direct effect.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The findings of this study suggest a stronger need for occupational safety and health regulations, targeted interventions and policy reforms to protect workers in PE. These measures could reduce the differential exposure to biomechanical strain and psychosocial stress, ultimately improving the musculoskeletal health of workers in PE.

To cite: Badarin K, Mangot-Sala L, Matilla Santander N, *et al*. *Occup Environ Med* 2024;**81**:595–602.

BACKGROUND

Musculoskeletal disorders (MSDs) are common among the workforce with nearly half of European workers reporting musculoskeletal pain at the end of a working day.[1] The most frequently reported MSD is low back pain, but disorders of the upper back, neck, shoulder and arm are also common.[2] Symptoms of MSDs include pain, stiffness, weakness or restricted range of motion.[2] These symptoms can have debilitating effects on a person's physical and emotional functioning, ability to work or activities of daily living thus reducing quality of life and well-being. Moreover, MSDs also create a substantial economic burden through medical costs and productivity loss.[3]

There is a general agreement in the literature that workers with strenuous working conditions are disproportionately affected by MSDs.[4–7] Additionally, different types of strenuous working conditions, such as high biomechanical workload,[6 8] repetitive work[6 9] and poor psychosocial factors, have been associated with different MSD outcomes.[4 5 10] Increasingly, research suggests that the nature of one's employment relationship can significantly influence working conditions and health.[11] Several studies have identified associations between precarious employment (PE) and adverse effects on mental health,[12] cardiovascular health[13] and mortality.[14 15] However, studies examining the relationship between PE and MSDs are comparatively scarce.

It can be hypothesised that PE increases the risk of MSDs, and that this is likely mediated by physically hazardous work and psychosocial factors. Specifically, workers in PE may face more hazardous working conditions within the same occupations compared with their peers in standard employment (SE). Therefore, to investigate the relationship between PE and MSDs, it is cogent to consider established links between different workplace exposures and specific MSDs. For example, repetitive work is a well-recognised risk factor for Carpal Tunnel Syndrome (CTS), therefore, an observed increased risk of CTS among workers in PE, compared with those in SE within the same occupation, could be attributed to a higher and differential exposure to repetitive work.

While there is a lack of consensus on a precise definition, there is agreement that PE encompasses a lack of employment security, inadequate income and benefits as well and lack of workers' rights and social protections.[16 17] PE could be associated with MSDs through physiological or psychosocial pathways.[18] The physiological pathway suggests that PE could contribute to an increased biomechanical load. This increase could be explained by the short-term or temporary nature of PE, which has been associated with inconsistent adherence to Occupational Safety and Health (OSH) regulations[19 20] or lack of training.[21] The psychosocial pathway suggests that factors associated with PE, such as economic pressures and job competition, could also increase psychosocial stress/strain, which can cause short-term (eg, increased muscle tension) and long-term (eg, MSDs) physiological reactions.[10] Contrarily, task variation among workers with high biomechanical workload has been suggested to safeguard workers' musculoskeletal health.[7 22] Therefore, task variation among precariously employed workers conceivably has a protective effect on musculoskeletal health compared with those in SE with long-term exposure to heavy physical work.[23]

Cross-sectional studies have found that workers in non-standard forms of employment (eg, contingent, part-time and atypical workers) are more likely to be exposed to physical and ergonomic hazards and report higher rates of musculoskeletal pain compared with those in SE.[19 24 25] However, because PE is multidimensional, examining MSDs in relation only to temporary or part-time employment incompletely captures its complexities.[16] Several studies that have used multidimensional measures of PE to investigate the relationship between PE and MSDs have found a higher prevalence of MSDs among those in PE.[26 27] One Swedish study found no association between PE and musculoskeletal pain.[23] Longitudinal studies examining the PE-MSD association have not been found.

In sum, existing evidence on PE and MSDs is derived from cross-sectional studies using self-reported data to measure PE. The knowledge base would benefit from longitudinal evidence derived from studies that go beyond using temporary or part-time employment to capture PE and employ multidimensional measures of PE that are based on standardised register data. Furthermore, considering the strong evidence connecting specific types of strenuous work to MSDs, it is important to explore whether workers in PE are at a disproportionately higher risk of MSDs compared with workers in SE with similar hazardous working conditions. Against this background, this longitudinal study investigates the effect of PE on the risk of diagnosed chronic MSDs among Swedish workers who are in occupations with strenuous working conditions.

METHOD

Study population

This longitudinal study used data from the Swedish Work, Illness and Labor-market Participation (SWIP) cohort, comprised of individuals aged 16–64 years old, residing in Sweden in 2005, totalling around 5.4 million people. The cohort was established by linking data from three registers, using Sweden's distinct personal identity numbers assigned to all residents. The Swedish Total Population Register[28] provided details on birth, death, civil status and migration. Sociodemographic information such as occupational data, educational attainment, birth country and unemployment was obtained from the Longitudinal Integrated Database for Health Insurance and Labor Market Studies register (LISA). Last, outcome data on MSDs were taken from the National Patient Register (NPR). Statistics Sweden provided the data, which were deidentified to protect confidentiality.

Participants and study design

We selected workers who were alive at the 2010 baseline and born between 1950 and 1989 (21–60 years old in 2010). The SWIP cohort is a closed cohort, and the youngest included in the cohort were born in 1989. To use the most up-to-date data available in the SWIP cohort, the 2010 baseline was chosen. Exclusion criteria were: (1) missing a Swedish Standard Classification of Occupations 1996 (SSYK-96) code, (2) yearly employer-based income <100 Swedish Krona in 2010, (3) died or emigrated before or in 2010, (4) unemployed >180 days in 2010, (5) registered as a student in 2010, (6) had an old age pension in 2010, (7) had a disability pension, (8) being self-employed or (9) having incomplete data for measuring PE exposure or the confounding variables. A flowchart detailing the selection criteria is shown in online supplemental material 1.

To investigate the effect of PE on MSDs, we limited our study to include only workers in occupations with high biomechanical workload, repetitive work or low job control, which are factors that have previously been linked to an increased risk of MSDs.[4–10] To select workers for each of the three samples, we used Swedish Job Exposure Matrices (JEMs). The Swedish JEMs provide gender-specific aggregated measures of exposure to physical and psychosocial workplace conditions for 355 occupations covered in the SSYK-96 codes.[29] The JEMs were constructed using responses to questions in the Swedish Work Environment Surveys 1997–2013 and have been described previously.[30 31] Workers with high biomechanical workload were identified through an index score based on exposure to heavy lifting, frequent bending and twisting and working in awkward positions. Repetitive work and low job control were measured by single item questions. Workers in the highest quartile were classed as having high biomechanical workload or repetitive work. Workers were classed as having low job control if they were in the lowest quartile. After excluding those with a diagnosis of the MSD outcome of interest before the start of follow-up (2011), five final samples were used to conduct five separate analyses (online supplemental material 1). The samples

were overlapping; therefore, the same individual could be present in all five samples.

Exposure: PE

The exposure, PE, was constructed for the baseline year 2010. Data on participants' employment were taken from the LISA database. The SWE-ROPE (2.0) was used to construct a PE score.[32] The SWE-ROPE includes five items covering three dimensions of PE: employment insecurity, income inadequacy and lack of rights and protection.[16 17] The scores for each of the five items are summed to obtain a score ranging from −9 to +2 and three categories were created (1) PE (a score <−3), (2) substandard employment (a score of −3 to −1) and (3) SE (a score of 0 to +2).

Outcome: chronic MSDs

Information on the first diagnosis of MSDs was taken from the NPR, which includes data on healthcare episodes in outpatient specialist care since 2001.[33] For each analysis, anyone with a previous diagnosis of the MSD outcome of interest before the start of follow-up (2011) was excluded. The register does not contain information on primary care. Different outcomes were investigated for the different samples. Among workers with heavy biomechanical load, PE and risk of MSDs of the back (International Classification of Diseases 10 codes (ICD-10) M54–M55) were investigated. Among workers with repetitive work, PE and the risk of synovitis and tenosynovitis (ICD10 M65–M68) (referred to in this paper as 'tendonitis'), or CTS (ICD10 G56) were investigated. Among workers with low job control, PE and the risk of soft tissue disorders related to use overuse and pressure (ICD10 M70–M78) or fibromyalgia (ICD10 M79.7) were investigated.

The specific MSD outcomes were selected based on expert opinion, from medical professionals, epidemiologists and social scientists, and established evidence linking distinct physical and psychosocial pathways to particular MSDs. For example, heavy biomechanical workload and back pain,[6 8] repetitive work and upper extremity disorders,[6 9] psychosocial factors and global MSDs.[4 5 10]

Confounders

The following confounders were taken from the LISA register for the baseline year 2010: *age; educational attainment*, (1) primary and lower secondary school or less (≤9 years), (2) secondary (10–11 years), (3) upper-secondary (12 years) and (4) tertiary (≥13 years); *civil status*, categorised as married, unmarried, divorced or widowed; *country of birth*, dichotomised into born in or out of Sweden. We adjusted for low job control among those with heavy biomechanical workload or repetitive work and vice versa. We further adjusted for diagnosed depression/anxiety using the outpatient register data.

Statistical analysis

First, we calculated the first cases of diagnosed back disorders, tendonitis, CTS, soft tissue disorders and fibromyalgia among men and women in the different exposure groups during the follow-up period (2011 to the end of 2019). Second, we examined the sex-specific distribution of the covariates among the exposure categories for workers in occupations with (1) high biomechanical workload, (2) repetitive work and (3) low job control. Third, crude (model 1) and adjusted (model 2) HRs with 95% CIs were estimated for the risk of an MSD diagnosis during the follow-up period. Those in SE were used as the reference group. All analyses were stratified by sex, based on previous evidence showing that the health effects of being in PE[13 14 34] and the incidence of MSDs[35 36] differ across men and women. For the Cox regression analyses, person-time was calculated from 1 January 2011 until either emigration, death, a case of the specific musculoskeletal outcome or the end of follow-up on 31 December 2019, as this is currently the last available data in the SWIP cohort. Finally, we conducted three sensitivity analyses:

1. Because the risk of MSDs may vary across occupations, we used a stratified Cox model with the SSYK code as the stratifying variable.
2. Because PE is more common among younger workers, we stratified the analysis by age (21–29 and 30–60 years old).

Data management and statistical analysis were conducted using SAS V.9.4.

RESULTS

Descriptive results

During follow-up, among workers with high biomechanical workload, 6% of men (n=21 577) and 7% of women (n=23 009) had MSDs of the back. Among workers with repetitive work, 2% of men (n=8185) and 4% of women (n=10 698) had a case of tendonitis and 0.3% of men (n=1198) and 0.6% of women (n=1862) had a case of CTS. Additionally, among workers with low job control, 6% of men (n=19 718) and 6% of women (n=19 731) had a case of soft tissue disorders, and 0.03% of men (n=120) and 0.5% of women (n=1648) had a case of fibromyalgia.

The proportions of precariously employed workers in the youngest category of workers, unmarried workers, workers born outside of Sweden and those with mental health disorders were larger than among those with SE (table 1, online supplemental materials 2 and 3). Among those with high biomechanical workload or repetitive work, higher education (secondary and tertiary) was also more prevalent among workers in PE compared with those in SE. The same pattern was observed for men with low job control. However, tertiary education was more prevalent among women with low job control in SE than for those in PE.

PE and the risk of diagnosed MSDs of the back

After adjusting for included confounders, an increased risk of diagnosed MSDs of the back was seen for men and women in PE (men: HR 1.18, 95% CI 1.14 to 1.22; women: HR 1.23, 95% CI 1.18 to 1.29, table 2, model 2) as well as in substandard employment compared with workers in SE (men: HR 1.08, 95% CI 1.05 to 1.12; women: HR 1.09, 95% CI 1.06 to 1.13, table 2, model 2). The risks among the substandard group were lower than those in the PE group, suggesting a dose-response type association among the PE categories.

PE and the risk of upper extremity MSDs

The adjusted results suggest that PE was not associated with an increased risk of diagnosed tendonitis for men or women in PE (table 3, model 2a). However, women in substandard employment had a decreased risk of diagnosed tendonitis (HR 0.94, 95% CI 0.90 to 0.99) table 3, model 2a). When the other upper extremity outcome was examined, men in PE had an increased risk of diagnosed CTS (HR 1.21, 95% CI 1.04 to 1.41, table 3 model 2b), but men in the substandard group had a decreased risk (HR 0.85, 95% CI 0.74 to 0.97, table 3 model 2b). No statistically significant association was found between PE and CTS among women.

Table 1 Distribution of baseline covariates among employment categories for men and women who work in occupations with heavy biomechanical workload*

	Employment categories: men, n=346 622				Employment categories: women, n=334 219			
	Precarious, n (%)	Substandard, n (%)	Standard, n (%)	Total	Precarious, n (%)	Substandard, n (%)	Standard, n (%)	Total
Age								
21–29 years old	29 108 (45.7)	24 695 (26.7)	31 171 (16.4)	84 974	32 903 (45.1)	26 208 (20.0)	10 924 (8.4)	70 035
30–39 years old	14 521 (22.8)	24 189 (26.2)	47 528 (24.9)	86 238	17 476 (23.9)	32 963 (25.2)	24 044 (18.5)	74 483
40–49 years old	11 756 (18.5)	23 931 (25.9)	58 367 (30.6)	94 054	13 432 (18.4)	36 238 (27.7)	46 631 (35.8)	96 301
50–60 years old	8325 (13.1)	19 587 (21.2)	53 444 (28.1)	81 356	9203 (12.6)	35 528 (27.1)	48 669 (37.4)	93 400
Country of birth								
Sweden	52 967 (83.1)	80 492 (87.1)	167 794 (88.1)	301 253	59 211 (81.1)	107 429 (82.0)	105 977 (81.4)	272 617
Other	10 743 (16.9)	11 910 (12.9)	22 716 (11.9)	45 369	13 803 (18.9)	23 508 (18.0)	24 291 (18.6)	61 602
Educational level								
Primary	12 500 (19.6)	17 841 (19.3)	37 294 (19.6)	67 635	10 927 (15.0)	20 379 (15.6)	16 512 (12.7)	47 818
Secondary	17 608 (27.6)	33 731 (36.5)	82 498 (43.3)	133 837	16 482 (22.6)	48 073 (36.7)	61 928 (47.5)	126 483
Upper-secondary	26 760 (42.0)	33 274 (36.0)	58 233 (30.6)	118 267	32 101 (44.0)	48 368 (36.9)	38 493 (29.5)	118 962
Tertiary	6842 (10.7)	7556 (8.2)	12 485 (6.6)	26 883	13 504 (18.5)	14 117 (10.8)	13 335 (10.2)	40 956
Civil status								
Married	13 765 (21.6)	28 699 (31.1)	71 787 (37.7)	114 251	21 578 (29.6)	57 066 (43.6)	58 716 (45.1)	137 360
Unmarried	44 831 (70.4)	55 721 (60.3)	100 804 (52.9)	201 356	43 595 (59.7)	57 425 (43.9)	48 464 (37.2)	149 484
Divorced	5039 (7.9)	7843 (8.5)	17 595 (9.2)	30 477	7519 (10.3)	15 417 (11.8)	21 951 (16.9)	44 887
Widowed	75 (0.1)	139 (0.2)	324 (0.2)	538	322 (0.4)	1029 (0.8)	1137 (0.9)	2488
Mental health disorder								
No mental health disorder	62 877 (98.7)	91 572 (99.1)	189 349 (99.4)	343 798	71 484 (97.9)	129 125 (98.6)	129 113 (99.1)	329 722
Mental health disorder	833 (1.3)	830 (0.9)	1161 (0.6)	2824	1530 (2.1)	1812 (1.4)	1155 (0.9)	4497

*The numbers displayed are from the sample of workers with a high biomechanical workload before excluding those with a previous diagnosis of the outcome of interest prior to the start of the 2011 follow-up.

PE and the risk of soft tissue disorders or fibromyalgia

Finally, the two outcomes investigated among individuals with low job control were examined. The adjusted results suggest that men in PE had an increased risk of soft tissue disorders (HR 1.07, 95% CI 1.03 to 1.12, table 4, model 2a). No statistically significant association was found between the PE group and soft tissue disorders among women. However, women in substandard employment had a decreased risk of soft tissue disorders compared with workers in SE (table 4, model 2a). For fibromyalgia, women in PE (HR 1.91, 95% CI 1.66 to 2.19) and substandard employment showed an elevated risk (HR 1.54, 95% CI 1.38 to 1.72) (table 4, model 2b). No statistically significant association was found between the PE group and fibromyalgia among men.

Table 2 The risk of diagnosed musculoskeletal disorders (MSDs) of the back among male and female workers in precarious employment who work in occupations with high biomechanical workload

Employment categories	Cases of MSDs of the back, n (%)	Model 1, HR (95% CI)	Model 2, HR (95% CI)
Men, n=335 700			
Precarious	4303 (7)	1.24 (1.20 to 1.28)	1.18 (1.14 to 1.22)
Substandard	5919 (7)	1.11 (1.08 to 1.14)	1.08 (1.05 to 1.12)
Standard employment	11 355 (6)	1	1
Women, n=323 941			
Precarious	5419 (8)	1.25 (1.20 to 1.29)	1.23 (1.18 to 1.29)
Substandard	9076 (7)	1.09 (1.07 to 1.12)	1.09 (1.06 to 1.13)
Standard employment	8514 (7)	1	1

Model 1: adjusted for age.
Model 2: age, education, civil status, native/non-native-born, decision authority at work, baseline diagnosis of depression/anxiety.

Sensitivity analyses

We ran a sensitivity analysis to investigate if the risk of MSDs varied across occupations. To do so, we used a stratified Cox model with the occupational code as the stratifying variable (online supplemental materials 4–6). The estimates from the sensitivity analysis were similar to those found in the main analysis.

A further sensitivity analysis (online supplemental material 7) showed that older workers in PE had slightly higher risks of MSDs of the back (men: 1.25, 95% CI 1.19 to 1.30 and women: HR 1.30, 95% CI 1.25 to 1.36) than younger workers (men: 1.11, 95% CI 1.03 to 1.19 and women: HR 1.19, 95% CI 1.09 to 1.32).

DISCUSSION

Summary

This study investigated the risk of chronic MSDs among people exposed to PE who work in occupations with either strenuous physical work, repetitive work or low job control. Among workers with high biomechanical workload, men and women in PE or substandard employment had increased risks of MSDs of the back when compared with workers in SE. The results suggested a dose-response type relationship among the PE groups. Among workers with repetitive work, no associations were found between PE and the risk of tendonitis, however, women in the substandard group had decreased risks. By contrast, men in PE had an increased risk of CTS. No association between PE and CTS was found for women. Among workers with low job control, PE was associated with an increased risk of

Table 3 The risk of diagnosed tendonitis or diagnosed carpal tunnel among male and female workers in precarious employment who work in occupations with repetitive work

	Tendonitis			Carpal Tunnel Syndrome		
PE categories	Cases of tendonitis, n (%)	Model 1a, HR (95% CI)	Model 2a, HR (95% CI)	Cases carpal tunnel, n (%)	Model 1b, HR (95% CI)	Model 2b, HR (95% CI)
Men, n=344 056				*Men, n=350 168*		
Precarious	1479 (2)	0.98 (0.93 to 1.05)	0.97 (0.92 to 1.04)	223 (0.3)	1.21 (1.04 to 1.41)	1.21 (1.04 to 1.41)
Substandard	2151 (2)	0.96 (0.91 to 1.01)	0.95 (0.91 to 1.00)	274 (0.3)	0.87 (0.76 to 0.99)	0.85 (0.74 to 0.97)
Standard employment	4555 (2)	1	1	701 (0.4)	1	1
Women, n=300 449				*Women, n=307 834*		
Precarious	2404 (3)	0.97 (0.92 to 1.02)	0.96 (0.91 to 1.01)	390 (0.5)	1.05 (0.92 to 1.19)	1.02 (0.90 to 1.15)
Substandard	3785 (4)	0.95 (0.91 to 0.99)	0.94 (0.90 to 0.99)	691 (0.6)	1.04 (0.94 to 1.15)	1.01 (0.92 to 1.12)
Standard employment	4509 (4)	1	1	781 (0.7)	1	1

Model 1: adjusted for age.
Model 2: age, education, civil status, native/non-native-born, decision authority at work, baseline diagnosis of depression/anxiety.
PE, precarious employment.

soft tissue disorders among men and PE was associated with an increased risk of fibromyalgia among women.

Comparison with previous studies

To our knowledge, this is the first longitudinal study to use a multidimensional construct of PE to investigate the long-term risk of MSD diagnoses among men and women in PE. Furthermore, this study offers a unique contribution, as we consider strenuous working conditions on a group level. Our findings align with a previous cross-sectional study using multidimensional measures of PE that indicated significant associations between PE and self-reported musculoskeletal health among Brazilian bus drivers and conductors in higher quartiles of precariousness.[27] Contrarily, however, an existing Swedish study found no significant association between PE and musculoskeletal pain.[23] The different outcomes investigated in the present study, and the larger-register-based sample with a special focus on three different strenuous working conditions could explain the differing results between this study and the aforementioned Swedish study. Our findings build on the existing evidence and suggest that workers exposed to PE and strenuous factors have increased long-term risks of diagnosed MSDs. However, the risk of MSDs among workers in PE varied by disorder and gender.

Interpretation of results

The elevated risks of MSDs found in this study could be attributed to two mechanisms. The first mechanism suggests that precarious employees may experience higher risks due to differential exposure within the same occupation. This means that although precarious and standard employees may hold the same job title, they might face varying work conditions. For instance, precarious workers might have less control over their schedules, fewer breaks, longer working hours or more physically demanding tasks than their counterparts. This difference in work conditions could expose precarious workers to more strenuous working conditions. Therefore, increased biomechanical strain and repetitive work could exacerbate wear and tear, leading to damage to muscles, tendons and nerves.[7 22] We found similar results when stratifying the Cox model on occupational code, which supports the argument that those in PE and SE may have differential exposure to strenuous work within the same occupation.

The second mechanism proposes a direct pathway between PE and MSDs. PE, characterised by job insecurity and lack of benefits, could directly contribute to the development of MSDs. The stress and uncertainty associated with PE could exacerbate physical ailments, potentially leading

Table 4 The risk of diagnosed soft tissue musculoskeletal disorders (MSDs) or diagnosed fibromyalgia among male and female workers in precarious employment who work in occupations with low decision authority

	Soft tissue MSDs			Fibromyalgia		
PE categories	Cases of soft tissue MSDs, n (%)	Model 1a, HR (95% CI)	Model 2a, HR (95% CI)	Cases of fibromyalgia, n (%)	Model 1b, HR (95% CI)	Model 2b, HR (95% CI)
Men, n=354 914				*Men, n=367 371*		
Precarious	3014 (5)	1.08 (1.03 to 1.12)	1.07 (1.03 to 1.12)	29 (0.04)	1.42 (0.89 to 2.26)	1.34 (0.84 to 2.14)
Substandard	4502 (5)	1.01 (0.97 to 1.04)	1.01 (0.97 to 1.05)	29 (0.03)	1.07 (0.68 to 1.67)	1.04 (0.66 to 1.62)
Standard employment	12 202 (6)	1	1	62 (0.03)	1	1
Women, n=325 284				*Women, n=336 061*		
Precarious	2564 (4)	1.04 (0.99 to 1.09)	0.98 (0.94 to 1.03)	385 (0.7)	2.20 (1.92 to 2.52)	1.91 (1.66 to 2.19)
Substandard	6333 (6)	0.99 (0.96 to 1.02)	0.95 (0.92 to 0.98)	676 (0.6)	1.74 (1.56 to 1.95)	1.54 (1.38 to 1.72)
Standard employment	10 834 (6)	1	1	587 (0.4)	1	1

Model 1: adjusted for age.
Model 2: age, education, civil status, native/non-native-born, decision authority at work, baseline diagnosis of depression/anxiety.
PE, precarious employment.

to both psychological and physical strain that manifests as MSDs. Moreover, job insecurity could discourage workers in PE from seeking early medical attention for minor injuries consequently leading to more severe MSDs.

Our results show that the risk of MSDs among workers in PE varied by disorder and sex. Men in PE had increased risks of MSDs of the back, CTS and soft tissue disorders, whereas women had increased risks of MSDs of the back and fibromyalgia. The differing results could stem from occupational segregation, as men and women may work in different sectors and be assigned different tasks. Moreover, biological differences, such as muscle mass, bone density and hormonal influences, can affect susceptibility to MSDs.[35 36] For example, women are more prone to conditions like fibromyalgia, which has been associated with hormonal and stress-related factors that could be further exacerbated by being in PE. We also found that PE was associated with a higher risk of MSDs of the back among older workers than younger workers. Older workers might face increased difficulties in physically demanding roles as physical capabilities and musculoskeletal health generally deteriorate with age. Moreover, older workers might have been exposed to more strenuous working conditions for a more extensive period compared with younger workers. While PE is more common among younger workers, it is important to acknowledge that PE is also prevalent among older workers and that the health effects of PE might differ between age groups.

Overall, the results suggest that current workplace health and safety regulations might not adequately protect the musculoskeletal health of workers in PE. Thus, our findings underscore the need for targeted OSH interventions and stronger workplace safety regulations to protect these vulnerable workers.[19 20] Additionally, employers and policymakers should recognise and address psychosocial stressors related to organisational factors such as economic pressures, and lack of rights, as well as limited access to care and social benefits, all of which might contribute to poor musculoskeletal health among workers in PE.[10]

Strengths and weaknesses

A limitation of this study is the potential for residual and uncontrolled confounding, as we could not account for various lifestyle factors such as body mass index or leisure-time physical activity, which might influence the relationship between PE and MSDs. Although adjusting for education can serve as a rough proxy for lifestyle factors since such factors can vary among different socioeconomic groups in Sweden.[37]

The SWIP cohort does not contain data from primary care, and most cases of MSDs can be solely diagnosed and managed in primary healthcare. In Sweden, the prevalence of people seeking primary care for MSDs is high, estimated at almost 60% of all patients in 2000.[38] Therefore, a significant portion of the population affected by milder cases of MSDs managed in primary care is not captured in this study.

The JEMs allowed for the estimation of workplace conditions within the register-based cohort. However, it should be noted that the JEMs can only provide an aggregated measure of workplace conditions at the occupational level.

It is also important to consider that the generalisability of our findings may be limited due to the focus on the Swedish population. Sweden has specific labour market conditions and social policies which may not reflect the employment contexts of other countries. As a result, the associations observed in this study may differ in populations with different regulatory environments, social protections or labour market structures. It could be possible that stronger associations may be found in countries with less welfare state policies.

A strength of this study is the large study population, which enabled the investigation of different samples of workers, those with (1) high biomechanical workload, (2) repetitive work or (3) low job control. Additionally, register-based studies like this one do not experience attrition bias. The investigation of diagnosed MSDs is a further strength of this study. As it has been suggested that case definitions for MSDs in occupational epidemiological research should not be based on self-reported symptoms alone.[39]

Our use of a multidimensional construct (SWE-ROPE) to measure PE is an additional advantage as it helps to reduce misclassification of PE, misclassification could be higher when only using a single dimension of PE, such as temporary employment. The SWE-ROPE was developed following the suggested dimensions of PE and has demonstrated its effectiveness in capturing the target population.[32] It should be noted that the exposure to PE was only measured at the 2010 baseline, therefore, this study does not account for employment transitions which have been observed among workers in PE in previous studies.[13] However, existing literature suggests that young adults, a group disproportionately exposed to PE in our sample, have a significantly higher risk of remaining in PE 10 years after the first PE measurement compared with peers in SE.[40]

CONCLUSION

This longitudinal study found an increased risk of diagnosed MSDs among workers in PE and poor working conditions. We conclude that the elevated risks of MSDs are likely due to differential exposure within the same occupation between precarious and standard employees or due to a direct pathway between PE and MSDs. Strengthening employment regulations and ensuring the enforcement of OSH measures could help mitigate the musculoskeletal risks associated with poor working conditions. These findings emphasise the need for targeted interventions and robust policy measures to safeguard the health and well-being of vulnerable workers in PE arrangements.

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Funding The project was funded by FORTE, The Swedish Research Council for Health, Working Life and Welfare, with no. 2019-01226.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved. Regional Ethics Board of Stockholm granted ethical permission for the study (no. 2017/1224-31/2 and 2018/1675-32). This is a register-based study and informed consent is not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data may be obtained from a third party and are not publicly available.

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REFERENCES

1 EU-OSHA. Work-related musculoskeletal disorders: why are they still so prevalent? Evidence from a literature review. 2020. Available: https://euosha.blumm.it/bundles/app/assets/website/download/Work_related_musculoskeletal_disorders_why_so_prevalent_report.pdf
2 Longo D, *et al*. Harrison's Principles of Internal Medicine. McGraw-Hill Education / Medical, 2015.
3 Bevan S. Economic impact of musculoskeletal disorders (MSDs) on work in Europe. *Best Pract Res Clin Rheumatol* 2015;29:356–73.
4 Bernal D, Campos-Serna J, Tobias A, *et al*. Work-related psychosocial risk factors and musculoskeletal disorders in hospital nurses and nursing aides: a systematic review and meta-analysis. *Int J Nurs Stud* 2015;52:635–48.
5 Bezzina A, Austin E, Nguyen H, *et al*. Workplace Psychosocial Factors and Their Association With Musculoskeletal Disorders: A Systematic Review of Longitudinal Studies. *Workplace Health Saf* 2023;71:578–88.
6 da Costa BR, Vieira ER. Risk factors for work-related musculoskeletal disorders: A systematic review of recent longitudinal studies. *Am J Ind Med* 2010;53:285–323.
7 Punnett L, Wegman DH. Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. *J Electromyogr Kinesiol* 2004;14:13–23.
8 Heneweer H, Staes F, Aufdemkampe G, *et al*. Physical activity and low back pain: a systematic review of recent literature. *Eur Spine J* 2011;20:826–45.
9 Muggleton JM, Allen R, Chappell PH. Hand and arm injuries associated with repetitive manual work in industry: a review of disorders, risk factors and preventive measures. *Ergonomics* 1999;42:714–39.
10 Hauke A, Flintrop J, Brun E, *et al*. The impact of work-related psychosocial stressors on the onset of musculoskeletal disorders in specific body regions: A review and meta-analysis of 54 longitudinal studies. *W & S* 2011;25:243–56.
11 Bodin T, Çağlayan Ç, Garde AH, *et al*. Precarious employment in occupational health – an OMEGA-NET working group position paper. *Scand J Work Environ Health* 2020;46:321–9.
12 Rönnblad T, Grönholm E, Jonsson J, *et al*. Precarious employment and mental health: a systematic review and meta-analysis of longitudinal studies. *Scand J Work Environ Health* 2019;45:3797:429–43:.
13 Matilla-Santander N, Muntaner C, Kreshpaj B, *et al*. Trajectories of precarious employment and the risk of myocardial infarction and stroke among middle-aged workers in Sweden: A register-based cohort study. *Lancet Reg Health Eur* 2022;15:100314.
14 Matilla-Santander N, Matthews AA, Gunn V, *et al*. Causal effect of shifting from precarious to standard employment on all-cause mortality in Sweden: an emulation of a target trial. *J Epidemiol Community Health* 2023;77:736–43.
15 Donnelly R. Precarious Work in Midlife: Long-Term Implications for the Health and Mortality of Women and Men. *J Health Soc Behav* 2022;63:142–58.
16 Kreshpaj B, Orellana C, Burström B, *et al*. What is precarious employment? A systematic review of definitions and operationalizations from quantitative and qualitative studies. *Scand J Work Environ Health* 2020;46:3875:235–47:.
17 Benach J, Muntaner C. Precarious employment and health: developing a research agenda. *J Epidemiol Community Health* 2007;61:276–7.
18 Afsharian A, Dollard MF, Glozier N, *et al*. Work-related psychosocial and physical paths to future musculoskeletal disorders (MSDs). *Saf Sci* 2023;164:106177.
19 Park J, Han B, Park J-S, *et al*. Nonstandard workers and differential occupational safety and health vulnerabilities. *Am J Ind Med* 2019;62:701–15.
20 Quinlan M, Mayhew C, Bohle P. The global expansion of precarious employment, work disorganization, and consequences for occupational health: a review of recent research. *Int J Health Serv* 2001;31:335–414.
21 Benavides FG, Benach J, Muntaner C, *et al*. Associations between temporary employment and occupational injury: what are the mechanisms? *Occup Environ Med* 2006;63:416–21.
22 Punnett L. Musculoskeletal disorders and occupational exposures: how should we judge the evidence concerning the causal association? *Scand J Public Health* 2014;42:49–58.
23 Jonsson J, Matilla-Santander N, Kreshpaj B, *et al*. Precarious employment and general, mental and physical health in Stockholm, Sweden: a cross-sectional study. *Scand J Public Health* 2021;49:228–36.
24 Kim I-H, Khang Y-H, Muntaner C, *et al*. Gender, precarious work, and chronic diseases in South Korea. *Am J Ind Med* 2008;51:748–57.
25 Park S, Lee J-H. Precarious Employment and Increased Incidence of Musculoskeletal Pain among Wage Workers in Korea: A Cross-Sectional Study. *IJERPH* 2021;18:6299.
26 Matilla-Santander N, González-Marrón A, Martín-Sánchez JC, *et al*. Precarious employment and health-related outcomes in the European Union: a cross-sectional study. *Crit Public Health* 2020;30:429–40.
27 Simões MRL, Souza C, Alcantara MA de, *et al*. Precarious working conditions and health of metropolitan bus drivers and conductors in Minas Gerais, Brazil. *Am J Ind Med* 2019;62:996–1006.
28 Ludvigsson JF, Almqvist C, Bonamy A-KE, *et al*. Registers of the Swedish total population and their use in medical research. *Eur J Epidemiol* 2016;31:125–36.
29 SCB SS. SSYK 1996 standard for svensk yrkesklassificering 1996 (Swedish standard classification of occupations 1996. 2001. Available: https://www.scb.se/contentassets/50bf86d2c66149d696f515a9481bc9e2/ov9999_1998a01_br_x70op9803.pdf
30 Badarin K, Hemmingsson T, Hillert L, *et al*. Physical workload and increased frequency of musculoskeletal pain: a cohort study of employed men and women with baseline occasional pain. *Occup Environ Med* 2021;78:558–66.
31 Almroth M, Hemmingsson T, Sörberg Wallin A, *et al*. Psychosocial working conditions and the risk of diagnosed depression: a Swedish register-based study. *Psychol Med* 2021;52:1–9.
32 Jonsson J, Matilla-Santander N, Kreshpaj B, *et al*. Exploring multidimensional operationalizations of precarious employment in Swedish register data - a typological approach and a summative score approach. *Scand J Work Environ Health* 2021;47:3928:117–26:.
33 Socialstyrelsen. National patient register. 2019. Available: https://www.socialstyrelsen.se/en/statistics-and-data/registers/national-patient-register
34 Jonsson J, Muntaner C, Bodin T, *et al*. Low-quality employment trajectories and risk of common mental disorders, substance use disorders and suicide attempt: a longitudinal study of the Swedish workforce. *Scand J Work Environ Health* 2021;47:509–20.
35 Côté JN. A critical review on physical factors and functional characteristics that may explain a sex/gender difference in work-related neck/shoulder disorders. *Ergonomics* 2012;55:173–82.
36 Hooftman WE, van Poppel MN, van der Beek AJ, *et al*. Gender differences in the relations between work-related physical and psychosocial risk factors and musculoskeletal complaints. *Scand J Work Environ Health* 2004;30:261–78.
37 Mäki NE, Martikainen PT, Eikemo T, *et al*. The potential for reducing differences in life expectancy between educational groups in five European countries: the

effects of obesity, physical inactivity and smoking. *J Epidemiol Community Health* 2014;68:635–40.
38 Wiitavaara B, Fahlström M, Djupsjöbacka M. Prevalence, diagnostics and management of musculoskeletal disorders in primary health care in Sweden - an investigation of 2000 randomly selected patient records. *J Eval Clin Pract* 2017;23:325–32.
39 Tamminga SJ, Kuijer P, Badarin K, *et al*. Towards harmonisation of case definitions for eight work-related musculoskeletal disorders - an international multi-disciplinary Delphi study. *BMC Musculoskelet Disord* 2021;22:1018.
40 Thern E, Matilla-Santander N, Bodin T, *et al*. Precarious employment at a young age and labor-market marginalization during middle-adulthood: A register-linked cohort study. *Scand J Work Environ Health* 2023;49:201–10.