

Characteristics and Consequences of Work-Related Musculoskeletal Pain among Cardiac Sonographers Compared with Peer Employees: A Multisite Cross-Sectional Study



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Background: Work-related musculoskeletal pain (WRMSP) among cardiac sonographers has been incompletely studied. The aim of this study was to compare the frequency, magnitude, and impact of WRMSP among cardiac sonographers with those of a control group of peer employees.

Methods: An electronic survey was sent to cardiac sonographers and peer employees assigned to different occupational exposures within the Department of Cardiovascular Medicine at 10 Mayo Clinic facilities in four states.

Results: A total of 416 subjects completed the survey: 111 sonographers (27%) and 305 peer-employee control subjects (73%). The mean age was 43 ± 11 years, and 307 subjects (74%) were women. The sonographers' response rate was 86%. WRMSP was experienced by a large majority of sonographers (95 [86%] vs 140 [46%] for control subjects, $P < .001$). This association persisted after multivariate adjustment (odds ratio, 8.18; 95% confidence interval, 4.33–15.46; $P < .001$). Compared with coworkers, sonographers' pain was perceived as more severe (pain score > 5 on a 10-point scale; 62% vs 29%, $P < .001$) and as getting worse (14% vs 2%, $P < .001$). The neck (58% vs 25%), shoulder (51% vs 11%), lower back (44% vs 26%), and hand (42% vs 9%) were the most frequently affected body regions ($P < .001$ for each). The presence of WRMSP in sonographers was more often associated with interference in performance of daily (37% vs 12%, $P < .001$) and work-related (42% vs 11%, $P < .001$) activities. Because of pain, sonographers more often sought medical evaluation (27% vs 12%, $P < .001$), missed work (13% vs 4%, $P < .001$), had work restrictions (5% vs 0.6%, $P = .005$), and were considering changing employment (9% vs 0.5%, $P < .001$) compared with control subjects.

Conclusions: WRMSP in cardiac sonographers is much more prevalent and severe compared with peer employees. WRMSP in sonographers affects daily and work-related activities, as well as future employment plans. Further studies assessing the potential role of preventive interventions are needed. (J Am Soc Echocardiogr 2019;32:1138–46.)

Keywords: Echocardiography, Ultrasound, Ergonomics, Work-related musculoskeletal disorders, Occupational pain

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Several publications have drawn attention to the prevalence of work-related musculoskeletal pain (WRMSP) among cardiac sonographers.¹⁻³ WRMSP is a common cause of work restrictions and results in loss of productive work time.⁴ Beyond the costs of compensation claims, medical expenses and resulting absenteeism, occupational musculoskeletal pain affects the physical health and well-being of staff members.^{3,5,6}

Most research studies on the topic had limited response rates to surveys, an absence of control groups, and a lack of statistical adjustments for confounders.^{1,2,5,7-9} Additionally, despite ergonomic improvements in the design of ultrasound systems and workstation equipment, the incidence of WRMSP among cardiac

Abbreviations

BMI = Body mass index
CTS = Carpal tunnel syndrome
DASH = The Disabilities of the Arm, Shoulder, and Hand Outcome Measure
WRMSP = Work-related musculoskeletal pain

sonographers remains high.^{6,9,10} The Mayo Clinic enterprise is composed of a large network of cardiac sonographers who perform a high volume of complex echocardiographic examinations.¹¹ In light of this, we recently detected concerning rates of WRMSP among cardiac sonographers (88%) compared with peer employees in a study initially designed for cardiac catheterization laboratory em-

ployees.^{11,12} However, the number of cardiac sonographers in this study was small, and information regarding sonography-specific factors, including the impact and particular type of pain, work environment characteristics, work scheduling and tasks, disorders related to scanning, and implications for future career plans, was lacking. Fully understanding the risk factors, mechanisms, and consequences of musculoskeletal pain are essential to designing effective interventions. To address gaps in knowledge, we sought to (1) determine the frequency, type, location, and magnitude of musculoskeletal symptoms among cardiac sonographers compared with peer employees within the cardiology department; (2) identify modifiable risk factors in an effort to prevent injuries; and (3) determine the impact of WRMSP on future employment plans, such as medical treatment and career-ending injuries.

METHODS

Study Design and Population

The study was performed through an electronic survey distributed to cardiac sonographers and peer employees within the Department of Cardiovascular Medicine at all 10 Mayo Clinic sites at which echocardiography is performed (Scottsdale, AZ; Jacksonville, FL; Rochester, Mankato, Austin, Owatonna, Red Wing, and Albert Lea, MN; and La Crosse and Eau Claire, WI). The cohort was divided into cardiac sonographers (the study group) and peer employees within the cardiology department (the control group). The control group was composed of peer employees assigned to different occupational exposures and hazards within the cardiology department and various affiliations with the echocardiography laboratory, including nurses (27%); electrocardiography, catheterization, laboratory, media production, and other cardiovascular technicians (15%); fellows (11%); staff physicians (11%); exercise physiologists (9%); administrative assistants (5%); administration (5%); patient appointment coordinators (4%); clinical assistants (3%); and others (10%; operations analyst, business analyst, professional development coordinator, education program coordinator, medical staff assignment coordinator, education specialist, receptionist). Secondary analyses included sonographers with pain versus control subjects with pain, sonographers with pain versus sonographers without pain, and control subjects with pain versus control subjects without pain. No medical records were accessed in the study. The study was approved by the Mayo Clinic institutional review board, and all patients provided written, informed consent.

Survey

The survey consisted of 58 questions divided into the following categories: demographics, medical history, work-related activities,

and, for those with musculoskeletal pain, its location, frequency, duration, progression, intensity, severity, and aggravating and alleviating factors. Additionally, the survey included questions about physical activity outside of work and whether sonographers regularly relaxed their handgrip for a few seconds while scanning. The questionnaire was designed by the Mayo Clinic Survey Center and electronically sent to participants in April 2015, with weekly reminders for 6 weeks to nonresponders. Questions related to work included scheduling, years in current position, percentage of time during work week spent scanning, work setting, current workload, ergonomics (scanning hand, scanning position), equipment and environment. The definition used for WRMSP was pain or discomfort experienced in the current year resulting from work activities. Medical diagnoses related to scanning (carpal tunnel syndrome [CTS], arthritis, spinal stenosis, herniated disks, and lateral epicondylitis) and the impact of WRMSP were collected. The impact of WRMSP included whether the pain was associated with interference in performance of daily, recreational, or work-related activities; whether subjects sought medical evaluation and received medical (prescription pain medication, over-the-counter medication, and alternative therapy) or surgical treatment; and whether they missed work days, had more work restrictions, or made changes to their work-related responsibilities. The same questionnaire was sent to all participants, and sonographer-related questions were answered "not applicable" by the control group.

To quantify physical function and symptoms in subjects with any or multiple musculoskeletal disorder of the upper limb, the QuickDASH questionnaire (the Disabilities of the Arm, Shoulder, and Hand Outcome Measure) was sent to participants.¹³⁻¹⁵ The QuickDASH is a patient-based, 11-item questionnaire; each item has five response options, and from the item scores, a summative score on a 100-point scale is calculated, with 100 indicating the most disability.¹³⁻¹⁵ Additionally, the QuickDASH Work questionnaire was also sent to participants. The QuickDASH Work is a four-item questionnaire (20-point scale) that quantifies subjects' ability to perform work activities.¹⁵ The definition of regular exercise was ≥ 20 min a day on ≥ 3 days a week. Pain was assessed by the Pain Rating Index and Present Pain Intensity scales.^{11,16} The Present Pain Intensity is a self-assessment-based descriptive pain measurement tool that includes none, mild, discomforting, distressing, horrible, and excruciating. A scale of 0 (pain free) to 10 (worst imaginable pain possible) was used to rate pain.

Sonographers' Work Assignments

Sonographers are usually assigned to six 75-min echocardiographic examinations per day with a 1-hour lunch break in between. Bedside echocardiographic studies are generally equally distributed among sonographers. Sonographers often perform studies in conjunction with fellows or student sonographers, and some have additional research, education, and administrative responsibilities. The time at work scanning was defined as the ratio of the number of working hours spent scanning by the total number of paid hours during a period (full-time or part-time). The value obtained was then divided into four groups: <25%, 25% to 50%, 51% to 75% and >75%.

Statistical Analysis

Continuous variables are presented as mean \pm SD or median (interquartile range) and categorical variables as percentages of the total. Continuous data were compared using the *t* test or

HIGHLIGHTS

- WRMSP in sonographers is highly prevalent and affects daily activities.
- Sonographers' pain is more severe than that of peer employees.
- The neck, shoulder, lower back, and hand are the most frequently affected regions.
- Because of pain, sonographers more often seek medical evaluation and miss work days.

Wilcoxon rank-sum test as appropriate. The groups compared were (1) sonographers versus control subjects, (2) sonographers with pain versus control subjects with pain, (3) sonographers with pain versus sonographers without pain, and (4) control subjects with pain versus control subjects without pain. Categorical variables were compared using either the Pearson χ^2 or the Fisher exact test as appropriate. Logistic regression analysis was performed to test associations between cardiac sonographers and age, gender, height, weight, body mass index (BMI), years in current position, work setting, and practice of regular exercise. These results are presented with odds ratios and associated 95% confidence limits. We adjusted for the most clinically relevant variables on the basis of prior studies. We excluded scanning-related activities from the model such as scanning position, scanning hand, working on the weekends, overnight echocardiography call, and regularly relaxing handgrip, because only sonographers performed those activities. For an analysis limited only to sonographers, we constructed univariate logistic regression models for age, sex, height, weight, BMI, time at work scanning, years in current position, scanning position, scanning hand, work setting, working on the weekends, overnight echocardiography call, regularly relaxing handgrip, and practice of regular exercise. All probability values were two sided, and a P value $< .01$ was considered to indicate statistical significance to decrease the changes of false-positive results on the basis of the number of comparisons. Statistical analysis was performed using JMP version 13.0 (SAS Institute, Cary, North Carolina).

RESULTS

Subject Characteristics

Of the 686 employees identified within the Department of Cardiovascular Medicine at the 10 Mayo Clinic facilities, 433 (63%) answered the questionnaire. The sonographers' response rate was 86%. Of those, 17 partially completed the survey, leaving 416 subjects in the final cohort, including 111 sonographers (27%) and 305 control subjects (73%; [Figure 1](#)). The mean age was 43 ± 11 years, and 307 subjects (74%) were women. The majority of responders worked in Rochester (233 [56%]), followed by Mayo Clinic Health System facilities in Minnesota and Wisconsin (116 [28%]), Arizona (37 [9%]), and Florida (30 [7%]). The workplace setting included both outpatient clinic and hospital. Of the sonographers, 64 (58%) scanned right-handed, 34 (30%) left-handed, and 13 (12%) alternated between the right and left hands. The majority of sonographers used a sitting position when scanning, sitting in a chair next to the patient bed (46 [41%]), next to the patient on an

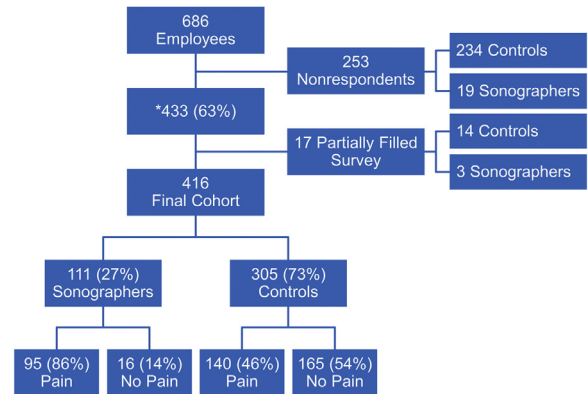


Figure 1 Flowchart of the recruitment process. Of the 686 employees identified, 433 (63%) responded to the survey. *Of them, 114 were sonographers (86% sonographer response rate) and 319 peer-employee control subjects. Of those, 17 partially completed the survey, leaving 416 subjects in the final cohort, including 111 sonographers (27%) and 305 control subjects (73%). Musculoskeletal pain was very frequent among cardiac sonographers (95 of 110 [86%] sonographers) compared with peer-employee control subjects (140 of 305 [46%] control subjects).

Table 1 Subject characteristics

Variable	Sonographers (n = 111)	Control subjects (n = 305)	P
Age (y)	40.6 ± 11.4	44.8 ± 11.5	.001
Sex, female	83 (75)	224 (73)	.78
Height (cm)	168.5 ± 9.4	169.9 ± 9.8	.31
Weight (kg)	158.9 ± 38.2	173.5 ± 39.0	<.001
BMI (kg/m ²)	25.1 ± 4.5	27.5 ± 6.2	<.001
Years in current position			.06
0–5	25 (23)	94 (31)	
6–10	24 (22)	47 (16)	
11–20	39 (36)	82 (27)	
≥20	20 (18)	77 (26)	
Work setting			.82
Hospital	36 (32)	95 (31)	
Outpatient clinic	75 (68)	209 (69)	
Handedness,*			.051
Right	89 (80)	270 (88)	
Left	9 (8)	19 (6)	
Ambidextrous	13 (12)	16 (5)	
Regular exercise	85 (77)	211 (69)	.14

Categorical variables are reported as number (percentage), and continuous variables are reported as mean ± SD.

*Handedness was defined in response to the question “Are you right-handed, left-handed, or ambidextrous in daily life?”

extender attached to the patient bed (44 [40%]), or next to the patient on the bed (17 [15%]). Four (4%) scanned standing bedside. [Table 1](#) summarizes baseline characteristics of subjects and control

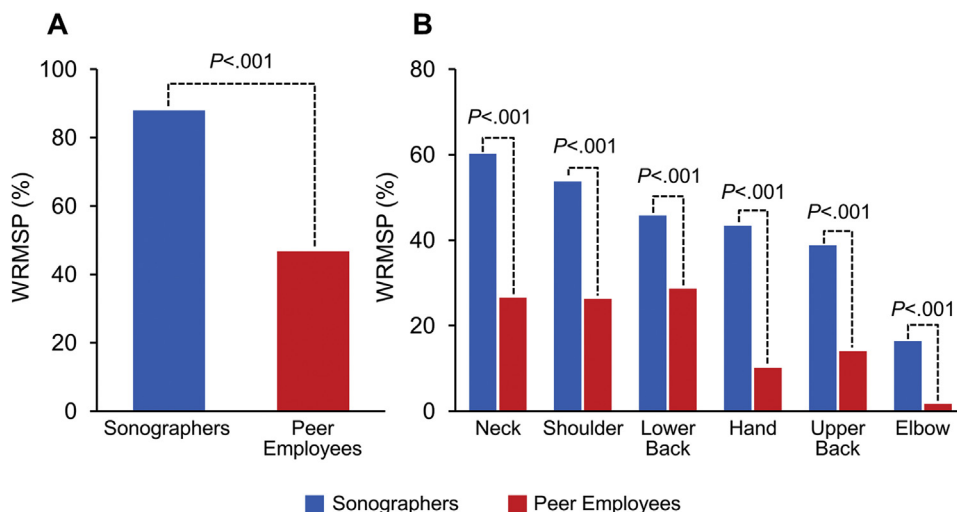


Figure 2 (A) Prevalence of WRMSP in cardiac sonographers compared to peer employees. Bar graphs comparing the frequency of WRMSP between sonographers (blue) and peer-employee control subjects. Sonographers reported a higher frequency of WRMSP than peer employees. **(B)** WRMSP by body region between sonographers and peer employees. Bar graphs comparing the frequency of WRMSP by body region between sonographers (blue) and peer employees (red). The percentage with WRMSP in all physical locations was greater in sonographers.

Table 2 Multivariate logistic regression analysis of musculoskeletal pain among sonographers and peer employees

Variable	Multivariate, OR (95% CI)	P
Age	0.99 (0.96–1.02)	.44
Sex, female	1.54 (0.81–2.95)	.18
Height	0.97 (0.87–1.10)	.74
Weight	1.04 (0.92–1.16)	.53
BMI	0.88 (0.64–1.22)	.45
Years in current position	1.04 (1.01–1.07)	.01
Work setting, hospital	1.47 (0.90–2.41)	.11
Regular exercise	1.58 (0.94–2.63)	.09
Sonographers	8.18 (4.33–15.46)	<.001

Categorical variables are reported as number (percentage), and continuous variables are reported as mean ± SD.

subjects. Sonographers were younger and had lower values of BMI ($P \leq .001$). Groups were similar regarding gender, height, years in current employment position, handedness, and practice of regular physical activity.

Musculoskeletal Pain

WRMSP was more common among cardiac sonographers than control subjects (95 [86%] vs 140 [46%], $P < .001$; Figure 2A). The occupation of cardiac sonographer was associated with WRMSP after adjustment for age, gender, weight, BMI, years in current position, workplace setting (outpatient clinic vs hospital), and practice of regular exercise (odds ratio, 8.18; 95% CI, 4.33–15.46; $P < .001$; Table 2). In a secondary analysis limited to sonographers that included scanning-related activities, no differences were observed using $P < .01$ to determine statistical significance. However, a nonsignificant difference was noted for regular exercise (94% in those without pain

vs 74% in those with pain, $P = .11$). Compared with peer employees, sonographers experienced more pain in the neck, shoulder, lower back, hand, upper back, and elbow ($P < .001$ for all; Figure 2B). The neck was the most frequently affected body region, with 58% of the sonographers having neck pain (vs 25%), followed by the shoulder (51% vs 11%), lower back (44% vs 26%), hand (42% vs 9%), upper back (37% vs 12%), and elbow (17% vs 3%; $P < .001$ for each). Symptoms of CTS such as tingling of the arm and hand were noted to be 4 times as frequent in sonographers compared with control subjects (50 [45%] vs 35 [11%], $P < .001$). For sonographers, hand pain was related to the scanning hand in nearly all with hand pain (45 of 46 sonographers [98%]).

Impact of Musculoskeletal Pain

The impact of WRMSP among cardiac sonographers compared with peer-employee control subjects is listed in Table 3. The presence of WRMSP in sonographers was significantly associated with interference in performance of daily activities, sleeping, recreational activities, and work-related activities. Because of pain, more sonographers missed work days ($P < .001$), had work restrictions ($P = .005$), made changes to their work-related responsibilities ($P = .009$), and were considering changing employment ($P < .001$). Headaches were more common in cardiac sonographers ($P = .001$). The scores on the QuickDASH and QuickDASH Work questionnaires were both greater in sonographers ($P < .001$).

Figure 3 illustrates medical treatment between sonographers and control subjects. Sonographers were more likely to seek medical evaluation ($P < .001$) and more often received clinical treatment and physical therapy compared with control subjects ($P < .01$).

Sonographers and Control Subjects with Pain

Table 4 describes characteristics of sonographers and control subjects with pain. Sonographers' pain was described as more severe (pain score > 5 on a 10-point scale) and was more apt to be getting worse ($P < .001$ for both), despite their being younger and having lower values of BMI. Sonographers with pain more often received massage

Table 3 The impact of WRMSP

Variable	Sonographers (n = 111)	Control subjects (n = 305)	P
Pain during daily activities			<.001
Very limited	2 (2)	2 (1)	
Moderately difficult	3 (3)	4 (1)	
Mildly limited	36 (32)	30 (10)	
Not limited	70 (63)	269 (88)	
Difficulty doing usual work because of pain			<.001
Unable	1 (1)	0 (0)	
Severely difficult	1 (1)	1 (0.5)	
Moderately difficult	4 (3)	3 (1)	
Mildly difficult	41 (37)	29 (9)	
No difficulty	64 (58)	272 (89)	
Doing your work as you would like			<.001
Unable	1 (1)	0 (0)	
Severely difficult	1 (1)	1 (0.5)	
Moderately difficult	9 (8)	2 (1)	
Mildly difficult	30 (27)	29 (10)	
No difficulty	70 (63)	273 (89)	
Spending your usual amount of time doing work			<.001
Unable	1 (1)	0 (0)	
Severely difficult	0 (0)	0 (0)	
Moderate difficult	7 (6)	2 (1)	
Mildly difficult	27 (25)	29 (9)	
No difficulty	76 (68)	274 (90)	
Difficulty sleeping because of the pain			<.001
Severely difficult	1 (1)	0 (0)	
Moderately difficult	10 (9)	9 (3)	
Mildly difficult	37 (33)	34 (11)	
No difficulty	63 (57)	262 (86)	
Pain during recreational activities			<.001
Unable	2 (2)	1 (0.5)	
Severely difficult	3 (3)	1 (0.5)	
Moderate difficult	12 (11)	12 (4)	
Mildly difficult	30 (27)	35 (11)	
No difficulty	64 (57)	256 (84)	
Pain during household chores			.02
Unable	2 (2)	1 (0.5)	
Severely difficult	1 (1)	3 (1)	

(Continued)

Table 3 (Continued)

Variable	Sonographers (n = 111)	Control subjects (n = 305)	P
Moderate difficult	6 (5)	7 (2)	
Mildly difficult	23 (21)	38 (12)	
No difficulty	79 (71)	256 (84)	
Headaches	40 (36)	62 (20)	.001
Plans to change jobs because of pain	10 (9)	1 (0.5)	<.001
Miss work because of pain	14 (13)	11 (4)	<.001
Work-related responsibilities have changed because of pain	10 (9)	9 (3)	.009
Work restrictions	6 (5)	2 (0.6)	.005
Placed on short- or long-term disability	3 (3)	1 (0.5)	.06
QuickDASH score	14.54 ± 13.11 (n = 94)	10.14 ± 11.26 (n = 132)	.007
QuickDASH Work score	13.44 ± 11.01 (n = 94)	7.08 ± 16.79 (n = 132)	<.001

Categorical variables are reported as number (percentage), and continuous variables are reported as mean ± SD.

therapy ($P < .001$) and topical medications ($P = .01$) compared with peer employees with pain. However, specific medical diagnoses of CTS, arthritis, spinal stenosis, herniated disks, and lateral epicondylitis were less common in both groups with pain and not significantly different ($P > .01$).

Sonographers with and without Pain and Control Subjects with and without Pain

Sonographers with pain compared with sonographers without pain were similar in age, gender, height, weight, BMI, workplace setting, years in current position, position while scanning, percentage of time at work scanning, overnight call, work weekends, scanning hand, scanning position, and use of relaxing handgrip (Table 5). The practice of regular exercise did not achieve significance ($P = .11$). When control subjects with pain were compared with control subjects without pain, years in current position were greater in those with pain (15.8 ± 11.7 years in control subjects with pain vs 12.6 ± 10.5 in control subjects without pain, $P = .01$). There were no statistically significant differences with regard to job occupation between control subjects with pain and control subjects without pain ($P = .49$).

DISCUSSION

In the present study, WRMSP was very frequent (86%) among cardiac sonographers compared with peer-employee control subjects (46%) within the cardiology department. WRMSP was strongly associated with cardiac sonographers even after adjustment for confounders. Neck, shoulder, and lower back were the most frequently affected body regions for sonographers. WRMSP interfered with

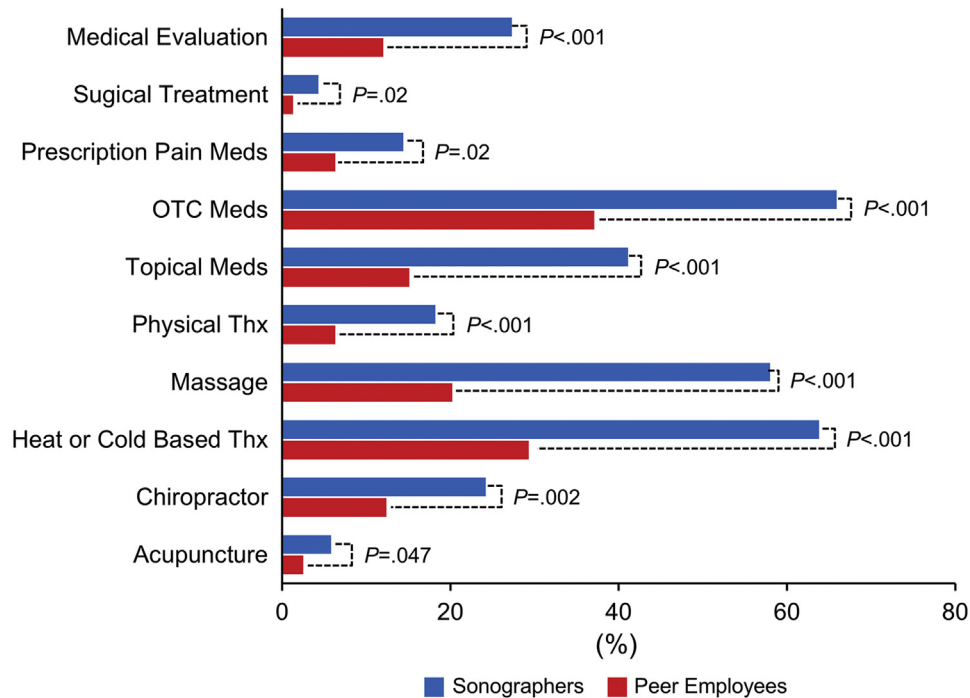


Figure 3 Prevalence of type of medical treatment between cardiac sonographers and peer employees. Bar graphs comparing the frequency of different types of medical treatment between sonographers (*blue*) and peer employees (*red*). Sonographers sought more often medical evaluation, surgical treatment, prescription pain medication, over-the-counter (OTC) pain medication, topical medication, physical therapy, massage therapy, heat- or cold-based therapies, acupuncture treatment, and chiropractic therapy compared with control subjects. *Meds*, Medications; *Thx*, therapy.

the performance of daily recreational activities, work-related activities, and sleep. The impact of pain on cardiac sonographers ranged from planning a job change to work restrictions. Because of pain, sonographers more often sought medical evaluation and more often received prescription pain medication and surgical treatment compared with peer-employee control subjects. The increased values on QuickDASH and QuickDASH Work questionnaires for sonographers underscore our findings on their disability in performing daily and work-related activities.¹³⁻¹⁵

To our knowledge, no prior study has comprehensively compared the prevalence, magnitude, and impact of WRMSP of cardiac sonographers with a large control group of peer employees. Prior studies have been limited by the small number of participants, insufficient information about specific types of WRMSP, work-related activities, work environment characteristics, a poor response rate to surveys, absence of control groups, or lack of statistical adjustments for important confounders.^{1,2,5,7,8,10,12}

WRMSP in Cardiac Sonographers

In agreement with prior studies,^{2,3,5,7-9} our results support the findings that WRMSP among cardiac sonographers remains high in the modern area (86%). No prior study, with the exception of our previous study,¹² has statistically adjusted WRMSP for confounding variables and compared with a control group.^{1-3,5,9,10} This study overcomes the weaknesses of our previous work by comprehensively evaluating variables specific to cardiac sonographers, more fully evaluating details related to the type and nature of pain, including using a validated occupational scoring system, and investigating the impact of WRMSP on future career plans. Additionally, we attempted to identify differences in the

characteristics of sonographers who experience WRMSP compared with those who do not. Disappointingly, our study did not demonstrate any statistical differences in the characteristics of these two groups. The overall findings are concerning as WRMSP in cardiac sonographers remains prevalent despite significant advances in workstation equipment and familiarization training with risk-reducing work postures.^{4,17}

Risk Factors

The occupation of cardiac sonographers was strongly associated with WRMSP. Regular physical exercise was reported by 74% of sonographers with pain compared with 94% without pain, but the high proportion of sonographers with pain likely limited the power in the analysis. Years in the current position was a significant predictor of WRMSP in the overall cohort. This suggests that WRMSP gradually develops by the accumulation of small repetitive stresses over time.^{9,18,19} In the present study, pain areas indicated by sonographers were consistent with the literature.^{2,3,5,7-9} As in our study, Evans *et al.*⁹ reported that shoulder, neck, and back pain constitute the most frequent sites of pain. Interestingly, the authors found that pressure applied to the transducer, shoulder abduction while scanning, and twisting of the neck were the most aggravating activities. Pike *et al.*⁷ studied 983 cardiac sonographers (32.8% response rate) and found that the duration of work without rest was a contributing factor to the development of WRMSP. Smith *et al.*² found an association with the number of individual studies per month (>100 scans), average scan time > 25 min, posture, high-pressure handgrip, and short stature (height < 63 inches). Our sonographers' scan time and number of scans per month were >25 min and >100 scans, respectively. However, in our study, the percentage of time at work

Table 4 Sonographers and control subjects with pain

Variable	Sonographers with pain (n = 95)	Control subjects with pain (n = 140)	P
Age (y)	41.1 ± 10.7	45.6 ± 11.3	.002
Sex, female	72 (76)	105 (75)	.89
Height (cm)	168.51 ± 9.41	170.10 ± 9.71	.22
Weight (kg)	72.28 ± 17.12	77.84 ± 18.53	.02
BMI (kg/m ²)	25.23 ± 4.53	27.07 ± 6.01	.01
Work setting			.83
Hospital	32 (33)	49 (35)	
Outpatient clinic	63 (66)	91 (65)	
Years in current position			.03
0–5	20 (21)	37 (27)	
6–10	22 (23)	23 (16)	
11–20	36 (38)	36 (26)	
≥20	16 (17)	43 (31)	
Handedness			.35
Right	78 (82)	121 (86)	
Left	5 (5)	9 (6)	
Ambidextrous	12 (13)	10 (7)	
Regular exercise	70 (74)	95 (67)	.34
Severity of pain > 5*	69 (62)	90 (29)	<.001
Pain response			<.001
Getting worse	15 (14)	7 (2)	
Getting better	29 (31)	43 (31)	
Same	50 (53)	89 (64)	
Medical evaluation	30 (31)	38 (27)	.46
Surgical treatment	4 (4)	1 (0.7)	.07
OTC pain medications	73 (77)	113 (81)	.47
Topical medications	45 (48)	45 (32)	.01
Prescription pain medication	15 (16)	20 (14)	.72
Physical therapy	20 (21)	20 (14)	.15
Massage	63 (68)	62 (44)	<.001
Heat- or cold-based therapies	71 (75)	88 (63)	.04
Carpal tunnel Dx	8 (8)	16 (11)	.45
Neck/disk/spine Dx	16 (17)	32 (23)	.26
Cervical Dx	3 (13)	1 (1)	.30
Thoracic/lumbar Dx	9 (9)	17 (12)	.52
Rotator cuff/shoulder bursitis Dx	15 (16)	13 (9)	.13
Tennis elbow Dx	12 (13)	15 (11)	.65
Headache Dx	36 (38)	38 (27)	.08

Dx, Diagnosis; OTC, over-the-counter.

Categorical variables are reported as number (percentage), and continuous variables are reported as mean ± SD.

*On a 10-point scale.

that was spent scanning was not related to WRMSP. Vanderpool *et al.*¹ studied 101 cardiac sonographers (47% respondents) on the prevalence of CTS and found that 63% of respondents currently or previously had CTS symptoms, but only 3% had been diagnosed with CTS. Our study, in comparison, revealed an 8% CTS diagnosis rate among sonographers, although there were no significant differences from control subjects. Interestingly, CTS-like symptoms such as tingling of the arm and hand were 4 times more common in sonographers than control subjects. However, there were no between-group differences regarding reported diagnosis of CTS, suggesting that CTS may be underdiagnosed in this population.

Addressing the Problem

The presence of WRMSP adversely affects sonographers to a significant extent. WRMSP affects home life, work responsibilities, sleep patterns, and well-being, all ultimately leading to an increase in medical expenses and decreased productivity.^{3,5,7} Although risk factors and symptoms are well known, our study more completely characterized the impact of WRMSP. This is novel, as our study provided specific information that may assist further development of interventions and educational programs to prevent WRMSP. In light of this, the Society of Diagnostic Medical Sonography recently published recommendations for the prevention and management of WRMSP.²⁰ The document urged the need for the development of a culture of safety among employers, manufacturers, and sonographers ranging from addressing equipment designs to safe work practices such as work postures, work schedules, and ergonomic workplace risk-reducing modifications.^{6,20} In this context, the role of innovative technologies addressing ergonomics of workstation equipment and echocardiography console and ultrasound probe design, as illustrated by the development of lightweight and compact point-of-care ultrasound systems, may prove beneficial.^{6,20,21}

Despite all efforts in addressing the problem, the level of scientific evidence has been limited mainly to symptom surveys and small-scale observational studies. Engen *et al.*²² studied the effects of massage alone (15 sonographers) and massage in combination with stretching exercises (14 sonographers) compared with a group of sonographers with no intervention (15 sonographers). The authors demonstrated significant improvement in work-related discomfort as documented by the decrease in QuickDASH and QuickDASH Work scores in the two intervention groups. Because cardiac sonographers perform tasks that require prolonged scanning, often from a stretched position, which are more physically demanding than tasks performed by general sonographers,^{2,3,7,22} further experimental studies such as randomized controlled trials are needed to determine the potential role of preventive interventions. Studies targeting modifiable risk factors, permissible exposure limits, and variation of work routines would give deeper understanding to these problems. Whether ergonomic interventions and minimizing risk factors can be implemented to ultimately reduce the prevalence of WRMSP among sonographers are yet to be known. Some limitations of the study should be acknowledged. The cross-sectional nature of the study cannot provide a cause-effect relationship. Although our survey rate was good (86%), there is the possibility that employees with histories of musculoskeletal pain or discomfort may

Table 5 Sonographer characteristics according to reported pain

Variable	Pain (n = 95)	No pain (n = 16)	P
Age (y)	41.1 ± 10.7	38.2 ± 14.8	.30
Sex, female	72 (76)	11 (69)	.55
Height (cm)	168.5 ± 9.4	168.7 ± 9.6	.85
Weight (kg)	72.3 ± 17.1	70.9 ± 19.0	.61
BMI (kg/m ²)	25.2 ± 4.5	24.6 ± 4.4	.41
Work setting			.57
Hospital	32 (33)	4 (25)	
Outpatient clinic	63 (66)	12 (75)	
Scanning position			.40
Sitting in a chair	37 (39)	9 (56)	
Stand	3 (3)	1 (6)	
Sitting on bed	16 (17)	1 (6)	
Sitting on an extender	39 (41)	5 (31)	
Years in current position			.33
0–5	20 (21)	5 (36)	
6–10	22 (23)	2 (14)	
11–20	36 (38)	3 (21)	
≥20	16 (17)	4 (28)	
Time at work scanning			.86
<25%	11 (12)	1 (6)	
25%–50%	10 (10)	2 (13)	
51%–75%	19 (20)	4 (27)	
>75%	55 (58)	8 (53)	
Overnight call	41 (43)	6 (37)	.79
Work weekends	47 (49)	5 (31)	.28
Scanning hand			.22
Right	57 (60)	7 (43)	
Left	26 (27)	8 (50)	
Ambidextrous	12 (13)	1 (6)	
Regular exercise	70 (74)	15 (94)	.11
Regularly relax handgrip	75 (80)	12 (80)	1.00

Categorical variables are reported as number (percentage), and continuous variables are reported as mean ± SD.

have felt more motivated to participate, leading to response bias. Employees also may not remember previous events or experiences accurately, leading to under- or overrepresentation. Because most sonographers are women, our findings are less generalizable to men. Because the control group was restricted to the cardiology department, our comparison group may not accurately reflect the general population. However, our control group was large, and job occupation within that group was not associated with musculoskeletal pain. It should be noted that our sonographers' daily work schedule of six 75-min echocardiographic examinations with a

1-hour lunch break may not reflect the daily clinical practice of other sonographers. Further studies are required to confirm our observations. We were not able to demonstrate a relationship with scanning position or scanning hand; however, it is possible that presence of pain affected choices of these activities. We did not evaluate specific exercise regimens or levels of physical fitness. Similarly, we could not demonstrate a relationship between the percentage of time spent scanning and pain among sonographers; however, work-related pain may have led to reductions in the percentage of time spent scanning. The low proportion of sonographers without pain limits the power in the analysis.

CONCLUSION

WRMSP is much more prevalent and severe among cardiac sonographers compared with peer employees within the cardiology department. The neck, shoulder, lower back, and hand are the most frequently affected body regions. WRMSP in sonographers affects daily, sleeping, recreational, and work-related activities, as well as future employment plans. Further studies assessing the potential role of preventive interventions are warranted.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.echo.2019.04.416>.

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