

BMJ Open Work-related musculoskeletal disorders, fatigue and stress among gas station workers in China: a cross-sectional study

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ABSTRACT

Introduction Work-related musculoskeletal disorders (WMSDs) are disorders of the musculoskeletal system that have the highest prevalence among workers worldwide. Workers in gas stations usually work in poor ergonomic working conditions, including prolonged standing and repetitive posturing.

Objective The study aimed to investigate the prevalence of WMSDs and fatigue and to identify the predictors of WMSDs among gas station workers.

Design The present study was a cross-sectional study.

Setting and participants 2962 gas station workers from an oil and gas company in China, with ages ranging from 17 to 75 years old, 55.47% female.

Results The prevalence of WMSDs within the 12 months prior to the study was 73.23%, with the highest prevalence in the neck, shoulders, ankles and feet. Furthermore, a correlation was observed between fatigue, stress and WMSDs. Fatigue and job role were the strongest predictors of WMSDs, with an OR range of 2.211–3.413.

Conclusions This research identified the detrimental impact of WMSDs and fatigue on gas station workers, indicating the critical need for interventions to reduce WMSDs and relieve fatigue.

INTRODUCTION

Gas station workers are key figures in the oil industry chain, subject to heavy workloads and safety-critical tasks, and related occupational stress, fatigue, health problems and environmental hazards. A recent review emphasised the importance of occupational health concerns for gas station workers, concluding that shift work and the specific work environment of gas station workers can adversely affect their sleep, stress levels, physical and mental health, and turnover intention.¹ The work design of this job role is varied in different countries and regions; for example, in developed countries such as the USA, self-service refuelling is common, and gas stations often employ managers, cashiers and similar staff while in developing countries such as China, they still rely on manual refuelling operations, which increases the number

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This study investigated the present condition of work-related musculoskeletal disorders (WMSDs) and occupational risk among gas station workers.
- ⇒ The Nordic Musculoskeletal Questionnaire and Smith Well-being Questionnaire were used to assess WMSDs, fatigue, stress and other work-related risk factors.
- ⇒ Logistic regression was conducted to determine the predictors of the WMSDs.
- ⇒ This was a cross-sectional study, unable to determine the mechanism and aetiology of WMSDs.

of gas station workers needed. Regardless of the operational mode, very little empirical research has focused on the occupational health concerns of gas station workers in comparison to the range of risk factors to which they are exposed.

Gas station workers face inevitable occupational stress, and their extensive workloads require an elevated level of alertness and motivation to fulfil their duties.¹ The duties of gas station workers encompass refuelling, sales and communication with customers and colleagues, alongside additional security responsibilities.² As a service industry, they also require emotional intelligence to provide exceptional service quality continually. When job demands exceed workers' abilities and coping skills, they become a risk factor, generating stress and various health problems.³ Occupational stress is a severe occupational hazard that generates problematic alcohol use,⁴ depression⁵ and impairment of physical health, psychological well-being and performance.⁶ It can also lead to sick leave, adversely affecting productivity and placing a financial burden on employers and society.⁷

Work-related musculoskeletal disorders (WMSDs) are one of the health problems that occupational populations have frequently reported and have a high prevalence.⁸ WMSDs



are common painful disorders affecting the body structure that are caused by a variety of factors, such as repetitive motion, excessive force, awkward and/or sustained postures and prolonged sitting and standing.⁹ Moreover, these MSDs may also be caused by or worsened by work conditions,¹⁰ highlighting the need to consider the role of occupational factors in their development. WMSDs can also result in physical and mental illness, chronic pain and disability.¹¹ WMSDs are widespread around the world and are the second most common cause of disability in the workplace.¹² They indirectly decrease industrial efficiency, which results in significant economic burdens.¹³ The prevalence of WMSDs and their related negative effects on workers' productivity, particularly in developing countries, should be treated seriously to decrease the impact on production and promote workers' well-being.¹⁴ Many previous studies on the health and well-being of gas station workers focus primarily on the negative effects of organic solvents such as benzene on physiological health and the nervous system. However, gas station workers usually experience poor ergonomic working conditions for long periods, as their work tasks include repetitive, awkward body movements,¹ which can contribute to an increase in WMSDs.

Psychosocial stressors, such as high workload or low time control, may contribute to an increased risk of MSDs by increasing biomechanical load or physical stress. Occupational stress is associated with physical symptoms and is prevalent over time.¹⁵ A review explored the impact of stressors on the onset of MSDs related to the neck/shoulder, upper limbs and waist, revealing that psychosocial factors were independent predictors of MSDs.¹⁶ It indicates that work-related stress may have an impact on the incidence of MSDs. Despite the existence of work stress issues and physical health problems among gas station workers, there remains a dearth of clear evidence regarding the impact of work stress on WMSDs.

Occupational fatigue is described as a state of 'extreme tiredness and reduced functional capacity experienced during or at the end of the workday',¹⁷ and it is a common occupational health problem in many industries and occupations across the world.¹⁸ Fatigue has a myriad of negative consequences; for example, fatigue is linked to various health problems, including sleep disorders, depression, obesity¹⁸ and MSDs, and it impacts work efficiency, job satisfaction and turnover intention.^{19 20} Gas station workers often experience high job demands, heavy workloads and shift work. Workers experience fatigue more quickly as a result of this condition. Thus, as a key component of safety, the fatigue of gas station workers should be given more consideration.

WMSDs and fatigue are both major occupational health issues. MSDs have been associated with fatigue in nurses and office workers.^{21 22} A longitudinal study found that burn-out could be a risk factor for the development of musculoskeletal pain in apparently healthy individuals.²³ Although the relationship between WMSDs and fatigue has been studied in several occupations,^{21 22} there is currently

a dearth of research related to gas station workers. Gas station employees are exposed to a multitude of risk factors for WMSDs in the workplace, including prolonged standing and repetitive motions when filling vehicles. Other factors that contribute to physical and mental fatigue include heavy workloads, maintaining a positive attitude when interacting with customers, remaining vigilant to operations that are prone to causing safety mishaps and working in shifts. Personal characteristics and work-related factors such as workload should also be considered. It is apparent that there is insufficient research on WMSDs and fatigue specific to gas station workers, and relevant risk factors should be further identified.

While WMSDs, occupational stress and fatigue are common issues that negatively affect the health and safety of gas station workers, few studies have been conducted in this field, particularly concerning physical and mental health. The current study aimed to examine the prevalence of WMSDs, determine the association between WMSDs, stress and fatigue and investigate the predictors of WMSDs among gas station workers. It contributes to developing a better understanding of the occupational risk factors that can result in WMSDs, which is of great significance for better monitoring and preventing WMSDs, stress and fatigue and enhancing the physical and mental health of gas station workers.

MATERIAL AND METHODS

Participants and procedure

Participants were staff from several gas stations in different cities of southern China within an oil company (N=2962, ages ranging from 17 to 75 years old, 55.47% female). The job positions reported were gas operator (34.98%), cashier (14.45%), front-court manager (24%), gas station manager (8.85%), convenience store supervisor (6.14%), finance department staff (3.81%), management and executive staff (2.3%) and other positions (5.47%). It should be noted that the front-court manager has a unique position in Chinese gas stations. The duties of this position include but are not limited to 'being responsible for organising the staff to carry out various operations, management and service work during the shift', 'being responsible for the normal operation of the gas station during the shift', which can also be described as 'on-site duty manager'.

We conducted an online survey among gas station employees from an oil and gas company in China, with the approval and cooperation of the company. There was no work experience requirement for participants. The questionnaire was distributed 2 months after the regular complete health check-up of employees, and the employees with known trauma or other musculoskeletal disease, cardiovascular disease, severe chronic obstructive pulmonary disease, neurological or psychiatric disorders and excessive obesity (body mass index, BMI>30 kg/m²) were excluded. Participants were asked to complete an

informed consent form, and they were free to withdraw from the survey at any point.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of the research.

Measurement of MSDs

WMSDs were assessed using the Chinese version of the Nordic Musculoskeletal Questionnaire (NMQ), a self-reported questionnaire that assesses the prevalence of musculoskeletal symptoms in nine areas of the body: the neck, shoulders, elbows, wrists and hands, hips, knees, lower back, upper back and ankles and feet.²⁴ Participants were asked to note the occurrence of these symptoms over the past week (weekly prevalence) and over the past year (annual prevalence). The NMQ was translated for use with Chinese samples and proved to be reliable and valid.²⁵ The questionnaire is suitable for application in a variety of workplaces, and data can be collected quickly and easily with one study.

Considering that MSDs in gas station workers are a long-standing problem, in this study, the incidence of MSDs in the past year was used as the evaluation index. WMSDs are defined by reports of discomfort, numbness, pain and restricted movement in one or more body regions in the past year.

Measurement of occupational stress and fatigue

Occupational stress and fatigue were evaluated using the Smith Well-being Questionnaire (SWELL).²⁶ The SWELL, which is based on the Demands-Resources-Individual-Effects model, was used to assess occupational fatigue, stress at work, workload, lifestyle, personality, job satisfaction and so on.²⁷ This questionnaire has been used to assess a variety of occupational groups in previous studies, allowing the identification of the overall occupational risks. This questionnaire was translated into Chinese using both forward and back translation.²⁸

The SWELL consists of 26 single-item questions, and most of the questions are on a 10-point Likert scale. In the current study, the main variables of interest were stress, fatigue, work characteristics (ie, workload, job support and control, noise exposure and fume exposure) and personal characteristics (ie, personality and lifestyle).

Analyses

Data analysis was conducted by using SPSS V.25. Descriptive analyses examined the frequencies of demographic variables, WMSD symptoms (NMQ), stress, fatigue, personal characteristics and work characteristics. Pearson correlation was used to examine the associations between stress, fatigue, WMSDs and other variables. Variable scores were categorised into a high/low group using a median split. Logistic regression was then conducted to determine the predictors of the WMSDs. Data were mean±SD and statistical significance was set at $p<0.05$.

RESULTS

Descriptive Statistics

Participants' descriptive characteristics and WMSD symptoms are shown in table 1. A total of 2962 participants completed the online survey. The average age of the participants was 36.67 ± 7.55 years; 55.47% of participants were female. According to the work content and actual workplace, participants' job roles were divided into front-line staff (N=2619; 88.42%) and non-front-line staff (N=343, 11.58%). Front-line staff work at gas stations on daily duty, including gas operators, cashiers, front-court managers, convenience store supervisors and gas station managers. Non-front-line staff include finance department staff, management and executive staff, and other positions that work in offices where they are not exposed to gasoline daily and are not required to remain in a standing position for long periods.

Participants had a mean stress score of 6.30 ± 2.55 and a mean fatigue score of 6.00 ± 2.49 . The results also showed that people with WMSD symptoms had unhealthier lifestyles ($t=14.03$, $p<0.001$), more negative personalities ($t=11.05$, $p<0.001$), higher levels of fatigue ($t=-20.262$, $p<0.001$) and stress ($t=-16.92$, $p<0.001$) than those without WMSDs symptoms.

Additionally, a single item from the SWELL on musculoskeletal problems (Do you suffer from MSDs (eg, arthritis; back pain; sciatica; repetitive strain injury)?) was used to gauge the effectiveness of the NMQ. Participants who reported WMSDs on the NMQ scored 6.11 ± 2.96 on this question, which was significantly higher than healthy participants ($t=29.24$, $p<0.001$).

Prevalence of WMSDs

As shown in online supplemental table 1 and figure 1, the prevalence of WMSDs among the respondents was unevenly distributed among most body regions and centred around three of them, namely the neck (42.27%), shoulders (35.89%) and ankles and feet (34.71%). The 12-month prevalence was 73.23%, and significant differences were found for age group ($\chi^2=17.95$, $p<0.001$) and job role ($\chi^2=50.82$, $p<0.001$) but not gender ($\chi^2=3.59$, $p=0.058$).

Associations among stress, fatigue and WMSDs

Pearson correlation was used to investigate the association among stress, fatigue, WMSDs (from the SWELL) and work and personal characteristics (online supplemental table 2). Stress showed significant positive correlations with fatigue ($r=0.61$, $p<0.001$) and WMSDs ($r=0.40$, $p<0.001$). Both stress, fatigue and WMSDs were significantly correlated with personal characteristics (lifestyle and personality, $p<0.001$) and other work characteristics (job control and support, noise, fumes, $p<0.001$).

Predictors of WMSDs

Logistic regressions were run to investigate the predictors of WMSDs. The dependent variable was WMSDs, measured with or without WMSD symptoms over the past

Table 1 Descriptive characteristics and MSDs symptoms of participants

Variables	WMSDs symptoms (NMQ)			P value
	All N=2962	No N=793	Yes N=2169	
Age, mean±SD	36.67±7.55	36.43±8.31	36.76±7.26	
Sex, n (%)				
Female	1643 (55.47)	417 (52.59)	1226 (56.52)	0.058*
Male	1266 (42.74)	361 (45.52)	905 (41.72)	
Unidentified	53 (1.79)	15 (1.89)	38 (1.75)	
Job role, n (%)				
Front-line staff	2619 (88.42)	757 (95.46)	1862 (62.86)	<0.001*
Non-front-line staff	343 (11.58)	36 (4.54)	307 (15.65)	
Personal characteristics, mean±SD				
Lifestyle	7.76±2.07	8.57±1.82	7.47±2.07	<0.001†
Personality	7.89±1.93	8.53±1.82	7.66±1.90	<0.001†
Work characteristics, mean±SD				
Workload	6.05±2.48	4.86±2.68	6.49±2.25	<0.001†
Job support and control	7.58±2.13	8.03±2.20	7.41±2.08	<0.001†
Noise	5.37±3.06	4.25±3.04	5.78±2.96	<0.001†
Fumes	7.38±2.92	6.89±3.08	7.55±2.84	<0.001†
Outcome, mean±SD				
Stress	6.30±2.55	5.05±2.77	6.76±2.30	<0.001†
Fatigue	6.00±2.49	4.45±2.61	6.56±2.19	<0.001†
MSDs (SWELL)	6.11±2.96	2.88±2.54	6.11±2.96	<0.001†

* χ^2 test.
†Independent-samples t-test.
MSD, musculoskeletal disorder; NMQ, Nordic Musculoskeletal Questionnaire; SWELL, Smith Well-being Questionnaire; WMSDs, work-related MSDs;

year. The independent variables included in the model were demographic variables (age, gender and job role), personal characteristics (personality and lifestyle), work characteristics (workload, job control and support, noise exposure and fume exposure), stress and fatigue, in which age was continuous, and other variables were categorical. **Table 2** shows the OR for each of the independent variables (IVs).

In the final model, the results showed that job role was the strongest predictor of reported WMSD symptoms, with an OR of 3.413 ($p<0.001$), which indicated that the front-line staff were more than three times more likely to report WMSD symptoms than non-front-line staff. Fatigue was the second strongest predictor of reported WMSD symptoms, with an OR of 2.211 ($p<0.001$), which indicated that participants who reported high fatigue were over two times more likely to report WMSD symptoms than those reporting low fatigue after controlling demographic and individual difference factors in the model.

The logistic regression model also found that stress (OR=1.327, $p<0.05$), gender (female; OR=0.610, $p<0.001$), negative personality (OR=1.322, $p<0.05$), unhealthy lifestyle (OR=2.032, $p<0.001$), heavy workload

(OR=1.345, $p<0.05$), lack of job control (OR=1.636, $p<0.001$), noise exposure (OR=1.585, $p<0.001$) and fume exposure (OR=1.327, $p<0.05$) significantly contributed to WMSDs.

DISCUSSION

This is a cross-sectional study using an online questionnaire to investigate the prevalence of and relationship between WMSDs, stress and fatigue, and the predictors of WMSDs among gas station workers. Participants reported medium-to-high levels of fatigue and stress, and the 12-month prevalence of WMSDs was 73.23%. The neck, shoulders, ankles and feet were the most common body regions affected by MSDs. The present study also showed a significant positive correlation between fatigue, stress and WMSDs, and with higher fatigue and stress, participants were more likely to have WMSDs. In addition, job roles and personal and work characteristics were predictors of WMSDs.

In terms of occupational fatigue and stress, the findings suggest that there was indeed a certain occupational health problem among gas station employees. First,

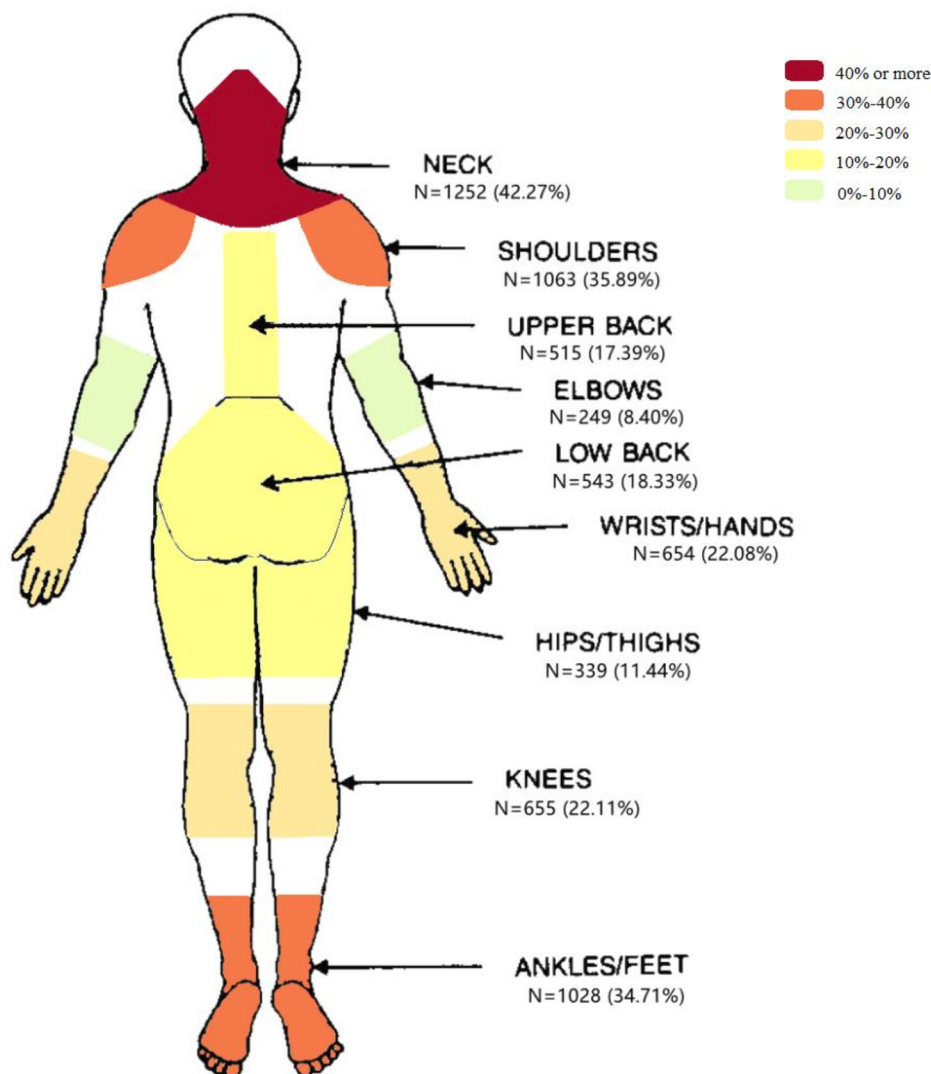


Figure 1 Regions of WMSDs in the previous 12-month period prevalence. WMSDs, work-related musculoskeletal disorders.

fatigue was clearly associated with multiple risk factors, including individual characteristics, work characteristics and environment. Given the nature of the gas station industry, workers usually work long hours each day, and most of this is shift work, both of which have been closely related to fatigue.²⁹ A growing body of literature has demonstrated that fatigue is common among gas station workers, as well as workers from the oil and gas industry, such as offshore drilling, the job characteristics of which are similar.^{30–32} Meanwhile, the current study provides evidence of a significant positive association between job stress and occupational fatigue among gas station workers. These findings align with previous research conducted on various occupational groups, including nurses,³³ call centre employees³⁴ and drivers,³⁵ thus confirming a consistent relationship between stress and fatigue. Nonetheless, this study represents the first investigation specifically focusing on the stress and fatigue experiences of gas station workers, highlighting the unique challenges faced by this particular occupational group. In addition to their primary responsibilities of providing refuelling

services, front-line gas station workers in China often have additional responsibilities such as safety duties, sales and prioritising customer satisfaction. Such multifaceted job demands may contribute to heightened job stress levels and subsequent fatigue among these workers. Our findings underscore the need for interventions to reduce stress and fatigue risk factors.

The majority of gas station workers reported having WMSDs in at least one anatomical region during the 12 months prior to the study, which is in line with previous research conducted both inside and outside of China.^{36,37} The clustering pattern of WMSDs observed in this study, notably in the neck (42.27%), shoulders (35.89%) and ankles and feet (34.71%), is somewhat different from findings in previous studies among gas station workers. Among Nigerian gas station workers, the reported prevalence pattern of body regions was highest in the lower back (54%) and shoulders (52%),³⁸ whereas in Ghana, it was highest in the lower back (43%).³⁶ This is due in part to the larger proportion of front-line employees in our study, who engage primarily in manual labour. Although

Table 2 OR of IVs on WMSDs

Variables	Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI
Demographics						
Age	1.009	(0.998 to 1.021)	1.006	(0.994 to 1.019)	1.005	(0.993 to 1.018)
Gender	0.689**	(0.574 to 0.829)	0.614**	(0.507 to 0.745)	0.610**	(0.501 to 0.742)
Job role	2.595**	(1.794 to 3.755)	3.666**	(2.499 to 5.378)	3.413**	(2.318 to 5.023)
Personal characteristics						
Personality			1.357*	(1.065 to 1.728)	1.322*	(1.035 to 1.689)
Lifestyle			2.108**	(1.667 to 2.666)	2.032**	(1.603 to 2.575)
Work characteristics						
Workload					1.345*	(1.052 to 1.720)
Job control and support					1.636**	(1.323 to 2.024)
Noise					1.478**	(1.199 to 1.823)
Fumes					1.585**	(1.286 to 1.954)
Stress					1.327*	(1.044 to 1.688)
Fatigue					2.211**	(1.755 to 2.784)
Nagelkerke R ²	0.116		0.208		0.238	

*p<0.05, **p<0.01.
WMSDs, work-related musculoskeletal disorders.

there are variations in the specific sites affected among gas station workers in different countries, the overall prevalence of moderate to high rates of WMSDs ranged from 51.2% to 86%.^{36–38} This demonstrates that WMSDs are a common issue within the gas station occupation. A cross-cultural comparison research of workers in similar occupational groups revealed disparities in the prevalence of self-reported MSD discomfort between Malaysia and Australia.³⁹ However, there were no significant differences in the frequency and severity of symptoms across five body regions among those reporting MSD discomfort, and they shared similar predictors. Therefore, future research seeking to generalise these findings to comparable job positions in other countries should carefully consider sociocultural backgrounds as influencing factors.

WMSDs are a multifactorial disorder linked to various demographic and work-related features. There is limited literature concerned with WMSDs in this particular field. Therefore, a comprehensive analysis based on the establishment of a logistic regression model was run to reveal the presence of multiple influencing factors for WMSDs among gas station workers, including personal and work characteristics. It is worth noting that fatigue and job role were found to be major risk factors for WMSDs. There is a clear relationship between WMSDs and occupational fatigue. This finding is consistent with previous research that has identified fatigue as a risk factor for WMSDs.⁴⁰ Fatigued workers usually perform poorly at work and may eventually face serious health problems. Ergonomically, the risk factors for gas station workers come from repetitive actions (such as filling vehicles) and long periods of

standing (as with cashiers). According to previous studies, maintaining an awkward and static posture for extended periods at work can cause discomfort, pain and chronic fatigue.¹⁹ This is supported by results from job roles, where front-line workers are more likely to have musculoskeletal problems than non-front-line workers. Front-line workers are more likely to be exposed to risk factors at work, such as repetitive motions, poor posture and physical strain. Adverse symptoms accumulate over time and can cause serious consequences for physical and mental health.

It is worthwhile to note that there was no significant difference in age between those with and without WMSDs. Similarly, in logistic regression, age was not a significant predictor of WMSDs. However, a recent study found that there was a relationship between age and MSDs complaints.⁴¹ In general, increased age causes workers' physical conditions to deteriorate, and as muscle strength and endurance decline, the risk of WMSDs increases.⁴² The different results suggest that some variables might modify the relationship between age and WMSDs, such as BMI, smoking habits and physical activity, which are individual characteristic variables associated with WMSDs, should be examined in future studies.

According to the logistic regression model, negative personality and unhealthy lifestyle were considered risk factors for WMSDs. These findings are similar to the results of other studies.^{43–44} Therefore, at the individual level, adopting a healthy lifestyle may be able to mitigate the incidence of WMSDs. Personality type and WMSDs appear to be correlated, and it is suggested that organisations may consider personality type factors in employee selection and training.

The results from this study provide insight into understanding the relationship between fatigue, stress and WMSDs among gas station workers. These findings have practical implications for identifying and addressing WMSDs, particularly among front-line workers who experience severe fatigue and stress. The consequences of WMSDs are considerable for employees and employers alike. Therefore, several measures can be taken to prevent the risk of WMSDs. For example, gas station workers should be aware of risk factors and make positive changes, such as stretching between breaks. Employers should consider implementing fatigue management strategies and providing ergonomic workstations to ensure the well-being and safety of their workers.

There are a few limitations of this study. First, the study absence of data on body composition, specifically BMI, and the level of habitual physical activity among participants. The lack of this information presents a challenge in accurately associating our findings with participants' age and functional status. Second, the study sample was exclusively from China; therefore, future studies should determine and verify our results in other regions, including workers from both developed and developing nations and state-owned and private businesses. Third, this was a cross-sectional study that used subjective measurement methods. Future studies should apply objective technologies, which lead to more accurate and objective conclusions. A prospective longitudinal design is also needed to better understand causal relationships between the variables.

Our study also has several strengths. This study investigated the present condition of WMSDs and occupational risk among gas station workers and provided evidence of an association between fatigue, stress and WMSDs. This finding has important occupational health implications and may inform the prevention of WMSDs among gas station workers. The research results can provide a reference for empirical studies, in particular, interventions to address the current situation.

CONCLUSION

There is a high prevalence of WMSDs among workers in the gas station industry, most frequently in the neck, shoulders, ankles and feet. The gas station workers had a medium-to-high level of fatigue and stress, and associations between fatigue, stress and WMSDs were found in this study. The participants who reported high fatigue were more than two times more likely to report WMSDs. In addition to the risk factor of fatigue, job role, stress, and personal and work characteristics played essential roles in the prediction of WMSDs.

Contributors Conceptualisation, JF; material preparation and data collection, JW; analyses, XT; original draft preparation, XT; review and editing, XT, JF and APS. All authors have read, critically revised and approved the final version of this manuscript. JF is responsible for the overall content (as guarantor).

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Patient consent for publication Not applicable.

Ethics approval This study involves human participants and this paper received ethical approval from School of Medicine Ethical Committee at Shenzhen University: PN-202300036. All participants provided informed consent prior to completing the first survey. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

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Supplementary Table 1. WMSDs in gas station workers

	Body Region								
	Neck	Shoulders	Elbows	Wrists/hands	Hips	Knees	Lower back	Upper back	Ankles/feet
12-month period prevalence (n=2169, 73.23%)	1252 (42.27%)	1063 (35.89%)	249 (8.40%)	654 (22.08%)	339 (11.44%)	655 (22.11%)	543 (18.33%)	515 (17.39%)	1028 (34.71%)
Gender									
Female	730 (24.65%)	643 (21.71%)	141 (4.76%)	399 (13.47%)	180 (6.08%)	339 (11.44%)	291 (9.82%)	290 (9.79%)	527 (17.79%)
Male	500 (16.9%)	402 (13.57%)	106 (3.58%)	249 (8.41%)	155 (5.23%)	309 (10.43%)	241 (8.14%)	219 (7.39%)	490 (16.54%)
Age									
≤ 30	231 (7.80%)	199 (6.72%)	55 (1.86%)	143 (4.83%)	75 (2.53%)	121 (4.09%)	116 (3.92%)	123 (4.15%)	227 (7.66%)
31–40	640 (21.61%)	532 (17.96%)	111 (3.75%)	323 (10.90%)	168 (5.67%)	302 (10.20%)	270 (9.12%)	248 (8.37%)	499 (16.85%)
41–50	312 (10.53%)	269 (9.08%)	70 (2.36%)	157 (5.30%)	79 (2.67%)	184 (6.21%)	127 (4.29%)	119 (4.02%)	251 (8.47%)
≥ 51	25 (0.84%)	19 (0.64%)	6 (0.20%)	11 (0.37%)	6 (0.20%)	22 (0.74%)	9 (0.30%)	7 (0.24%)	13 (0.44%)
Job role									
Frontline staff	1002 (33.83%)	855 (28.87%)	220 (7.43%)	583 (19.68%)	268 (9.05%)	583 (19.68%)	445 (15.02%)	403 (13.61%)	978 (33.02%)
Non-frontline staff	248 (8.37%)	206 (6.95%)	28 (0.95%)	70 (2.36%)	70 (2.36%)	70 (2.36%)	96 (3.24%)	110 (2.71%)	46 (1.55%)

Supplementary Table 2. Correlation among stress, fatigue, WMSDs, work and personal characteristics

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Stress	1								
(2) Fatigue	0.61**	1							
(3) WMSDs	0.40**	0.47**	1						
(4) Lifestyle	-0.20**	-0.25**	-0.30**	1					
(5) Personality	-0.18**	-0.25**	-0.24**	0.63**	1				
(6) Workload	0.71**	0.59**	0.41**	-0.21**	-0.20**	1			
(7) Job control and support	-0.07**	-0.12**	-0.12**	0.30**	0.38**	-0.08**	1		
(8) Noise	0.38**	0.40**	0.35**	-0.15**	-0.14**	0.43**	-0.03	1	
(9) Fumes	0.23**	0.23**	0.11**	0.00	0.01	0.28**	0.06**	0.46**	1

** $p < 0.001$