Original Article

How Work Organization Affects the Prevalence of WMSDs: A Case-control Study*

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Abstract

Objective In this study, we aimed at exploring the association between work-related musculoskeletal disorders (WMSDs) and work organization based on a case-control study.

Methods A total of 1938 workers who claimed to suffer from WMSDs were selected from Beijing, Henan, Hubei, and the Guangdong province. The control group consisted of 2009 workers employed in similar industries without severe disease or musculoskeletal discomforts. We used a modified version of the questionnaire developed by the NMQ and the DMQ to investigate individual and work-related factors.

Results A total of 13 variables (P<0.1) were selected by the chi-square test and finally, 7 variables entered into the equation, with 6 variables reaching statistical significance (P<0.05). The odds ratios (OR) of 'work changing with season' and 'sufficient rest time' did not reach 1 (0.749 and 0.441, respectively). In addition, 'sufficient rest time' seemed to be the stronger protective factor according to its higher standardized coefficient. And 'repetitive work every minute', 'constantly repetitive work' (every day), 'shortage of site personnel', and 'often switching shifts with others' seemed to be the risk factors.

Conclusion Work organization may have comprehensive effects on the occurrence of WMSDs. This pattern of associations suggests that further investigation into the mechanism of how work organization affects the prevalence of WMSDs is required.

Key words: WMSDs; Work organization; Case-control study; Prevalence; Risk factors

Biomed Environ Sci, 2015; 28(9): 627-633 doi: 10.3967/bes2015.088 ISSN: 0895-3988

www.besjournal.com (full text) CN: 11-2816/Q

*This work was supported by the Research Fund from National Science and Technology Infrastructure Program of the People's Republic of China (2014BAI12B03) and Major Project of Beijing Academy of Science and Technology (PXM2014-178304-000002-00131228).

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INTRODUCTION

Work-related musculoskeletal disorders (WMSDs), also known as occupational musculoskeletal injuries, have led to economic loss worldwide due to their high prevalence and negative impact on work efficiency. In 2000, WSMDs were included in the WHO Bone and Joint Decade (BJD) 2000-2010 project as well as on the List of Occupational Diseases by ILO (version 2010). Although still not considered a compensatory disease in China, WMSDs have a great impact on the occupational population and are increasingly becoming a forefront topic.

The US, Department of Labor defines WMSDs as injuries or disorders of the muscles, nerves, tendons, joints, cartilage, or spinal discs caused by exposure to related risk factors in the workplace[1]. Such exposure can be found in improper physical labor exertion and poor working conditions[2] and lists the neglect of ergonomics as the main reason for injury during work hours. Clinical physical diagnosis combined with self-evaluation based on scientific questionnaire is the most commonly used method to identify WMSDs because there is no generally accepted diagnostic standard for such diseases worldwide. As a typical public health problem worldwide, WMSDs account for a large proportion of work injuries and associated compensation[3-10]. The risk factors of WMSDs can be categorized into work-related factors and non-work-related causes. Non-work-related factors such as age, gender, habit, and mental status cause some WMSDs. In contrast, occupational factors such as workload, static load, repetitive operations, poor posture, cryogenic environment, and vibration explain why WMSDs are common among physical laborers. We based our study on a previous study in which the prevalence of WMSDs was reported to be 70.3% and most occupational factors showed similar influence on the prevalence of WMSDs with domestic and foreign research. We focused our study on work organization factors to gain more knowledge of the development of WMSDs.

Substantial evidence suggests that the development of WMSDs is greatly associated with work organization factors, including scheduling issues[11-12]. Healthcare workers, especially nurses, are at a very high risk for WMSDs due to the field's shift-heavy culture and extended work hours[13-14]. In fact, a longitudinal study[15] focusing on low back pain (LBP) in nurses for 2 years found that nurses were 1.15 times more likely to develop LBP than day-shift workers, although evidence from a cross-industry study is still needed.

WMSDs are professional health problems that have a wide range of influence. Through epidemiological investigation of many places and industries, we found and analyzed the characteristics of WMSDs. We found in our literature review that although some scholars had focused on the impact of work organization factors on the prevalence of WMSDs, few used a large sample from several industries and the factors they considered had limitations. Thus, our goal, through our large sample covering many industries, was to define more factors affecting the prevalence of WMSDs and improve workers' health.

METHODS

Study Population

A cross-sectional study was conducted from 2009 to 2010 to investigate the prevalence and related occupational characteristics of WMSDs among 41 work sites (factories) in Beijing, Henan, Hubei, and Guangdong province. Researchers from four universities, a municipal center for disease control and prevention, and a provincial institute of occupational disease prevention and treatment functioned as a study team to ensure that the questionnaires were hand delivered to involved workers and to guarantee a healthy response rate. A total of 7542 workers participated in the study, and 7200 valid questionnaires were obtained (response rate, 95.5%). From this, a sample was selected involving 3947 employees.

Selection of Cases and Controls

Cases and controls were both part of the population of a previous cross-sectional study and had to meet the following inclusion criteria: (a) at least 18 years old; (b) at least 12 months of employment in present position; and (c) no history of severe injuries or diseases, rheumatoid arthritis, infectious disease, hereditary disease, or cancer diagnosed in hospital. The cases group was defined as those who claimed to suffer from WMSDs in the provided questionnaire; control group participants came from the same population but had no musculoskeletal complaints. Cases and controls were matched by age, gender, height, weight, and degree of education.

Questionnaire

We used a revised, combined version of the Nordic Musculoskeletal Questionnaire (NMQ)[16] and the Dutch Musculoskeletal Questionnaire (DMQ)[17], which the self-reported questionnaire participants filled out; this provided a complete picture of the true state of occupational health in China[18]. Questions regarding risk factors mainly came from the DMQ, while those about WMSDs were mostly from the NMQ. We defined WMSD as positive musculoskeletal symptoms such as ache, pain, or discomfort in one of the nine body parts, which lasted for more than 24 h and were not relieved after rest[19].

The questionnaire consisted of three parts. Part one collected the demographic data of the subjects as well as some basic work-related information such as work type, length of service, weekly hours, and shift work. Part two detailed the prevalence of WMSDs and sick leave resulting from WMSDs. Part three covered several occupational factors including dynamic load, awkward work posture, repetitive operations, workspace, and vibration.

Data Collection

All questionnaires were hand delivered to workers by well-trained students to ensure complete and accurate data collection. At each factory, workers were called to a meeting room to complete the questionnaire in front of the interviewers who would then check the information. The Ethics Committee of Peking University approved this study.

Statistical Analysis

Demographic characteristics of the cases and controls were described, respectively, by descriptive statistics and compared via *t*-test and chi-square test, including age, gender, height, weight, and degree of education. To explore the risk factors associated with poor work organization, chi-square test was firstly used to discover the potential instances where $P<0.1$. Secondly, we used collinearity diagnosis for analysis of variance of the selected variables. If tolerance values (TOL) were around 1 and variance inflation factors (VIF) fell below 10, no obvious collinearity problem among the potential risk factors was suggested. Finally, odds ratios (OR) and 95% confidence intervals (CI) were estimated by using binary logistic regression, with a probability level of $P<0.05$ considered statistically significant. All statistical analysis was conducted using SPSS version 20.0.

RESULTS

Demographic Description

A total of 3947 subjects were selected from the population of across-sectional study: 1938 cases and 2009 controls. To explore occupational risk factors, cases and controls were matched by demographic characteristics such as gender, age, height, weight, and degree of education as presented in Table 1.

Table 1. Demographic Characteristics of Workers Participating in the Investigation

Items	Control (n=2009)	Case (n=1938)	*P* Value
Gender			
Female	248	253	0.504[a]
Male	1761	1685	
Age (years)			
Mean	32.65	33.16	0.058[b]
Standard deviation	8.42	8.53	
Height (cm)			
Mean	170.663	170.749	0.660[b]
Standard deviation	6.113	6.216	
Weight (kg)			
Mean	66.013	66.337	0.322[b]
Standard deviation	10.062	10.480	
Degree of education			
Primary school	17	14	
Secondary school	419	365	0.391[a]
High school	943	947	
College/university	630	612	

Note. [a]Two-sided *P* value from χ^2 test; [b]Two-sided *P* value from *t*-test.

Composition of WMSDs Types

Up to nine body parts were listed as possible WMSD sites, and an individual could suffer from more than one, as presented in Table 2.

Chi-square Test

To compare the characteristics of factors associated with work organization by self-reported

WMSDs status, a chi-square test was performed to find out 12 variables whose P<0.1 among all of the 18 variables that could, to some extent, reflect work organization, as presented in Table 3.

Collinearity Diagnosis

The VIF values of all variables were <10, with TOL values around 1, indicating that there was no obvious collinearity problem among the potential risk factors associated with work organization.

Logistic Regression model

Binary logistic regression was conducted to further explore the risk factors of WMSDs associated

Table 2. Composition of WMSD Types

Body Part	Cases, *n*	Proportion, %
Neck	1239	64.0
Shoulder	991	51.2
Back	824	42.6
Elbow	405	20.9
Low back	1359	70.1
Wrist	747	38.5
Hip	377	19.5
Knee	675	34.8
Ankle	615	31.7

Table 3. Results of Selecting Potential Risk Factors of WMSDs by the Chi-square Test

Variable	Response	Controls (n=2009) n (%)	Cases (n=1938) n (%)	χ^2	P Value[a]
Sufficient rest time	No	1072 (53.4)	1411 (72.8)	159.880	<0.001
	Yes	937 (46.6)	527 (27.2)		
Getting back to work right after break	No	321 (16.0)	235 (12.1)	12.095	0.001
	Yes	1688 (84.0)	1703 (87.9)		
Decided by yourself to start or finish working	No	1647 (82.0)	1635 (84.4)	4.003	0.046
	Yes	362 (18.0)	303 (15.6)		
Decided by yourself to have a break	No	1506 (75.0)	1492 (77.0)	2.213	0.146
	Yes	503 (25.0)	446 (23.0)		
Shortage of site personnel	No	1197 (59.6)	919 (47.4)	58.667	<0.001
	Yes	812 (40.4)	1019 (52.6)		
Often switching shift with others	No	1741 (86.7)	1582 (81.6)	18.747	<0.001
	Yes	268 (13.3)	356 (18.4)		
Often working overtime	No	1212 (60.3)	853 (44.0)	105.241	<0.001
	Yes	797 (39.7)	1085 (56.0)		
Working 50 h and above every week	No	1340 (67.8)	1099 (57.4)	45.446	<0.001
	Yes	636 (32.2)	817 (42.6)		
Carrying out the same work nearly every day	No	328 (16.3)	236 (12.2)	13.865	<0.001
	Yes	1681 (83.7)	1702 (87.8)		
Carrying out various work every day	No	1585 (78.9)	1564 (80.7)	1.996	0.165
	Yes	424 (21.1)	374 (19.3)		
Carrying out work in turn with colleagues	No	1119 (55.7)	1065 (55.0)	0.222	0.654
	Yes	890 (44.3)	873 (45.0)		
Work changing with season	No	1838 (91.5)	1810 (93.4)	5.123	0.026
	Yes	171 (8.5)	128 (6.6)		
Getting work done in the same workspace	No	654 (32.6)	552 (28.5)	7.703	0.006
	Yes	1355 (67.4)	1386 (71.5)		
Working outdoors	No	1627 (81.0)	1569 (81.0)	0.000	1.000
	Yes	382 (19.0)	369 (19.0)		
Highly repetitive work every minute	No	1110 (55.3)	804 (41.5)	74.833	<0.001
	Yes	899 (44.7)	1134 (58.5)		
Work related to cold breeze or temperature changes	No	1137 (56.6)	919 (47.4)	33.276	<0.001
	Yes	872 (43.4)	1019 (52.6)		
Work often involving dealing with customers, patients, and public	No	1744 (86.8)	1652 (85.2)	2.016	0.168
	Yes	265 (13.2)	286 (14.8)		
Often driving during work	No	1845 (91.8)	1793 (92.5)	0.635	0.441
	Yes	164 (8.2)	145 (7.5)		

Note. [a]Two-sided P value from χ^2 test.

with work organization, with backward selection used to set up the regression model and, finally, 7 variables were entered into the equation. Table 4 shows *P* values of each variable according to Wald chi-square test. Six variables were statistically significant ($P<0.05$), indicating that 'carrying out the same work every day' , 'work changing with season', 'highly repetitive work every minute', 'sufficient rest time', 'shortage of site personnel', and 'often switching shifts with others' had the most impact on the prevalence of WMSDs. The assessment of the it of the logistic regression model is reflected in Table 5.

'Work changing with season' and 'sufficient rest time' appeared to be protective factors of WMSDs as the ORs were less than 1 (0.749 and 0.441, respectively), meaning employees who changed work with the season and had sufficient rest time, when compared with those employees who did not, most likely had a lower risk of suffering WMSDs. In addition, sufficient rest time seemed to be an obvious protective factor as it had a relatively lower OR value (0.441), and its 95% CI did not reach 1. In addition, it became the stronger protective factor due to its higher standardized coefficient (0.141).

The risk of WMSDs for workers who performed repetitive work every minute was 1.508 times higher than those who did not. This showed a statistical association between WMSDs and carrying out the same work every day, shortage of site personnel, and often switching shifts with others, as these three work habits had ORs ranging from 1.236 to 1.464, which designated them as possible risk factors. Also, often switching shifts with others showed a stronger effect on WMSDs with a higher standardized coefficient than the other two factors.

DISCUSSION

WMSDs have complex pathogenesis. Work organization plays an important role in the prevalence of WMSDs among possible etiologies. Unlike individual factors, which are mostly unchangeable (e.g., gender and age), rules of work organization are established by managers and could vary due to human demands. This study focused on the risk factors associated with certain work organization structures to find solutions to improve workers' health.

Carrying out the Same Work Every Day

This study demonstrated that workers who perform continual repetitive work have a higher risk of WMSDs (OR=1.236; 95% CI: 1.019-1.500). Reviewing previous studies[20], it is logical to conclude that highly repetitive operation on a continual basis can induce WMSDs. In early explorations, researchers focused on the mechanism of biomechanics and held the view that repetitive work

Table 4. Results of Assessing Risk Factors of WMSDs by Logistic Regression Model

Variable	B	S.E.	*P* Value	OR	OR 95% CI	
					Lower	Upper
Carrying out the same work almost every day	0.212	0.099	0.031	1.236	1.019	1.500
Work changing with season	−0.289	0.128	0.024	0.749	0.583	0.962
Highly repetitive work every minute	0.411	0.069	<0.001	1.508	1.318	1.726
Work related to cold breeze or temperature changes	0.117	0.069	0.091	1.124	0.981	1.287
Sufficient rest time	−0.818	0.141	<0.001	0.441	1.074	1.426
Shortage of site personnel	0.261	0.069	<0.001	1.298	1.134	1.486
Often switching shifts with others	0.381	0.071	<0.001	1.464	1.273	1.684

Table 5. Assessment of Logistic Regression Model Fitness

−2 Log Likelihood	Goodness of Fit		Predicted	Hosmer-Lemeshow Test	
	Cox & Snell R^2	Nagelkerke R^2	%Correct	χ^2	*P* Value
5088.216	0.076	0.101	62.1	10.247	0.248

referred to workload and unchanged posture, which caused muscle fatigue. However, with in-depth etiology studies[21], gradually realized that psychosocial factors also had a large influence on WMSDs, with some researchers suggesting them to be greater influencers than biomechanical issues[21]. Researches concluded that unfavorable psychological and social factors induced adverse working posture, shortened the time interval between rest and activity, and possibly reduced cooperation with colleagues, thus, workers' ability to resist WMSDs was lessened[22].

Work Changing with Season

'Work changing with season' appeared to be a protective factor of WMSDs as its OR was less than 1 (0.749; 95% CI: 0.58-0.962). This might be explained as a release from repetitive work due to the variety of each season, or a protection from bad weather, as some outdoor operations were probably shifted indoor when winter arrived. However, the shift mechanism was not clear as it was not evident in the questionnaire, so this result reminded us that avoiding cold weather could be a measure of preventing WMSDs.

Highly Repetitive Work every Minute

As was mentioned previously, highly repetitive work may cause a series of psychological and physiological problems that could contribute to WMSDs. Our study results suggest that the risk of WMSDs for workers who perform repetitive work every minute is 1.508 times higher than those who do not. Nevertheless, significantly fewer workers reported musculoskeletal pain following stage-matched interventions, including job rotations, workstation adjustments, longer rest periods, etc[23].

Sufficient Rest Time

Rest may ease the stress and fatigue of workers, especially in combination with a proper work-rest schedule. Sufficient rest time seemed an obvious protective factor in our study as it had a relatively lower OR value (0.441), and its CI did not reach 1. Meanwhile, the factor of working longer periods did not enter the regression equation, likely implying that sufficient rest could effectively ease the fatigue that accumulates during extended working hours. The question now before researchers is what number constitutes 'sufficient' rest? Frequent short breaks have been suggested when drawing up optimal work-rest schedules[24]. In studying three kinds of lifting activities, with a load of 25% MVC and duration of 4.5 min, a rest time of 15 min guaranteed the recovery of nearly all erector spine muscle and returned heart rates to resting level[25]. Thus, increasing break times and/or performing proper extensional activities during continual low-load-level work would ease muscle fatigue and help restore muscle activity[26].

Shortage of Site Personnel

In this study, shortage of personnel on the worksite was easily a risk factor for WMSDs. Less personnel usually meant a higher average workload per employee, which could lead to cumulative damage of muscle. For individuals, WMSDs resulted from overload and overtime. Though the difference between case subjects' and controls' injuries did not show statistical significance for working overtime hours, we did not exclude it because it was a potential result of having a shortage of personnel at the site.

Often Switching Shifts with Others

Often switching work shifts with others showed a strong effect on WMSDs with a higher standardized coefficient (OR=1.464; 95% CI: 1.273-1.684). Switching shifts often disturbed workers' quality of sleep, thus affecting the muscle recovery, similar insufficient rest time. However, switching shifts with others was often a spontaneous decision not condoned by worksite management. In some cases, individual workers carried out shift changes more than once a day, which is not recommended[27].

CONCLUSION

China, the largest developing country in the world, has a booming economy and is faced with many occupational health challenges. Though WMSDs are mostly chronic and non-lethal, they do harm workers' health and constitute a great economic burden to society. In our study, we assessed the association between WMSDs and work organization factors to clarify such factors' function in the occurrence of WMSDs. Protective factors such as 'work changing with season' and 'sufficient rest time' were defined. Other factors, 'performing repetitive work every minute', 'shortage of site personnel', 'often switching shifts with others', and 'carrying out the same work every day', were found to increase the risk of WMSDs. These results suggest that further exploration of reasonable work organization, considering the environment (workspace), proper work posture, and enforcing rules of shift work, is warranted. A future cohort study could convincingly prove the effect of intervention measures on work organization to decrease the number of WMSD instances.

ACKNOWLEDGMENTS

We wish to extent our appreciation to the National Musculoskeletal Disorders Research Cooperation Group for their assistance in data collection and entry.

Received: May 22, 2015;

Accepted: August 19, 2015

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