

Preplanned Studies

Impact of Rest Break, Shift Work, and Overtime on Musculoskeletal Disorders — China, 2018–2023

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Summary

What is already known about this topic?

Impact of individual and biomechanical risk factors on musculoskeletal disorders (MSDs) has been researched; however, the factors of intervenable work organization (e.g., overtime and rest breaks) require in-depth investigation, particularly in the context of national policy changes in China by 2025.

What is added by this report?

Among 88,609 participants, 37.5% (33,247/88,609) had MSDs. We found that working hours [prevalence ratio (*PR*)=1.18], shift work (lower back, elbows, hips/thighs, and ankles/feet, *P*<0.05), overtime (*PR*=1.23), staff shortages (*PR*=1.23), covering for absent coworkers (*PR*=1.18), and resuming work after rest (*PR*=1.09) were all likely associated with a significantly increased prevalence of MSDs and pain scores in several body parts (*P*<0.05).

What are the implications for public health practice?

Our findings contribute to efforts to standardize work organization management to prevent MSDs, providing reference for employers and policymakers to regulate rest breaks, manage overtime, and ensure adequate levels of staffing to comply with occupational health regulations.

examine the association between work organization and MSDs, while pain scores were collected to analyze the association with work organization.

Results: Among the participants, 37.5% (33,247/88,609) had MSDs. The most prevalent MSDs were in the neck (22.4%, 19,835/88,609), shoulders (18.7%, 16,535/88,609), and lower back (14.9%, 11,415/88,609). Regarding work organization, the results suggested that working hours [prevalence ratio (*PR*)=1.18], shift work (lower back, elbows, hips/thighs, and ankles/feet, *P*<0.05), overtime (*PR*=1.23), staff shortages (*PR*=1.23), working for colleagues (*PR*=1.18), and resuming work after rest (*PR*=1.09) were likely associated with a significantly increased prevalence of MSDs and pain scores in several body parts (*P*<0.05).

Conclusions: This study showed a positive association between MSD prevalence and factors related to poor work organization, providing evidence on the risks to workers' musculoskeletal health. The findings of this study could be useful for employers and policymakers responsible for managing work environments.

ABSTRACT

Introduction: This study aimed to explore the association between work organization and musculoskeletal disorders (MSDs).

Methods: A cross-sectional analysis of 88,609 participants was conducted between 2018 and 2023 across seven regions of China. Work organization exposure was assessed using the Chinese version of the MSDs Questionnaire. MSDs were determined using the criteria of the US National Institute for Occupational Safety and Health for musculoskeletal injuries. Log-binomial regression was employed to

Musculoskeletal disorders (MSDs) are a major global public health concern. The affected proportion has increased with the aging global population; an estimated 1.69 billion individuals are affected, an increase of 26.1% from 2010 (1.48 billion) (1). The most commonly reported risk factors for MSDs are demographic variables such as sex, age, and smoking, followed by physically demanding work and psychosocial variables (2), indicating that MSDs are common among occupational populations. In China, recently, a nationwide survey of 15 key industries estimated the standardized prevalence of MSDs to be as high as 41.2% (3). Occupational MSDs, such as bursal synovitis and carpal tunnel syndrome, were

included in the List of Occupational Diseases by China in 2025. Since then, MSDs have become an important topic in China as well.

MSD risk factors can be categorized as work- and non-work-related factors. Work-related factors such as shift work, frequency and duration of overtime, work and rest breaks, and level of staffing are associated with the development of MSDs. Several studies have supported the efficacy of interventions aimed at reducing musculoskeletal fatigue and improving work efficiency by adjusting for factors such as break frequency, rest duration, and work type (4). Although work organization is important for the prevention of MSDs, research on the impact of these factors on MSDs is insufficient to provide systematic evidence. Therefore, the present study aimed to investigate the effects of work organizations on MSDs in a large sample of the Chinese occupational population, which may serve as a reference for developing interventions targeting work organizations.

This cross-sectional study was based on a national occupational survey conducted by the National Institute of Occupational Health and Poison Control of the Chinese Center for Disease Control and Prevention. This survey selected 29 key industries with large populations and potentially MSDs-relation in seven regions of China (north, east, central, south, southwest, northwest, and northeast). Stratified random sampling categorized enterprises into three classes (large, medium, and small), and representative enterprises were selected. A total of 72 large, 48 medium-sized, and 321 small enterprises were enrolled in this study. All workers with working age ≥ 1 year who met the inclusion and exclusion criteria were recruited as participants. Building on a previous occupational survey (3), the sample size was increased to 88,609 participants. The inclusion criteria were as follows: 1) ≥ 1 year of working age and 2) voluntary participation. The exclusion criteria were as follows: 1) pregnancy, rheumatoid arthritis, congenital spinal diseases, tumors, and other serious diseases, and 2) having undergone severe trauma or major surgery during the previous year. This study was approved by the Medical Ethical Review Committee of the aforementioned institute and all participants provided informed consent.

This survey was conducted between January 1, 2022, and December 31, 2024. To collect information, we used the Chinese version of the MSDs questionnaire and an electronic questionnaire based on the Nordic Musculoskeletal Questionnaire. The survey

was conducted face-to-face; each investigator organized multiple respondents to respond to the questionnaire system and assisted them in defining key terms. The questionnaire was programmed with built-in consistency checks to reduce data entry errors. After collection, the staff reviewed the data for accuracy and completeness of selected items. The criteria of the US National Institute for Occupational Safety and Health for musculoskeletal injuries were used to determine MSDs; the cases were defined as musculoskeletal discomfort within the past year and episodes of discomfort ≥ 1 time (discomfort exceeding a week-long period) (5). Work organization was self-reported, and each participant was asked about their work organization exposure. The pain scores of body parts were assessed using a self-reported 11-point scale as: 0="no pain" and 10="extreme pain".

All statistical analyses were performed using SPSS software (version 26.0; IBM Corp., Armonk, NY, USA). Normally distributed continuous variables were expressed as mean $\pm$ standard deviation (SD) and analyzed using the Student's *t*-test or one-way analysis of variance (ANOVA). The skewed distribution of continuous variables was expressed as median values (P_{25} , P_{75}) and analyzed using the Wilcoxon rank-sum test or the Kruskal-Wallis H test. Categorical variables were expressed as frequency (%) and analyzed using χ^2 test or Fisher's exact test. For significant differences in pain scores between the groups, pairwise multiple comparisons were used (Bonferroni correction). Log-binomial regression was applied to assess the associations between work organization and MSD prevalence while adjusting for covariates.

In the current study, 88,609 participants were included (Table 1), of whom 67.7% (59,989/88,609) were males. The mean age was 32.32 years (32.32 ± 9.16). The mean working age was 7.51 years (7.51 ± 7.19). Among the study participants, 37.5% had MSDs (any body part). The most prevalent MSDs were located in the neck (22.4%, 19,835/88,609), shoulders (18.7%, 16,535/88,609), and lower back (14.9%, 13,194/88,609). With regard to work organization and MSDs, those in jobs with exposure to extended hours/day (working hours > 8 hours/day or overtime), staff shortages, working to cover absent colleagues, and those who resumed work after rest were more likely to have a higher prevalence rate of MSDs. Conversely, workers with the option of rest or work and sufficient rest time were more likely to have a lower prevalence of MSDs.

Statistically significant differences in pain scores

TABLE 1. Work organization characteristics of study participants in 2018–2023.

Characteristic	Any body part n (%)	Neck n (%)	Shoulders n (%)	Upper back n (%)	Lower back n (%)	Elbows n (%)	Wrists/hands n (%)	Hips/thighs n (%)	Knees n (%)	Ankles/feet n (%)
Rest break frequency (time)										
≤1	12,179 (39.8)	7,702 (25.2)	6,438 (21.0)	4,436 (14.5)	4,852 (15.9)	2,194 (7.2)	3,774 (12.3)	3,191 (10.4)	3,057 (10.0)	3,468 (11.3)
2	9,015 (35.9)	5,355 (21.3)	4,449 (17.7)	2,981 (11.9)	3,515 (14.0)	1,610 (6.4)	2,674 (10.6)	2,255 (9.0)	2,280 (9.1)	2,681 (10.7)
≥3	12,053 (36.6)	6,778 (20.6)	5,648 (17.2)	3,998 (12.2)	4,827 (14.7)	2,170 (6.6)	3,990 (12.1)	2,997 (9.1)	3,268 (9.9)	4,260 (13.0)
Rest break duration (min)										
≤10	9,967 (37.5)	6,071 (22.8)	5,098 (19.2)	3,696 (13.9)	3,898 (14.7)	2,089 (7.9)	3,542 (13.3)	2,747 (10.3)	2,844 (10.7)	3,491 (13.1)
>10 to 30	10,299 (38.9)	6,196 (23.4)	5,203 (19.7)	3,539 (13.4)	4,197 (15.9)	1,888 (7.1)	3,115 (11.8)	2,625 (9.9)	2,667 (10.1)	3,027 (11.4)
>30 to 60	7,712 (36.7)	4,555 (21.7)	3,745 (17.8)	2,536 (12.1)	3,088 (14.7)	1,271 (6.0)	2,276 (10.8)	1,916 (9.1)	1,943 (9.2)	2,266 (10.8)
>60	5,269 (36.2)	3,013 (20.7)	2,489 (17.1)	1,644 (11.3)	2,011 (13.8)	726 (5.0)	1,505 (10.4)	1,155 (7.9)	1,151 (7.9)	1,625 (11.2)
Working days per week (days)										
≤5	14,384 (39.1)	9,073 (24.6)	7,391 (20.1)	4,944 (13.4)	5,597 (15.2)	2,296 (6.2)	4,005 (10.9)	3,435 (9.3)	3,502 (9.5)	4,282 (11.6)
>5 to 7	18,863 (36.4)	10,762 (20.8)	9,144 (17.7)	6,471 (12.5)	7,597 (14.7)	3,678 (7.1)	6,433 (12.4)	5,008 (9.7)	5,103 (9.9)	6,127 (11.8)
Working (h/day)										
≤8	16,059 (35.0)	9,870 (21.5)	8,032 (17.5)	5,473 (11.9)	6,368 (13.9)	2,787 (6.1)	4,571 (10.0)	3,863 (8.4)	4,066 (8.9)	4,467 (9.7)
>8	17,188 (40.3)	9,965 (23.4)	8,503 (19.9)	5,942 (13.9)	6,826 (16.0)	3,187 (7.5)	5,867 (13.7)	4,580 (10.7)	4,539 (10.6)	5,942 (13.9)
Shift work system										
Fixed day shift	13,194 (35.1)	7,903 (21.1)	6,589 (17.6)	4,236 (11.3)	5,130 (13.7)	2,248 (6.0)	3,961 (10.6)	3,023 (8.1)	3,194 (8.5)	3,257 (8.7)
Fwo-shift	12,723 (38.2)	7,298 (21.9)	6,165 (18.5)	4,430 (13.3)	4,922 (14.8)	2,359 (7.1)	4,446 (13.3)	3,311 (9.9)	3,364 (10.1)	4,935 (14.8)
Fthree-shift	3,024 (41.0)	1,814 (24.6)	1,459 (19.8)	1,074 (14.6)	1,299 (17.6)	563 (7.6)	875 (11.9)	949 (12.9)	899 (12.2)	988 (13.4)
Four-shift	1,806 (41.1)	1,168 (26.6)	999 (22.7)	801 (18.2)	851 (19.3)	446 (10.1)	582 (13.2)	585 (13.3)	571 (13.0)	613 (13.9)
Other	2,500 (41.7)	1,652 (27.6)	1,323 (22.1)	874 (14.6)	992 (16.5)	358 (6.0)	574 (9.6)	575 (9.6)	577 (9.6)	616 (10.3)
Overtime	18,429 (42.3)	10,942 (25.1)	9,265 (21.3)	6,601 (15.1)	7,566 (17.4)	3,678 (8.4)	6,319 (14.5)	5,151 (11.8)	5,291 (12.1)	6,704 (15.4)
Sufficient rest	12,353 (27.3)	6,728 (14.9)	5,441 (12.0)	3,370 (7.5)	4,188 (9.3)	1,741 (3.8)	3,209 (7.1)	2,438 (5.4)	2,510 (5.5)	2,988 (6.6)
Resumed work after rest	31,055 (38.1)	18,515 (22.7)	15,527 (19.1)	10,666 (13.1)	12,349 (15.2)	5,522 (6.8)	9,754 (12.0)	7,886 (9.7)	8,057 (9.9)	9,805 (12.0)
Decide work time	5,521 (33.4)	3,150 (19.1)	2,668 (16.2)	1,866 (11.3)	2,113 (12.8)	1,084 (6.6)	1,548 (9.4)	1,326 (8.0)	1,457 (8.8)	1,513 (9.2)
Decide rest time	6,012 (31.0)	3,331 (17.2)	2,860 (14.7)	1,888 (9.7)	2,313 (11.9)	1,051 (5.4)	1,662 (8.6)	1,387 (7.2)	1,525 (7.9)	1,514 (7.8)
Staff shortage	17,512 (45.4)	10,977 (28.4)	9,221 (23.9)	6,747 (17.5)	7,528 (19.5)	3,721 (9.6)	5,923 (15.3)	5,177 (13.4)	5,282 (13.7)	6,140 (15.9)
Often work to cover a colleague	6,146 (48.1)	4,120 (32.2)	3,428 (26.8)	2,635 (20.6)	2,895 (22.6)	1,561 (12.2)	2,200 (17.2)	2,041 (16.0)	2,109 (16.5)	2,310 (18.1)
Total (N)	33,247 (37.5)	19,835 (22.4)	16,535 (18.7)	11,415 (12.9)	13,194 (14.9)	5,974 (6.7)	10,438 (11.8)	8,443 (9.5)	8,605 (9.7)	10,409 (11.7)

were associated with differences in the following factors: rest break frequency and duration, working days/week, working hours per day, shift work, overtime, sufficient rest, resumed work after rest, option of rest or work time, staff shortage, and working to cover absent colleagues ($P<0.05$) (Table 2). Further pairwise comparisons showed that less frequent rest breaks (≤ 1 time) group had higher pain scores (neck, shoulders, and lower back) than >1 time group, rest break duration ≤ 10 minutes group had higher neck pain score than 10–30 minutes group, and fixed day shift group had less pain scores (neck, shoulders, and lower back) than three- and four-shift groups ($P<0.05$) (Supplementary Table S1, available at <https://weekly.chinacdc.cn/>).

In Table 3, Supplementary Table S2, and Supplementary Table S3 (available at <https://weekly.chinacdc.cn/>), the log-binomial regression analysis showed that participants who often worked to cover absent colleagues or were affected by staff shortages were 1.18 or 1.23 times more likely to develop MSDs, respectively ($P<0.05$). Workers who resumed work after rest had a significantly higher prevalence of MSDs [prevalence ratio (PR)=1.09, $P<0.05$]. The PR for workers who usually worked overtime, more than 5 days/week, or 8 hours/day were 1.23, 1.09, and 1.18, respectively ($P<0.05$). Similarly, those who worked in two-, three-, or four-shift work systems were more likely to develop MSDs (lower back, elbows, hips/thighs, and ankles/feet) ($P<0.05$). Conversely, opting for rest time, rest break frequency >1 time, and sufficient rest were protective factors against MSDs ($P<0.05$).

DISCUSSION

MSDs are common worldwide and have considerable impacts on occupational and public health. The changing nature of the work environment over the past decades has increased the complexity of assessing risk factors for MSDs, and focusing on work organization factors is important for mitigating this risk. However, studies on the impact of work organization on MSDs based on a large population are limited. The data used in this study were obtained from a national occupational survey database (2018 to 2023) investigating workers in key industries since 2018.

In this study, we found that the prevalence of MSDs among the occupational population was 37.5%, and

the three body parts with the highest rates of MSDs were the neck, shoulders, and lower back. These results are consistent with those of a previous relevant study (6). As a common factor, work organization is an essential component of the occupational system. After controlling for various sociodemographic factors, we found a positive association between the prevalence of MSDs in any body part and the following factors: working days >5 days/week; working hours > 8 hours/day; overtime; resuming work after rest; staff shortages; and working to cover absent colleagues. This could be because of staying longer in a job compresses rest time, which adversely affects the musculoskeletal restitution of work-time-stressed areas, thereby increasing the likelihood of MSDs (7). Prior research has reported that job rotation, staff shortage, frequent overtime, and abundant resting time all influence the likelihood of MSDs (8). Additionally, we found a significant positive correlation between MSDs in the shift work groups. Shift work, entailing two-, three-, or four-shift rotations during workdays, requires workers to work frequently in the evening or at night. Although the mechanism underlying increased MSDs due to shift work is not well understood, it is likely that shift work disrupts circadian rhythms and sleep patterns. This disruption can contribute to sleep complicate musculoskeletal recovery (9).

Notably, the pain scores reported by workers in shift work, extended hours/day, lower rest break frequency, and staff shortage situations were higher than those in groups without the above situations, possibly due to a reduction in rest time. It has also been observed previously that the higher the work-time ratio, the greater the chance of neck or shoulder pain (10).

This study has several limitations. First, the data were obtained through a questionnaire. The accuracy of the answers depended on how well each participant could remember the work factors and musculoskeletal discomfort, possibly leading to recall bias in the data. Second, as an observational (rather than experimental) study, the causality between work organization and MSDs cannot be determined.

In conclusion, the prevalence of MSDs among workers in a study population representing key industries in China was 37.5% (33,247/88,609). The highest rates of MSDs were observed in the neck, shoulders, and lower back. A positive association was found between MSD prevalence and the following work organization factors: working days >5 days/week; working hours >8 hours/day; shift work (two-, three-,

TABLE 2. Analysis of MSDs pain scores and work organization factors.

Characteristic	Neck		Shoulders		Upper back		Lower back		Elbows		Wrists/hands		Hips/thighs		Knees		Ankles/feet	
	M (P ₂₅ , P ₇₅)	Z/H	M (P ₂₅ , P ₇₅)	Z/H	M (P ₂₅ , P ₇₅)	Z/H	M (P ₂₅ , P ₇₅)	Z/H	M (P ₂₅ , P ₇₅)	Z/H	M (P ₂₅ , P ₇₅)	Z/H	M (P ₂₅ , P ₇₅)	Z/H	M (P ₂₅ , P ₇₅)	Z/H	M (P ₂₅ , P ₇₅)	Z/H
Rest break frequency (time)																		
≤1	0 (0, 5)	0 (0, 4)	0 (0, 4)	0 (0, 0)	0 (0, 0)	0 (0, 2)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
2	0 (0, 4)	513.0*§	0 (0, 3)	338.6*§	0 (0, 0)	206.3*§	0 (0, 0)	74.5*§	0 (0, 0)	32.4*§	0 (0, 0)	81.4*§	0 (0, 0)	123.1*§	0 (0, 0)	58.8*§	0 (0, 0)	74.5*§
≥3	0 (0, 4)	0 (0, 3)	0 (0, 3)	0 (0, 0)	0 (0, 0)	0 (0, 1)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
Rest break duration (min)																		
≤10	0 (0, 5)	0 (0, 4)	0 (0, 4)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
>10 to 30	0 (0, 4)	42.0*§	0 (0, 4)	59.1*§	0 (0, 0)	59.1*§	0 (0, 3)	102.4*§	0 (0, 0)	150.5*§	0 (0, 0)	93.9*§	0 (0, 0)	64.1*§	0 (0, 0)	84.2*§	0 (0, 0)	56.6*§
>30 to 60	0 (0, 4)	0 (0, 4)	0 (0, 4)	0 (0, 0)	0 (0, 0)	0 (0, 2)	0 (0, 2)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
>60	0 (0, 4)	0 (0, 4)	0 (0, 4)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
Working days per week (days)																		
≤5	0 (0, 5)	-20.5†§	0 (0, 4)	-15.1†§	0 (0, 0)	-7.5†§	0 (0, 2)	-2.9†§	0 (0, 0)	7.5†§	0 (0, 0)	6.3†§	0 (0, 0)	0.4	0 (0, 0)	-0.8	0 (0, 0)	-0.2
>5 to 7	0 (0, 4)	0 (0, 3)	0 (0, 3)	0 (0, 0)	0 (0, 0)	0 (0, 1)	0 (0, 1)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
Working (h/day)																		
≤8	0 (0, 4)	3.1†§	0 (0, 4)	6.2†§	0 (0, 0)	7.8†§	0 (0, 1)	4.9†§	0 (0, 0)	7.7†§	0 (0, 0)	17.5†§	0 (0, 0)	8.2†§	0 (0, 0)	5.9†§	0 (0, 0)	19.7†§
>8	0 (0, 5)	0 (0, 4)	0 (0, 4)	0 (0, 0)	0 (0, 0)	0 (0, 2)	0 (0, 2)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
Shift work system																		
Fixed day shift	0 (0, 4)	0 (0, 4)	0 (0, 4)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
Two-shift	0 (0, 4)	0 (0, 3)	0 (0, 3)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
Three-shift	0 (0, 5)	685.3*§	0 (0, 4)	432.0*§	0 (0, 0)	485.0*§	0 (0, 4)	426.9*§	0 (0, 0)	304.4*§	0 (0, 0)	216.3*§	0 (0, 0)	571.1*§	0 (0, 0)	467.0*§	0 (0, 0)	983.4*§
Four-shift	0 (0, 5)	0 (0, 5)	0 (0, 5)	0 (0, 4)	0 (0, 4)	0 (0, 5)	0 (0, 5)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 2)	0 (0, 1)	0 (0, 1)	0 (0, 1)
Other	0 (0, 5)	0 (0, 5)	0 (0, 5)	0 (0, 0)	0 (0, 0)	0 (0, 3)	0 (0, 3)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
Overtime	0 (0, 5)	22.3†§	0 (0, 4)	23.2†§	0 (0, 0)	21.6†§	0 (0, 3)	21.7†§	0 (0, 0)	21.2†§	0 (0, 0)	26.9†§	0 (0, 0)	22.8†§	0 (0, 0)	24.2†§	0 (0, 1)	38.0†§
Sufficient rest	0 (0, 2)	-71.8†§	0 (0, 0)	-66.6†§	0 (0, 0)	-61.8†§	0 (0, 0)	-60.1†§	0 (0, 0)	-43.6†§	0 (0, 0)	-56.2†§	0 (0, 0)	-53.4†§	0 (0, 0)	-53.3†§	0 (0, 0)	-60.1†§
Resumed work after rest	0 (0, 5)	19.1†§	0 (0, 4)	18.6†§	0 (0, 0)	11.9†§	0 (0, 2)	14.4†§	0 (0, 0)	5.6†§	0 (0, 0)	13.2†§	0 (0, 0)	9.3†§	0 (0, 0)	11.3†§	0 (0, 0)	15.1†§
Decide work time	0 (0, 4)	-17.7†§	0 (0, 2)	-16.8†§	0 (0, 0)	-12.8†§	0 (0, 0)	-14.9†§	0 (0, 0)	-4.8†§	0 (0, 0)	-17.4†§	0 (0, 0)	-12.4†§	0 (0, 0)	-11.7†§	0 (0, 0)	-18.3†§
Decide rest time	0 (0, 3)	-26.3†§	0 (0, 1)	-24.2†§	0 (0, 0)	-20.3†§	0 (0, 0)	-18.9†§	0 (0, 0)	-11.8†§	0 (0, 0)	-21.8†§	0 (0, 0)	-18.1†§	0 (0, 0)	-16.8†§	0 (0, 0)	-25.6†§
Staff shortage	0 (0, 5)	55.2†§	0 (0, 5)	48.6†§	0 (0, 3)	48.2†§	0 (0, 4)	44.8†§	0 (0, 0)	38.5†§	0 (0, 1)	38.3†§	0 (0, 0)	45.6†§	0 (0, 0)	47.2†§	0 (0, 2)	44.1†§
Often work to cover a colleague	0 (0, 5)	34.6†§	0 (0, 5)	31.0†§	0 (0, 4)	33.7†§	0 (0, 5)	31.0†§	0 (0, 0)	30.3†§	0 (0, 3)	23.6†§	0 (0, 1)	32.0†§	0 (0, 2)	33.9†§	0 (0, 3)	28.1†§

* Wilcoxon rank-sum test;

† Kruskal-Wallis H test.

§ P<0.05.

TABLE 3. Prevalence ratios and 95% confidence intervals (CI) of work organization for MSDs.

Characteristic	Any body part PR (95% CI)	Neck PR (95% CI)	Shoulders PR (95% CI)	Lower back PR (95% CI)
Rest break frequency (time)				
≤1	Ref	Ref	Ref	Ref
2	0.97 (0.95, 0.99)*	0.96 (0.93, 0.99)*	0.96 (0.92, 0.99)*	0.98 (0.94, 1.02)
≥3	0.98 (0.95, 0.99)*	0.97 (0.94, 1.01)	0.98 (0.94, 1.02)	1.01 (0.96, 1.05)
Rest break duration (min)				
≤10	Ref	Ref	Ref	Ref
>10 to 30	1.01 (0.99, 1.03)	0.99 (0.96, 1.02)	0.99 (0.96, 1.03)	1.02 (0.98, 1.06)
>30 to 60	0.99 (0.97, 1.01)	0.96 (0.92, 0.99)*	0.95 (0.91, 0.99)*	1.00 (0.96, 1.05)
>60	0.98 (0.96, 1.01)	0.93 (0.89, 0.97)*	0.93 (0.89, 0.97)*	0.97 (0.92, 1.02)
Working days per week (days)				
≤5	Ref	Ref	Ref	Ref
>5 to 7	1.09 (1.07, 1.11)*	1.09 (1.06, 1.13)*	1.12 (1.08, 1.16)*	1.09 (1.05, 1.14)*
Working (h/day)				
≤8	Ref	Ref	Ref	Ref
>8	1.18 (1.15, 1.20)*	1.17 (1.14, 1.21)*	1.21 (1.17, 1.25)*	1.24 (1.19, 1.28)*
Shift work system				
Fixed day shift	Ref	Ref	Ref	Ref
Two-shift	1.02 (0.99, 1.05)	1.01 (0.96, 1.04)	1.02 (0.97, 1.07)	1.10 (1.04, 1.16)*
Three-shift	1.03 (0.99, 1.06)	0.97 (0.93, 1.03)	0.98 (0.93, 1.04)	1.12 (1.05, 1.19)*
Four-shift	1.03 (0.98, 1.08)	0.99 (0.93, 1.06)	1.03 (0.96, 1.11)	1.16 (1.07, 1.26)*
Other	0.99 (0.96, 1.04)	0.97 (0.92, 1.02)	0.98 (0.92, 1.03)	1.02 (0.95, 1.09)
Overtime	1.23 (1.20, 1.25)*	1.26 (1.22, 1.29)*	1.27 (1.23, 1.31)*	1.29 (1.24, 1.34)*
Sufficient rest	0.72 (0.70, 0.73)*	0.66 (0.64, 0.68)*	0.64 (0.62, 0.66)*	0.64 (0.61, 0.66)*
Resumed work after rest	1.09 (1.05, 1.13)*	1.07 (1.02, 1.13)*	1.17 (1.10, 1.24)*	1.09 (1.02, 1.16)*
Decide work time	0.99 (0.97, 1.02)	0.98 (0.95, 1.02)	1.02 (0.98, 1.06)	0.99 (0.96, 1.05)
Decide rest time	0.95 (0.93, 0.97)*	0.94 (0.91, 0.98)*	0.98 (0.94, 1.02)	0.95 (0.91, 0.99)*
Staff shortage	1.23 (1.21, 1.26)*	1.29 (1.26, 1.33)*	1.32 (1.28, 1.37)*	1.32 (1.27, 1.37)*
Often work to cover a colleague	1.18 (1.15, 1.20)*	1.28 (1.24, 1.32)*	1.29 (1.24, 1.33)*	1.30 (1.25, 1.35)*

Note: Adjusted for age, sex, survey year, enterprise, city, industry, working age, education level, monthly income level, body mass index, smoking status, exercise status, and workplace risk factors (often standing at work, sitting often at work, squatting or kneeling often at work, lifting heavy loads, exerting great force on the upper limbs or hands, using vibration tools at work, working in the same postures at a high pace).

Abbreviation: MSDs=musculoskeletal disorders; PR=prevalence ratio.

* $P<0.05$.

or four-shift work systems); overtime; resuming work after rest; staff shortages; and working to cover absent colleagues. These results suggest that further cohort studies with larger populations are required to validate these findings. To reduce the impact of MSDs on the workforce in China, adjusting work organization conditions for the specific needs is warranted. This finding offers valuable recommendations for improving shiftwork systems, increasing rest time, and providing more flexibility in assigning overtime.

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SUPPLEMENTARY MATERIAL

SUPPLEMENTARY TABLE S1. Pairwise multiple comparisons analysis of MSD pain scores.

Characteristic	Neck	Shoulders	Upper back	Lower back	Elbows	Wrists/hands	Hips/thighs	Knees	Ankles/feet
Rest break frequency (time)									
≤1 vs. 2	3234.0*	2484.5*	1830.3*	1367.7*	613.7*	1382.5*	1246.5*	1057.0*	428.5*
≤1 vs. ≥3	3829.8*	2918.8*	1889.9*	1002.8*	505.7*	602.1*	1317.3*	724.1*	-821.4*
2 vs. ≥3	595.8*	434.3*	59.7	-364.9	-107.9	-780.4*	70.9	-332.9	-1249.9*
Rest break duration (min)									
≤10 vs. >10 to 30	-868.1*	-1076.7*	-249.0	-1627.2*	285.6	460.2*	-371.7	-303.3	716.8*
≤10 vs. >30 to 60	31.3	25.0	580.5*	-779.2*	877.2*	1083.2*	244.3	661.1*	1194.7*
≤10 vs. >60	513.7	349.1	1055.7*	-190.9	1632.5*	1642.3*	958.7*	1103.3*	837.5*
>10 to 30 vs. >30 to 60	899.4*	1101.7*	829.5*	848.1*	591.6*	622.9*	616.0*	964.4*	477.9*
>10 to 30 vs. >60	1381.9*	1425.8*	1304.7*	1436.4*	1346.9*	1182.0*	1330.4*	1406.6*	120.7
>30-60 vs. >60	482.4	324.1	475.2	588.3*	755.3*	559.1*	714.4*	442.1	-357.2
Shift work system									
Fixed day shift vs. two-shift	355.4	-164.8	-713.0*	-205.0	-271.1	-1478.4*	-659.6*	-338.9	-3778.8*
Fixed day shift vs. three-shift	-2171.8*	-1699.0*	-2104.6*	-2477.0*	-1127.5*	-1065.5*	-3428.8*	-2712.4*	-3622.9*
Fixed day shift vs. four-shift	-6414.1*	-5695.4*	-5958.7*	-5704.1*	-3659.8*	-3173.8*	-4971.5*	-4930.0*	-4953.7*
Fixed day shift vs. other	-5413.4*	-3560.1*	-2122.7*	-1661.7*	161.7	150.5	-1467.5*	-1173.7*	-1524.4*
Two-shift vs. three-shift	-2527.2*	-1534.1*	-1391.6*	-2272.0*	-856.4*	412.9	-2769.2*	-2373.5*	156.0
Two-shift vs. four-shift	-6769.5*	-5530.5*	-5245.7*	-5499.1*	-3388.7*	-1695.4*	-4311.9*	-4591.1*	-1174.9*
Two-shift vs. other	-5768.8*	-3395.2*	-1409.7*	-1456.7*	432.9	1628.9*	-807.9*	-834.7*	2254.4*
Three-shift vs. four-shift	-4242.3*	-3996.4*	-3854.1*	-3227.1*	-2532.3*	-2108.3*	-1542.7*	-2217.6*	-1330.9*
Three-shift vs. other	-3241.6*	-1861.1*	-18.1	815.3	1289.3*	1215.9*	1961.3*	1538.8*	2098.5*
Four-shift vs. other	1000.7	2135.3*	3836.0*	4042.4*	3821.6*	3324.2*	3504.0*	3756.3*	3429.3*

Abbreviation: MSDs=musculoskeletal disorders.

* $P<0.05$.

SUPPLEMENTARY TABLE S2. Prevalence ratios and 95% confidence intervals of work organization for MSDs.

Characteristic	Upper back PR (95% CI)	Elbows PR (95% CI)	Wrists/hands PR (95% CI)
Rest break frequency (time)			
≤1	Ref	Ref	Ref
2	0.94 (0.89–0.98)*	0.95 (0.89–1.02)	0.96 (0.91–1.01)
≥3	0.97 (0.92–1.02)	1.03 (0.96–1.10)	1.02 (0.97–1.07)
Rest break duration (min)			
≤10	Ref	Ref	Ref
>10 to 30	0.98 (0.94–1.02)	0.94 (0.88–1.01)	0.95 (0.91–0.99)*
>30 to 60	0.95 (0.90–0.99)*	0.86 (0.80–0.92)*	0.89 (0.85–0.94)*
>60	0.90 (0.85–0.96)*	0.80 (0.73–0.87)*	0.89 (0.84–0.94)*
Working days per week (days)			
≤5	Ref	Ref	Ref
>5 to 7	1.15 (1.10–1.20)*	1.07 (1.01–1.14)*	1.08 (1.03–1.13)*
Working (h/day)			
≤8	Ref	Ref	Ref
>8	1.22 (1.17–1.27)*	1.17 (1.10–1.25)*	1.22 (1.17–1.28)*
Shift work system			
Fixed day shift	Ref	Ref	Ref
Two-shift	1.10 (1.04–1.16)*	1.19 (1.10–1.28)*	1.13 (1.07–1.20)*
Three-shift	1.06 (0.98–1.14)	1.13 (1.01–1.25)*	1.09 (0.99–1.18)
Four-shift	1.17 (1.07–1.28)*	1.32 (1.16–1.50)*	1.23 (1.10–1.37)*
Other	1.05 (0.97–1.13)	1.09 (0.97–1.23)	0.99 (0.91–1.09)
Overtime	1.34 (1.28–1.40)*	1.49 (1.41–1.59)*	1.37 (1.31–1.43)*
Sufficient rest	0.60 (0.57–0.62)*	0.59 (0.56–0.63)*	0.62 (0.60–0.65)*
Resumed work after rest	1.10 (1.02–1.18)*	0.98 (0.90–1.08)	1.03 (0.96–1.11)
Decide work time	1.05 (0.99–1.10)	1.19 (1.12–1.27)*	1.03 (0.98–1.08)
Decide rest time	0.96 (0.92–1.01)	1.03 (0.96–1.11)	0.97 (0.92–1.02)
Staff shortage	1.40 (1.34–1.45)*	1.60 (1.51–1.69)*	1.41 (1.35–1.46)*
Often work to cover a colleague	1.37 (1.31–1.43)*	1.61 (1.52–1.71)*	1.42 (1.36–1.49)*

Note: Adjusted for age, sex, survey year, enterprise, city, industry, working age, education level, monthly income level, body mass index, smoking status, exercise status, and workplace risk factors (often standing at work, sitting often at work, squatting or kneeling often at work, lifting heavy loads, exerting great force on the upper limbs or hands, using vibration tools at work, working in the same postures at a high pace).

Abbreviation: MSDs=musculoskeletal disorders; PR=prevalence ratio; CI=confidence interval.

* $P<0.05$.

SUPPLEMENTARY TABLE S3. Prevalence ratios and 95% confidence intervals of work organization for MSDs.

Characteristic	Hips/thighs PR (95% CI)	Knees PR (95% CI)	Ankles/feet PR (95% CI)
Rest break frequency (time)			
≤1	Ref	Ref	Ref
2	0.98 (0.92–1.03)	0.97 (0.92–1.03)	0.94 (0.89–0.99)*
≥3	0.99 (0.94–1.05)	1.01 (0.95–1.07)	0.99 (0.94–1.04)
Rest break duration (min)			
≤10	Ref	Ref	Ref
>10 to 30	0.95 (0.90–1.01)	0.97 (0.92–1.02)	0.99 (0.95–1.05)
>30 to 60	0.90 (0.85–0.96)*	0.99 (0.93–1.04)	0.97 (0.93–1.03)
>60	0.85 (0.79–0.91)*	0.88 (0.82–0.94)*	0.96 (0.91–1.02)
Working days per week (days)			
≤5	Ref	Ref	Ref
>5 to 7	1.16 (1.10–1.22)*	1.16 (1.10–1.22)*	1.13 (1.08–1.18)*
Working (h/day)			
≤8	Ref	Ref	Ref
>8	1.30 (1.24–1.37)*	1.23 (1.17–1.29)*	1.26 (1.21–1.32)*
Shift work system			
Fixed day shift	Ref	Ref	Ref
Two-shift	1.15 (1.08–1.23)*	1.09 (1.02–1.16)*	1.23 (1.15–1.30)*
Three-shift	1.25 (1.15–1.35)*	1.12 (1.03–1.22)*	1.19 (1.10–1.29)*
Four-shift	1.23 (1.11–1.37)*	1.10 (0.99–1.22)	1.32 (1.19–1.46)*
Other	1.01 (0.92–1.11)	0.98 (0.89–1.07)	1.03 (0.94–1.12)
Overtime	1.47 (1.40–1.54)*	1.44 (1.37–1.51)*	1.40 (1.34–1.46)*
Sufficient rest	0.57 (0.54–0.60)*	0.59 (0.57–0.62)*	0.61 (0.58–0.63)*
Resumed work after rest	1.07 (0.99–1.16)	1.14 (1.05–1.24)*	1.14 (1.06–1.24)*
Decide work time	1.02 (0.97–1.09)	1.07 (1.01–1.13)*	1.02 (0.96–1.07)
Decide rest time	0.95 (0.90–1.01)	1.03 (0.98–1.09)	0.94 (0.89–0.99)*
Staff shortage	1.52 (1.45–1.59)*	1.45 (1.38–1.51)*	1.42 (1.37–1.48)*
Often work to cover a colleague	1.43 (1.36–1.50)*	1.41 (1.34–1.48)*	1.40 (1.34–1.47)*

Note: Adjusted for age, sex, survey year, enterprise, city, industry, working age, education level, monthly income level, body mass index, smoking status, exercise status, and workplace risk factors (often standing at work, sitting often at work, squatting or kneeling often at work, lifting heavy loads, exerting great force on the upper limbs or hands, using vibration tools at work, working in the same postures at a high pace).

Abbreviation: MSDs=musculoskeletal disorders; PR=prevalence ratio; CI=confidence interval.

* $P<0.05$.