Prevalence of work-related musculoskeletal disorders among sonographers in China: results from a national web-based survey

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Abstract: Objectives: The aims of present study were to determine the prevalence of work-related musculoskeletal disorders (WRMSDs) among sonographers in China and to provide evidence for appropriate intervention measures to be taken. **Methods:** A self-reported questionnaire was used to screen WRMSDs experienced by sonographers during the past 12 months. This questionnaire survey was created and hosted on the WeChat official account platform for sonographers. **Results:** In the present study, 567 sonographers from 521 medical institutions completed the questionnaire. The vast majority (99.3%) of respondents reported experiencing symptoms of WRMSDs for at least one body region during the past 12 months. Work-related musculoskeletal pain or discomfort was most frequently reported for the neck (95.1%), right shoulder (84.1%), lower back (82.4%), right wrist/hand (81.0%), upper back (78.1%), right forearm/elbow (72.0%), and left shoulder (66.1%). Scanning hours per day, number of patients per day, and years of experience were positively associated with the occurrence and frequency of experiencing WRMSDs of some common and specific anatomical regions. Taking a regular rest break during the scanning working day was associated with a reduction of WRMSDs of the right shoulder and right wrist/hand. Adopting a sitting posture while performing scanning was associated with a reduction of WRMSDs, particularly for the lower back and the neck. Performing regular physical activity during leisure time was associated with a reduction of WRMSDs of the neck. **Conclusions:** The prevalence of WRMSDs among sonographers in China was extremely high. It is necessary and essential to reduce the number of scanning hours and patients per day, adopt a sitting posture while performing scanning, schedule regular rest breaks during the scanning working day, and encourage performance of regular physical activity during leisure time to alleviate this WRMSD issue experienced by sonographers.

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Introduction

Work-related musculoskeletal disorders (WRMSDs) are common in many industries and professions. WRMSDs account for a high proportion of work-related injuries. It is estimated that 60% of work-related injuries in the USA are due to WRMSDs[1]. WRMSDs have become a leading reason for absence from work. The risk factors of WRMSDs include repetitive motions, forceful or awkward movements, duration of pressure, overuse of particular anatomical structures or regions, poor posture or improper positioning, excessive force and strain, and vibrations[2].

With the advantages of its noninvasive and radiation-free character, sonography is widely used as an important medical diagnostic tool in clinical medicine. Occupational hazards associated with sonographers were first reported by Craig in 1985[3], which prompted the performance of an increasing number of studies to better quantify the prevalence of work-related injuries and to address occupational health problems among sonographers. When performing scanning, sonographers involve prolonged repetitive motions, poor or static posture, forceful movements of cer-

tain body regions, and sustained pressure against the patient's body. It is well recognized that sonographers are at high risk of developing WRMSDs. Over the past few decades, researchers in a growing number of countries have conducted studies to determine the prevalence and potential risk factors of WRMSDs among sonographers[4-6]. The reported prevalence of WRMSDs among sonographers ranges from 63% to 98.7%, which is extremely high[7]. It has been stated that more than 80% of sonographers suffered from WRMSDs and that 20% of these professionals had to end their careers because of WRMSDs[8]. In response to these findings, some developed countries, such as the USA and Australia, have developed risk-reducing industry standards to prevent and control WRMSDs experienced by workers in the sonography field[9].

While studies about WRMSDs among sonographers have been extensively conducted in some countries, information about the health status of sonographers in China was sparse. Evidence and results from other countries cannot be directly applied to sonographers in China for the following reasons. First, the shortage of health care professionals in China is even more obvious compared with that of developed countries, and the shortage of sonographers is no exception[10]. Second, most medical care workers in China are very busy — some doctors can see up to 100 patients a day — and sonographers in China have been reported to scan more patients than do sonographers in the other countries because of the workforce shortage[11]. Third, WRMSDs are compensable injuries in most developed countries, while WRMSDs are not compensable injuries in China[12,13]. Hence, little attention is paid to the prevention of WRMSDs among sonographers in China, and the self-protection awareness of sonographers is low. Furthermore, most sonographers in China are not equipped with height-adjustable examination tables, which may adversely affect the posture of sonographers[9]. Finally, adults in China are generally shorter in stature than Caucasian adults[14]. Nevertheless, it is easy for tall sonographers to adjust themselves to adopt a more comfortable posture. Overall, it is necessary to conduct research related to WRMSDs associated with sonographers in China. The purpose of the present study was to investigate the prevalence of WRMSDs of sonographers and to make plausible recommendations to address the current problem. This study should be useful to provide evidence for the appropriate preventive measures to be taken regarding the WRMSDs experienced by sonographers.

Subjects and Methods

Survey and participants

A self-reported questionnaire was used to screen WRMSDs experienced by sonographers during the past 12 months. This survey was in the form of an electronic questionnaire. This questionnaire survey was created and hosted on the WeChat official account platform for sonographers. An invitation letter for participants, which described the purpose and cut-off date of the questionnaire survey, was published on the WeChat official account in October 2016. Sonographers with scanning experience of at least 1 year were invited to participate in the survey. Participants were required to finish the questionnaire within half a month. Pregnant sonographers or subjects suffering from cancer or rheumatic arthritis were excluded. Non-work-related musculoskeletal injuries were not included in the analysis. This study was approved by the Medical Ethics Committee of Guangdong Province Hospital for Occupational Disease Prevention and Treatment. Informed consent information was included on the first page of questionnaire, and informed consent had to be provided in order to successfully complete the questionnaire. When the active period of the web-based survey expired, the data were downloaded from the web server. If participants provided a personal name and a name of a medical institution within the questionnaire, the completed questionnaire was considered to be valid.

Questionnaire

Based on relevant literature[15-17], we designed the questionnaire for sonographers in China. The questionnaire consisted of three sections, as follows. (A) Demographic variables, which included age, gender, years of scanning experience, height, handedness, and performance of physical exercise during leisure time. (B) Musculoskeletal symptoms, which adopted the standardized Nordic questionnaire to identify symptomatic regions[15]. The validity and reliability of this symptom survey has previously been reported[15,18]. Musculoskeletal symptoms included pain, soreness, swelling, numbness, muscle spasm, burning and/or tingling, and loss of sensation. Some of these symptoms may cause a loss of muscle strength[4]. The musculoskeletal symptoms section mainly covered details about specific locations and length of time of experiencing work-related musculoskeletal pain or discomfort during the past 12 months for 15 body regions. These 15 body regions included the neck, left and right shoulder, left and right forearm/elbow, left and right wrist/hand, upper back, lower back, left and right thigh/leg, left and right knee, and left and right ankle/foot. The length of time of experiencing symptoms was divided into four categories: 1 to 7 days (seldom), 8 to 30 days (sometimes), more than 30 days but not every day (frequently), and every day (always). A musculoskeletal disorder was defined by musculoskeletal symptoms that persisted for at least 1 day during the past 12 months[15]. (C) Workload, organization, and posture. The workload and organization section included the types of scans performed, average scanning days per week, average scanning hours per day, average number of patients per day, and whether a rest

Table 1. Demographics of all respondents (n=567)

Demographic variables	Number	Percentage (%)
Gender		
Male	128	22.6
Female	439	77.4
Age		
20-29	89	15.7
30-39	296	52.2
40-49	140	24.7
>50	42	7.4
Years of experience		
1-5	129	22.8
6-10	149	26.3
11-15	110	19.4
16-20	104	18.3
>20	75	13.2
Height		
<160cm	186	32.8
160-169cm	272	48.0
>169cm	109	19.2
Physical activity		
No/seldom	439	77.4
Once or twice per week	85	15.0
At least 3 times per week	43	7.6

break of at least 5 minutes per working hour was regularly taken. Whether an assistant responsible for the writing of reports was present at the sonographer's workstation was also covered in this third section. Posture (sitting, alternately sitting and standing, standing) during scanning was inquired about mainly in the third section.

Statistical analysis

Valid data that we obtained were fed into the SPSS software package (version 20.0; SPSS Inc., USA) for statistical analysis. For descriptive statistics, categorical variables were presented as numbers and percentages, and continuous variables were presented as means and standard deviations. A Chi-square test was used to compare the prevalence of work-related musculoskeletal symptoms for the left and right body regions. Based on relevant literature[19], respondents were subdivided into a high level of pain or discomfort group and a low level of pain or discomfort group, according to the length of time of experiencing symptoms during the past 12 months for the identified common body regions. Respondents who reported experiencing work-related musculoskeletal symptoms frequently or always formed the high level of pain or discomfort group, and the remaining respondents were put into the low level of pain or discomfort group. A multivariate logistic regression method was used to investigate

the relationship between demographic variables, work-related factors, the occurrence of musculoskeletal symptoms, and the prevalence of high level of pain or discomfort during the past 12 months for the identified common body regions. The variance inflation factor (VIF) was used for the regression model to investigate the potential of collinearity among independent variables. Collinearity was assumed to be present if VIF were higher than 10[20]. VIF was computed using SPSS. Odds ratios (ORs) and corresponding 95% confidence intervals (CIs) were determined. A p-value of <0.05 was considered statistically significant.

Results

When the active period of this survey expired, we downloaded 643 completed questionnaires in total. After 76 questionnaires were excluded because of a missing personal name or the name of a medical institution, 567 valid questionnaires were fed into the SPSS software for analysis. In this survey, 567 respondents came from 521 medical institutions which covered 20 provinces, 4 municipalities, and 4 autonomous regions in China.

Demographics

For this survey, 77.4% of 567 respondents were female. The mean age and height of all respondents were 36.9±7.6 years and 162.4±6.7 cm, respectively. The mean years of scanning were 12.2±7.4 years, and almost half of respondents had less than 10 years of scanning experience. Only a small proportion (5.3%) of respondents reported being left-handed; however, they were used to using their right hand to manipulate transducers against patients. The vast majority (77.4%) of respondents never or seldom exercised, 15.0% reported performance of physical exercise once or twice per week, and 7.6% exercised at least three times per week. Among all respondents, 95.8% were nonsmokers, 3.4% were regular smokers, and less than 1% indicated that they were former smokers. Table 1 lists the demographic characteristics of respondents.

Work-related musculoskeletal symptoms

From the present survey, 563 (99.3%) respondents reported experiencing work-related musculoskeletal symptoms in at least one body region. Based on the collected data, the highest prevalences of musculoskeletal pain or discomfort were related to the neck (95.1%), right shoulder (84.1%), lower back (82.4%), right wrist/hand (81.0%), upper back (78.1%), right forearm/elbow (72.0%), and left shoulder (66.1%) regions. The prevalence rates of musculoskeletal pain or discomfort of the right shoulder, forearm/elbow, wrist/hand, and thigh/hip regions were significantly higher than of the corresponding left regions (P < 0.001), while no statistical differences were found between the left and right sides of the

knee or ankle/foot (P > 0.05). Table 2 presents the prevalences of experiencing musculoskeletal symptoms with respect to body regions. Fig. 1 shows the percentages of musculoskeletal pain or discomfort experienced for four lengths of time for 15 body regions.

**Table 2.** Prevalence of work-related musculoskeletal symptoms in 15 body regions

Regions with symptoms	Percentage (%)
Neck	95.1
Left shoulder	66.1
Right shoulder	84.1
Left forearm/elbow	33.3
Right forearm/elbow	72.0
Left wrist/hand	25.2
Right wrist/hand	81.0
Upper back	78.1
Lower back	82.4
Left thigh/hip	25.6
Right thigh/hip	39.5
Left knee	22.2
Right knee	26.6
Left ankle/foot	10.2
Right ankle/foot	12.3

Work load, organization, and posture

Ultrasound scanning was divided into the categories of pediatric, gynecological, obstetric, ordinary adult, cardiac, vascular, bedside, and other types of scanning. Roughly 10% of sonographers mainly performed one category of sonography, and the vast majority (90%) performed more than two categories of scanning in their working days or weeks. More than half (52%) of respondents reported spending at least 8 h on scanning per day. Nearly 95% of sonographers worked more than 5 days per week. While the majority reported no rest time or taking rest breaks of less than 5 min per hour during continuous scanning, less than 10% reported taking rest breaks of at least 5 min per working hour. More than half (60.5%) of respondents reported that they were supported by assistants with the typing of scanning reports, and the remainder of respondents were responsible for both scanning and typing of reports. Nearly 80% of sonographers adopted a sitting posture during scanning, and 21.7% adopted a posture of alternately alternately sitting and standing. The workload, schedule, and posture data of respondents are presented in Table 3.

Relationship between factors and occurrence of work-related musculoskeletal symptoms

The maximum value of the VIF was 2.9, which allowed collinearity not to be taken into account in the regression model. Multivariate logistic regression was used to analyze associations between individual factors, work-related factors, and the prevalence of symptoms for five
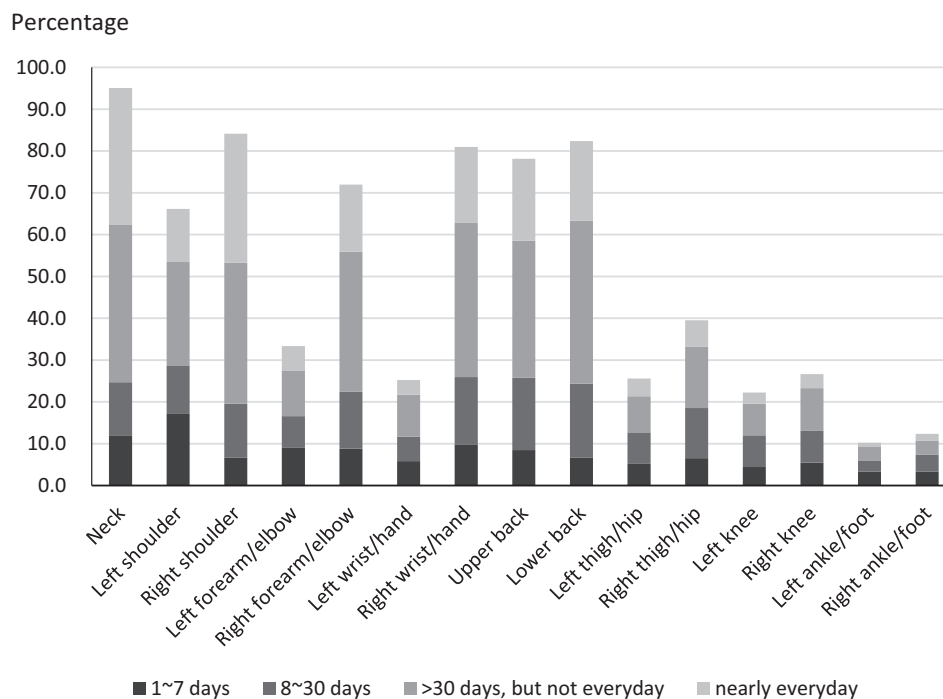
Percentage

Fig. 1. Percentage of musculoskeletal symptoms of four lengths in 15 body regions (n=567)

Table 3. Workload, schedule and posture of respondents (n=567)

Variables	Number	Percentage (%)
Scanning hours per day		
<=4 h	28	4.9
4-6 h	44	7.8
6-8 h	200	35.3
>=8 h	295	52.0
Working days per week		
<5 days	31	5.5
5-6 days	275	48.5
>=6 days	261	46.0
Number of patients per day		
<30	42	7.4
30-49	151	26.6
50-69	231	40.8
70-89	89	15.7
>=90	54	9.5
Categories of sonography		
Pediatric	198	34.9
Gynecological	454	80.1
Obstetric	434	76.5
Ordinary adult	449	79.2
Cardiac	311	54.9
Vascular	318	56.1
Bedside	186	32.8
Others	72	12.7
Posture		
Sitting	440	77.6
Standing	4	0.7
Alternatively sitting and standing	123	21.7

common body regions (neck, right shoulder, lower back, right wrist/hand, and upper back). Compared with the age group of 20 to 29 years, the age group of 30 to 39 years had a higher prevalence of symptoms of the neck (OR= 4.26, 95% CI: 1.03-17.58) and upper back (OR=2.24, 95% CI: 1.09-4.59), while no significant association was found for other three regions. Performance of regular physical activity during leisure time was significantly associated with a reduction of the prevalence of neck pain (OR=0.30, 95% CI: 0.12-0.79), while physical activity did not significantly change the risk of developing musculoskeletal symptoms for the other four regions. A regular rest break of at least 5 min per hour was significantly associated with a reduction of the prevalence of symptomatic right shoulder (OR=0.45, 95% CI: 0.23-0.88) and right wrist/hand pain or discomfort (OR=0.44, 95% CI: 0.23-0.86), while a break duration of less than 5 min per hour did not demonstrate a similar relationship. Sonographers who did not adopt a sitting posture during the

whole working day experienced a higher prevalence of symptoms of the lower back than that of sedentary sonographers (OR=2.04, 95% CI: 1.09-3.82). Years of experience and scanning hours per day were significantly associated with a higher prevalence of upper back pain or discomfort. Sonographers with experience of 16 to 20 years had significantly greater odds of reporting symptomatic upper back pain or discomfort than that of the group with experience of less than 5 years (OR=3.45, 95% CI: 1.20-9.93), and the OR was greater for the group of more than 20 years' experience (OR=6.81, 95% CI: 1.48-31.28). Sonographers scanning for more than 6 h per day had significantly greater odds of reporting symptomatic upper back pain or discomfort than that of the group scanning for less than 4 h per day (OR=3.00, 95% CI: 1.15-7.84). With regard to gender, height, assistants, and number of patients per day, no significant association was observed among groups for the prevalence of musculoskeletal symptoms for the five common body regions. Table 4 presents the ORs computed for the prevalence of work-related musculoskeletal symptoms of the neck, right shoulder, right wrist/hand, upper back, and lower back.

Relationship between factors and prevalence of high level of musculoskeletal pain or discomfort

The prevalence of reporting high level of musculoskeletal pain or discomfort of the neck, right shoulder, lower back, right wrist/hand, and upper back was 70.4%, 64.6%, 55.0%, 52.4%, and 58.0%, respectively. Multivariate logistic regression was used to analyze associations between individual factors, work-related factors, and the prevalence of high level of pain or discomfort of the neck, right shoulder, lower back, right wrist/hand, and upper back. Years of scanning experience increased the risk of high level of musculoskeletal pain or discomfort of the neck, right shoulder, right wrist/hand, and upper back. Sonographers with experience of 16 to 20 years had significantly greater odds of reporting high level of musculoskeletal pain or discomfort of the neck and upper back than that of the group of less than 5 years' experience, and ORs were greater for the group of sonographers of more than 20 years' experience. Compared with the group with experience of less than 5 years, sonographers with experience of more than 20 years had significantly greater odds of reporting high level of musculoskeletal pain or discomfort of the right shoulder and right wrist/hand. Scanning hours per day was significantly associated with high level of musculoskeletal pain or discomfort of the right shoulder, right wrist/hand, and upper back. Sonographers spending more than 8 h on scanning per day had significantly greater odds of experiencing high level of musculoskeletal pain or discomfort of the right shoulder and right wrist/hand than that of the group of less than 4 h per day of scanning. Sonographers scanning for 6-8 h per day had significantly greater odds of experiencing high

Table 4. Association between presence of symptoms in common region and factors analyzed by multivariate logistic regression

Variables	Neck pain			Right shoulder pain			Right wrist/hand pain			Upper back pain			Lower back pain		
	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value
Gender															
Male	Ref			Ref			Ref			Ref			Ref		
Female	1.07	0.28-4.11	0.93	1.72	0.78-3.76	0.18	1.33	0.63-2.8	0.45	1.53	0.74-3.18	0.25	1.06	0.5-2.25	0.89
Age															
20-29	Ref			Ref			Ref			Ref			Ref		
30-39	4.26	1.03-17.58	0.05	2.14	0.90-5.06	0.08	1.80	0.80-4.01	0.15	2.24	1.09-4.59	0.03	2.12	0.93-4.81	0.07
40-49	1.98	0.31-12.58	0.47	1.53	0.49-4.81	0.47	1.10	0.38-3.19	0.86	2.22	0.79-6.21	0.13	2.57	0.85-7.77	0.10
>50	2.18	0.14-33.48	0.58	0.75	0.16-3.64	0.72	0.41	0.09-1.81	0.24	0.56	0.11-2.83	0.48	1.89	0.40-8.94	0.42
Years of experience															
1-5	Ref			Ref			Ref			Ref			Ref		
6-10	1.47	0.34-6.46	0.61	1.66	0.69-3.97	0.26	1.58	0.71-3.54	0.26	1.29	0.64-2.62	0.47	1.07	0.48-2.41	0.86
11-15	0.59	0.13-2.76	0.51	0.81	0.33-2.01	0.66	0.77	0.33-1.79	0.55	0.79	0.37-1.69	0.54	0.63	0.27-1.51	0.30
16-20	2.18	0.32-14.93	0.43	1.41	0.48-4.19	0.54	1.61	0.58-4.49	0.36	3.45	1.20-9.93	0.02	0.96	0.34-2.70	0.94
>20	2.54	0.24-27.27	0.44	2.27	0.55-9.33	0.26	3.09	0.80-11.87	0.10	6.81	1.48-31.28	0.01	1.24	0.32-4.85	0.76
Height															
<160cm	Ref			Ref			Ref			Ref			Ref		
160-169cm	0.89	0.33-2.42	0.83	0.97	0.55-1.71	0.90	1.16	0.68-1.96	0.59	1.01	0.61-1.68	0.97	0.85	0.50-1.46	0.55
>169cm	0.89	0.18-4.36	0.89	1.35	0.52-3.52	0.54	1.09	0.46-2.59	0.85	1.27	0.54-3.02	0.58	0.83	0.34-2.01	0.67
Physical activity															
No regular exercise	Ref			Ref			Ref			Ref			Ref		
Once or twice per week	0.30	0.12-0.79	0.01	0.96	0.50-1.88	0.91	1.52	0.77-3.01	0.23	0.79	0.43-1.45	0.44	1.00	0.52-1.91	1.00
At least 3 times per week	0.30	0.08-1.07	0.06	0.83	0.34-2.05	0.69	0.75	0.34-1.65	0.47	1.06	0.43-2.63	0.90	0.86	0.36-2.04	0.73
Scanning hours per day															
<=4 h	Ref			Ref			Ref			Ref			Ref		
4-6 h	2.64	0.35-19.96	0.35	1.55	0.45-5.37	0.49	1.63	0.42-6.38	0.48	2.20	0.73-6.62	0.16	1.92	0.55-6.65	0.31
6-8 h	2.86	0.57-14.37	0.20	1.21	0.42-3.5	0.73	0.58	0.19-1.82	0.35	3.00	1.15-7.84	0.03	1.35	0.48-3.84	0.57
>=8 h	2.96	0.61-14.36	0.18	1.62	0.56-4.66	0.37	1.05	0.34-3.26	0.94	3.14	1.22-8.06	0.02	1.46	0.52-4.06	0.47
Working days per week															
<5 days	Ref			Ref			Ref			Ref			Ref		
5-6 days	1.77	0.34-9.26	0.50	0.48	0.14-1.68	0.25	1.20	0.45-3.19	0.72	0.76	0.29-2.01	0.58	1.08	0.41-2.84	0.88
>=6 days	1.50	0.30-7.60	0.62	0.81	0.23-2.89	0.74	1.04	0.39-2.76	0.94	1.03	0.39-2.74	0.95	1.30	0.49-3.46	0.60

Table 4. Association between presence of symptoms in common region and factors analyzed by multivariate logistic regression (continued)

Variables	Neck pain			Right shoulder pain			Right wrist/hand pain			Upper back pain			Lower back pain		
	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value
Number of patients per day															
<30	Ref			Ref			Ref			Ref			Ref		
30-49	0.41	0.07-2.34	0.32	1.38	0.57-3.33	0.47	1.06	0.43-2.60	0.90	0.84	0.35-2.04	0.70	1.85	0.79-4.35	0.16
50-69	0.60	0.10-3.44	0.56	2.11	0.86-5.16	0.10	1.52	0.61-3.75	0.37	1.10	0.45-2.69	0.83	2.08	0.89-4.89	0.09
70-89	0.65	0.08-5.16	0.68	1.71	0.60-4.87	0.31	1.36	0.48-3.84	0.56	0.66	0.25-1.76	0.40	2.43	0.88-6.68	0.09
>=90	1.04	0.07-14.49	0.98	2.67	0.75-9.56	0.13	0.97	0.32-2.95	0.96	0.70	0.24-2.09	0.53	1.37	0.47-3.96	0.56
Rest break															
No rest	Ref			Ref			Ref			Ref			Ref		
Less than 5 min/h	1.20	0.25-5.91	0.82	1.87	0.62-5.59	0.26	1.36	0.53-3.47	0.52	1.54	0.66-3.63	0.32	1.86	0.68-5.05	0.22
More than 5 min/h	0.37	0.13-1.12	0.08	0.45	0.23-0.88	0.02	0.44	0.23-0.86	0.02	0.69	0.35-1.36	0.28	0.71	0.35-1.42	0.33
Posture															
Sitting	Ref			Ref			Ref			Ref			Ref		
Not Sitting	2.72	0.74-10.09	0.13	1.18	0.65-2.16	0.59	1.38	0.77-2.44	0.28	1.46	0.85-2.50	0.17	2.04	1.09-3.82	0.03
Assistant															
Equipped	Ref			Ref			Ref			Ref			Ref		
Not equipped	0.58	0.25-1.35	0.20	0.78	0.47-1.27	0.31	0.74	0.47-1.17	0.20	0.88	0.56-1.38	0.57	0.72	0.45-1.15	0.17

level of pain or discomfort of the upper back than that of the group of less than 4 h per day of scanning. The number of patients per day was significantly associated with experiencing high level of musculoskeletal pain or discomfort of the lower back. Taking a rest break of at least 5 min per hour was associated with a decreased risk of experiencing high level of musculoskeletal pain or discomfort of the right shoulder. Scanning while in a sitting posture decreased the risk of reporting high level of musculoskeletal pain or discomfort of the neck and lower back. ORs computed for the prevalence of high level of musculoskeletal pain or discomfort of the neck, right shoulder, right wrist/hand, upper back, and lower back are presented in Table 5.

Discussion

WRMSDs have been recognized as a major occupational problem in the sonography profession[3,4]. There is still little relevant research about the prevalence of WRMSDs among sonographers in China. The present survey included 567 respondents from 521 medical institutions in China. The large sample size of respondents and medical institutions make the results of this study representative of a large proportion of sonographers in China, to a certain extent. The present study shows that as many as 99.3% of respondents experienced symptoms of WRMSDs for at least one body region during past 12 months. The prevalence rate of WRMSDs among sonographers in China is astonishing, and it is much higher than that of relevant data reported in other countries. The prevalence of WRMSDs among North American sonographers in 1997 was 81% and had increased to 90% in 2008[16,17]. Furthermore, 91% of sonographers in British Columbia reported work-related musculoskeletal pain or discomfort[19]. Roughly 80% of sonographers in Italy and 86.0% in Israel experienced one or more symptoms of WRMSDs[21,22]. The prevalence of WRMSDs among sonographers was as high as 95.4% in Australia[23] and 88.1% in Enugu state of Nigeria[24]. It is well recognized that most WRMSDs are multifactorial. Physical, psychosocial/organizational, and individual factors modulate the risk of developing WRMSDs[25]. From the present study, the heavy workload of sonographers in China was one of the main reasons for the higher prevalence of WRMSDs. This large-scale survey showed that scanning hours per day, scanning days per week, or number of patients per day in China was much more than those reported for other countries[16,17,19,26,27]. Smith et al.[28] found that the numbers of scans performed (100 or more scans performed per month) increased the risk of experiencing musculoskeletal symptoms among sonographers. Russo et al.[19] also found a positive relationship between scanning hours per day and musculoskeletal symptoms. From the present study, more than half of sonographers spent more

than 8 h on scanning per day, and the majority reported scanning 30-69 patients per day and working for 6 days or more per week, coupled with taking fewer rest breaks during scanning time. Not surprisingly, we observed a much higher prevalence rate of WRMSDs among sonographers.

The present study indicates that the prevalence rates of work-related musculoskeletal pain or discomfort of the right shoulder, forearm/elbow, wrist/hand, and thigh/hip regions were significantly higher than were those of the left regions. Typical scanning requires unsupported abduction of the scanning arm, repetitive and sustained twisting of the trunk and neck, and static contractions to maintain the arm in a fixed position while pressing the transducer against the patient. While only a small proportion of respondents of the present study was left-handed, all respondents reported using the right hand to manipulate the transducer because of the same teaching practice, training, and similar layout of workstations being used in different medical institutions. Sonographers using the right hand to operate the transducer tend to incline toward the right side. The asymmetrical characteristics of dynamic movement and static contractions of body regions among sonographers induce the higher prevalence of work-related musculoskeletal pain or discomfort of the right shoulder, forearm/elbow, wrist/hand, and thigh/hip regions compared with the prevalence of such pain or discomfort for the left regions. This research reveals that common symptomatic anatomical regions were the neck, right shoulder, lower back, right wrist/hand, upper back, right forearm/elbow, and left shoulder, and the prevalence of discomfort for these regions was 95.1%, 84.1%, 82.4%, 81.0%, 78.1%, 72.0%, and 66.1%, respectively. These common symptomatic anatomical regions among sonographers are consistent with the findings of Pike et al.[16] and Necas et al.[26].

The current study indicates that scanning hours per day and number of patients per day were positively associated with the occurrence and frequency of experiencing musculoskeletal pain or discomfort for specific anatomical regions among sonographers. The present study reports a positive relationship between scanning hours per day and the occurrence of musculoskeletal symptoms of the upper back. Performing more than 6 h of scanning per day was positively associated with the sonographers of this group experiencing musculoskeletal symptoms of the upper back, but this positive association was not observed for the group of sonographers performing less than 4 h of scanning per day. Because of the low number of sonographers who performed a smaller number of scanning hours per day included in this survey, it was not possible to determine the differences in the occurrence of experiencing musculoskeletal symptoms of the neck, right shoulder, lower back, and right wrist/hand among the groups of scanning hours per day established in this study. The

Table 5. Association between prevalence of high musculoskeletal pain in common regions and factors analyzed by multivariate logistic regression

Variables	Neck pain			Right shoulder pain			Right wrist/hand pain			Upper back pain			Lower back pain		
	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value
Gender															
Male	Ref			Ref			Ref			Ref			Ref		
Female	1.29	0.66-2.54	0.46	1.01	0.53-1.91	0.98	0.90	0.49-1.65	0.73	1.17	0.63-2.18	0.62	1.13	0.61-2.09	0.70
Age															
20-29	Ref			Ref			Ref			Ref			Ref		
30-39	1.86	0.95-3.64	0.07	1.67	0.86-3.23	0.13	1.28	0.67-2.44	0.46	1.82	0.94-3.52	0.08	2.05	1.07-3.93	0.03
40-49	1.71	0.68-4.31	0.25	1.10	0.45-2.68	0.84	1.13	0.48-2.68	0.78	1.27	0.52-3.08	0.60	2.30	0.96-5.52	0.06
>50	2.07	0.44-9.70	0.36	0.88	0.24-3.14	0.84	0.86	0.25-2.92	0.81	0.56	0.16-1.97	0.36	1.66	0.48-5.72	0.42
Years of experience															
1-5	Ref			Ref			Ref			Ref			Ref		
6-10	1.12	0.59-2.13	0.73	1.20	0.64-2.26	0.56	1.46	0.80-2.67	0.22	0.90	0.49-1.65	0.73	1.10	0.60-2.02	0.77
11-15	0.88	0.44-1.79	0.73	0.94	0.47-1.88	0.86	1.20	0.62-2.34	0.59	0.91	0.47-1.78	0.79	0.75	0.38-1.47	0.40
16-20	2.55	1.05-6.17	0.04	2.14	0.93-4.97	0.08	1.65	0.75-3.60	0.21	2.81	1.25-6.32	0.01	1.63	0.73-3.63	0.24
>20	4.78	1.32-17.32	0.02	3.16	1.07-9.38	0.04	4.10	1.46-11.53	0.01	6.73	2.25-20.14	<0.01	2.06	0.73-5.84	0.18
Height															
<160cm	Ref			Ref			Ref			Ref			Ref		
160-169cm	1.39	0.88-2.20	0.16	1.26	0.82-1.94	0.29	1.02	0.68-1.54	0.92	1.08	0.72-1.64	0.71	1.20	0.80-1.82	0.38
>169cm	0.89	0.41-1.93	0.76	0.66	0.32-1.38	0.27	0.76	0.37-1.53	0.44	1.22	0.59-2.50	0.60	1.03	0.50-2.10	0.95
Physical activity															
No regular exercise	Ref			Ref			Ref			Ref			Ref		
Once or twice per week	0.74	0.42-1.29	0.29	1.18	0.68-2.02	0.56	1.25	0.75-2.09	0.39	1.45	0.86-2.46	0.16	1.55	0.91-2.64	0.11
At least 3 times per week	0.92	0.42-2.00	0.82	1.13	0.55-2.32	0.74	0.73	0.37-1.44	0.37	1.30	0.64-2.62	0.47	1.02	0.51-2.03	0.96
Scanning hours per day															
<=4 h	Ref			Ref			Ref			Ref			Ref		
4-6 h	1.34	0.48-3.79	0.58	2.50	0.89-6.97	0.08	2.51	0.90-6.97	0.08	1.71	0.59-4.98	0.32	2.02	0.72-5.64	0.18
6-8 h	1.74	0.69-4.35	0.24	2.27	0.93-5.56	0.07	1.88	0.76-4.65	0.17	2.71	1.06-6.94	0.04	1.31	0.54-3.20	0.55
>=8 h	2.35	0.95-5.83	0.07	2.85	1.17-6.92	0.02	2.55	1.05-6.24	0.04	2.28	0.9-5.78	0.08	1.58	0.65-3.80	0.31
Working days per week															
<5 days	Ref			Ref			Ref			Ref			Ref		
5-6 days	1.46	0.64-3.31	0.37	0.85	0.37-1.94	0.70	0.82	0.37-1.78	0.61	0.82	0.37-1.83	0.64	0.98	0.45-2.15	0.96
>=6 days	1.79	0.78-4.10	0.17	1.12	0.49-2.57	0.79	0.94	0.43-2.05	0.88	1.00	0.45-2.23	1.00	1.37	0.63-3.02	0.43

Table 5. Association between prevalence of high musculoskeletal pain in common regions and factors analyzed by multivariate logistic regression (continued)

Variables	Neck pain			Right shoulder pain			Right wrist/hand pain			Upper back pain			Lower back pain		
	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value
Number of patients per day															
<30	Ref			Ref			Ref			Ref			Ref		
30-49	0.92	0.42-2.05	0.84	1.01	0.47-2.19	0.98	0.93	0.44-1.97	0.84	1.52	0.70-3.33	0.29	2.39	1.10-5.18	0.03
50-69	1.26	0.57-2.82	0.57	1.31	0.6-2.84	0.50	1.23	0.58-2.61	0.59	1.99	0.91-4.35	0.08	2.78	1.28-6.02	0.01
70-89	1.09	0.44-2.69	0.86	0.89	0.37-2.11	0.79	1.51	0.65-3.52	0.34	1.05	0.44-2.51	0.91	3.12	1.31-7.43	0.01
>=90	1.27	0.46-3.49	0.65	1.37	0.52-3.60	0.53	0.70	0.28-1.75	0.44	2.12	0.82-5.45	0.12	2.32	0.91-5.96	0.08
Rest break															
No rest	Ref			Ref			Ref			Ref			Ref		
Less than 5 min/h	0.86	0.42-1.75	0.67	0.92	0.46-1.83	0.82	0.78	0.40-1.51	0.45	0.55	0.28-1.11	0.10	1.62	0.80-3.28	0.18
More than 5 min/h	0.77	0.40-1.45	0.42	0.42	0.23-0.77	0.01	0.61	0.33-1.12	0.11	0.96	0.52-1.79	0.90	0.86	0.47-1.59	0.64
Posture:															
Sitting	Ref			Ref			Ref			Ref			Ref		
Not Sitting	1.75	1.06-2.89	0.03	1.07	0.68-1.67	0.78	1.49	0.97-2.29	0.07	1.53	0.99-2.36	0.06	1.89	1.21-2.95	0.01
Assistant															
Equipped	Ref			Ref			Ref			Ref			Ref		
Not equipped	0.84	0.56-1.26	0.39	0.74	0.50-1.08	0.12	0.79	0.55-1.14	0.20	0.88	0.61-1.28	0.51	0.88	0.61-1.27	0.49

number of scanning hours per day was positively associated with reporting high level of musculoskeletal pain or discomfort of the neck, upper back, right shoulder, and right wrist/hand, and the number of patients per day was positively associated with reporting high level of musculoskeletal pain or discomfort of the lower back. Full-time sonographers in China generally worked longer scanning hours per day than those reported for full-time or part-time sonographers in other countries[16,21,26]. The average number of hours spent on scanning per day among sonographers in the USA was 6.8±2.0 from the study by Pike et al.[16]. Sonographers in Washington and Oregon states spent 36 scanning hours per week on average[16,26]. The majority (49%) of sonographers in Italy worked 3-5 h per day[21]. The present study indicates that it is necessary to reduce and limit the scanning hours per day for sonographers in China in order to alleviate this WRMSD issue.

This study indicates that sonography experience of more than 16 years was associated with a higher prevalence of the sonographers experiencing WRMSDs of the upper back. Nevertheless, no significant difference was observed in the percentage of sonographers reporting symptoms of WRMSDs of the neck, right shoulder, right wrist/hand, and lower back among the different experience groups. This result suggests that the majority of respondents experienced symptoms of WRMSDs within a period of scanning experience of 1 to 5 years and that this was caused mainly by a heavy workload. The present study shows that years of experience was positively associated with the prevalence of high level of pain or discomfort for WRMSDs of the neck, right shoulder, right wrist/hand, and upper back, especially for those sonographers with scanning experience of more than 16 years. The currently available literature suggests that the association between years of experience and the prevalence of WRMSDs among sonographers is inconsistent across studies. Vanderpool et al.[29] and Janga et al.[30] did not observe a significant relationship between the number of years of scanning and the prevalence of work-related musculoskeletal symptoms. Evans et al.[17] stated that sonographers with more than 21 years of experience reported more hand/finger pain than did less experienced sonographers.

The present research suggests that taking regular rest breaks during scanning was significantly associated with a reduction of musculoskeletal symptoms of the right shoulder and right wrist/hand. Taking inadequate rest breaks can be considered to be another risk factor of developing WRMSDs among sonographers. Prolonged working hours combined with inadequate rest time leads to reduced muscle recovery time during the course of the working day. Findings from the current literature suggest that, for various occupations, a person who maintains an efficient posture and actions and whose work schedule in-

cludes a recovery phase can perform and sustain work without injury[31]. This study reveals that less than 10% of sonographers reported taking a rest break of at least 5 min per working hour. Scheduling a regular break time during continuous scanning per working hour for sonographers in China is an essential and important intervention measure to alleviate the WRMSD problem. The findings of this study suggest that taking a rest break of at least 5 min per hour may be effective to reduce the risk of experiencing musculoskeletal symptoms of the right shoulder and right wrist/hand. However, with regard to a reasonable rest break schedule per day among sonographers in China, it still needs further research to ensure both the efficiency of the medical service and the occupational health of sonographers.

This study's findings indicate that adopting a sitting posture while performing scanning was associated with reduced experience of work-related musculoskeletal symptoms, particularly for the lower back and the neck. This finding is consistent with findings of Schoenfeld et al.[22,32], who reported that standing correlated with increased musculoskeletal stress. Because the vast majority of examination beds are not height-adjustable in China, standing sonographers have an increased chance of having to lean over patients and toward screens, which increases the risk of experiencing work-related musculoskeletal symptoms of the lower back and the neck. Therefore, we also support previous recommendations that sonographers should universally adopt a sitting posture[32].

This research indicates that performance of regular physical activity during leisure time significantly reduces the prevalence of work-related musculoskeletal symptoms of the neck. This study further indicates that performance of physical activity was helpful in the recovery from muscle strain and the prevention of WRMSDs of the neck. Similar to this finding, Magnavita et al.[21] also found that regular physical activity was associated with a reduction of the prevalence of work-related musculoskeletal symptoms. Only 7.6% of sonographers included in this study reported performance of physical activity, and the physical activity level among sonographers in China was much lower than that of sonographers in other countries[16,21,29]. Regular physical exercise should be promoted to prevent and control the occurrence and aggravation of WRMSDs among sonographers in China. In addition, sonographers in China are encouraged to exercise and stretch muscle groups used during scanning in their rest break time and leisure time. This study reveals that the age group of 30 to 39 years had a higher prevalence of WRMSDs of the neck and back compared with the age group of 20 to 29 years, which may suggest that physiological tissue degeneration and attenuated recovery of injured tissues of the neck and back are more obvious with age than those of other regions. The relationship between age and

WRMSDs was still uncertain because of different population characteristics, sample sizes, group divisions, and other confounders[6,16,28,33].

The current study has the following limitations. First, this cross-sectional study cannot establish the cause-and-effect relationship between the WRMSDs and relevant factors. Second, sonographers suffering from WRMSDs might have been more interested in this web-based survey and willing to complete the questionnaire, and this selection bias would have led to a higher prevalence of WRMSDs being reported and stronger associations between work-related factors and WRMSDs being determined than the reality. Third, because the majority of participants performed multiple categories of sonography, it is difficult to quantify physical factors. Hence, physical factors were not analyzed in this survey. Third, this study did not investigate psychosocial factors. Therefore, future prospective or intervention research is required to explore and confirm effective protective measures against WRMSD issues among sonographers.

The high prevalence of WRMSDs among sonographers in China suggests that WRMSDs are a major problem. It is obvious that sonographers in China perform more scanning hours and days and see more patients than do sonographers in other countries. Lack of rest time is a common problem for sonographers in China. It is urgent to take comprehensive intervention measures to alleviate the WRMSD issue. The present study reveals that it is essential to reduce the number of scanning hours and patients per day, adopt a sitting posture while performing scanning, schedule regular rest breaks during the scanning working day, and encourage performance of regular physical activity during leisure time to alleviate this WRMSD issue experienced by sonographers.

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