Prevalence of Musculoskeletal Symptoms in Interventional Radiologists

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ABSTRACT

Purpose: To investigate the prevalence of musculoskeletal symptoms, defined as aches, pains, discomfort, or numbness, by using a validated assessment tool among interventional radiologists.

Materials and Methods: A Web-based survey using the Nordic Musculoskeletal Questionnaire was disseminated to interventional radiologist members by email in November 2015. Musculoskeletal symptoms were evaluated in 9 body areas. Information regarding participant demographics, practice details, use of radio-protective equipment, and exercise routines was also gathered. Univariate and multivariate analyses were performed to determine risk factors associated with more severe symptoms.

Results: Of 4,096 SIR members at the time of the survey, 640 completed the questionnaire in its entirety (16% response rate). Respondents consisted of 69 females (11%) and 571 males (89%), with a mean age of 47.5 ± 10.2 years old, a mean body mass index of 25.5 ± 3.9 kg/m^2, and a mean practice length of 17.1 ± 9.8 years. Prevalence of musculoskeletal symptoms was 88% in the 12 months preceding the survey. For those reporting musculoskeletal issues, 58% attributed the symptoms to work-related activities. Lower back (61%), neck (56%), and shoulder complaints (46%) were the most common. Symptoms prevented 21.2% of respondents from being able to work over the same time period. Multivariate analysis identified female gender, above-normal body mass index, and a practice length of 10 years or more as factors associated with a higher risk of moderate-to-severe symptoms.

Conclusions: Musculoskeletal symptoms are prevalent among interventional radiologists, the majority of which are attributed to work-related causes.

ABBREVIATIONS

BMI = body mass index, NMQ = Nordic Musculoskeletal Questionnaire

Interventional radiologists perform a broad range of minimally invasive procedures using imaging guidance. These specialized techniques expose the interventionalist to a variety of occupational health concerns including radiation exposure and work-related musculoskeletal injury (1–7). The weight of radioprotective equipment varies by size, configuration, and material (lead, composite, or lead-free), with a median apron weight of approximately 5 kg (range, 2–8 kg) (8,9). Prolonged standing with few opportunities for rest and poor posture can exacerbate existing back pain. Back and neck strain can also be amplified by ergonomically challenging environments and ceiling-mounted monitors (1). The result is a population of interventional radiologists who are at risk for work-related musculoskeletal disorders with potential implications for their personal health and the longevity of their interventional radiologist careers.

The earliest study of musculoskeletal issues of interventionalists was reported in 1992 when Moore et al (5) surveyed 236 radiologists regarding back pain and use of lead aprons. Although the results were not statistically significant, back pain was reported by more than 50% of respondents who wore a lead apron for more than 10 hours per week. In 2001, Machan (10) surveyed 308 interventional radiologists regarding their musculoskeletal symptoms. A total of 84% reported aches or pains in the neck and/or back.

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Appendix A can be found by accessing the online version of this article on *www.jvir.org* and clicking on the Supplemental Material tab.

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EDITORS' RESEARCH HIGHLIGHTS

- Nearly 9 of 10 interventional radiologists experience musculoskeletal pain.
- Most subjects attributed musculoskeletal pain to work-related activities.
- Back, shoulder, and neck pains were the most common.
- Factors that increased risk for musculoskeletal pain include female sex, body mass index greater than 25, and practice length greater than 10 years.

In addition, nearly one-fourth of respondents were limited in their ability to practice due to their symptoms (10).

The purpose of this study was to investigate the prevalence of musculoskeletal symptoms among interventional radiologists. Associated factors suspected of worsening or palliating symptoms such as number of procedural days per week, types of safety equipment used, exercise routine, and physician demographics were also examined. By better understanding the prevalence and types of musculoskeletal problems encountered by interventional radiologists, future research can be directed at strategies to avoid injury and lessen their impact upon clinical and nonprofessional life.

MATERIALS AND METHODS

Survey

This study and its associated survey were reviewed and approved by the SIR Safety and Health Committee and performed in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments and comparable ethical standards. A Web-based electronic survey was created using SurveyMonkey (SurveyMonkey, Palo Alto, California). The survey used the Nordic Musculoskeletal Questionnaire (NMQ), a validated tool for studying the prevalence of musculoskeletal symptoms, which has been used for similar studies in a variety of occupations as well as other medical specialties (11,12).

The survey contained a maximum of 28 questions, depending on responses. Following the NMQ format, musculoskeletal symptoms were defined as aches, pains, discomfort, or numbness in any one of 9 body regions: neck, upper back, lower back, shoulders, elbows, wrists and hands, hips and thighs, knees, and ankles and feet (10). Additional data regarding participant demographics, practice details, use of radio-protective equipment, and exercise routine were also gathered (**Appendix A** [available online on the article's Supplemental Material page at *www.jvir.org*]).

A link to the survey was disseminated by email to society members beginning on November 9, 2015. Each email link was unique to prevent duplication by a single respondent. After 3 reminder emails were sent, the survey was closed on December 12, 2015. An incentive of two $25 gift cards was offered to increase participation, and 2 respondents who included their email address in the survey were selected randomly as winners.

A total of 4,096 members of the SIR were surveyed, consisting of active members (attending physicians), fellows in training, and residents in training. Demographic information including age, sex, and level of training for the general membership of SIR was obtained in March 2016 through correspondence with SIR staff for comparison purposes. Sex data were available only for 77% of members, of whom 10% were female. The average age of SIR members was 47 years old. Attendings accounted for 79% of membership, followed by resident members (15%), and fellows (6%).

Analysis

Primary outcome. A symptom severity score was calculated as the sum of positive answers to the questions regarding musculoskeletal symptoms in the previous 12 months and the previous 7 days, the ability to work because of symptoms, the impact of symptoms on life outside of the profession, and the use of medical care or medications to treat symptoms. A positive answer for each question was scored as 1, and bilateral injuries were scored as 2. The maximum possible score was 37. For analysis purposes, the primary outcome was separated into 2 equal populations by using the median of the symptom severity score. Survey respondents with a score below the median were considered the "None-to-Mild" symptom group (symptom score <7), and those at or above the median were the "Moderate-to-Severe" symptom group (symptom score ≥ 7).

Statistical Methods

Descriptive statistics are mean ± SD for numerical measurements and frequency values (percentages) for categorical variables.

To evaluate potential contributing factors to more severe injuries, uni- and multivariate logistic regression models were applied. The symptom severity score was considered the outcome variable. Univariate and multivariate models were used. Variables with statistically significant associations in the univariate model ($P > .05$) were selected for the multivariate model. All data were analyzed using Stata IC version 14.2 software (StataCorp, College Station, Texas) for Windows (Microsoft, Redmond, Washington). A P value less than .05 was considered statistically significant.

RESULTS

Of the 4,096 members surveyed, 666 interventional radiologists accessed the survey Web site. A total of 640 participants completed the survey in its entirety (96% completion rate, 16% response rate). Internal consistency of the questionnaire was acceptable (Cronbach's alpha = 0.767).

Tables 1 and **2** summarize the characteristics of the respondents and their answers to the questions about

Table 1. Summary of the Characteristics of the Study Population

Characteristic	Summary (n = 640)
Mean ± SD age, y	47.5 ± 10.2
Gender	
Females	69 (10.8)
Males	571 (89.2)
Working country	
United States	601 (93.9)
Non-US	39 (6.1)
Position	
Attending	555 (86.7)
Fellow	29 (4.5)
Resident	56 (8.7)
Practice type	
Academic	265 (41.5)
Nonacademic	374 (58.5)
Mean ± SD practice length, y	17.1 ± 9.8
Dexterity	
Right-handed	556 (86.9)
Left-handed	30 (4.7)
Ambidextrous	54 (8.4)
Mean ± SD body mass index, kg/m^2	25.5 ± 3.9
Routine exercise	
Yes	504 (78.8)
No	136 (21.2)
Mean ± SD exercise time (h/week)	3.4 ± 2.6
Musculoskeletal problem during the last year	
Yes	560 (87.5)
No	80 (12.5)
Mean ± SD musculoskeletal injury scale (0–37)	7.3 ± 5.2

Note–Values are mean ± SD or n (%).

musculoskeletal symptoms. The sample cohort consisted of 69 females (11%) and 571 males (89%), with a mean age of 47.5 ± 10.2 years old, a mean body mass index (BMI) of 25.5 ± 3.9 kg/m^2, and a mean practice length of 17.1 ± 9.8 years. Figure 1 describes the number of physicians surveyed compared to their practice length.

Musculoskeletal symptoms were experienced by 560 respondents (88%) in the preceding 12 months and by 429 respondents (76%) within 7 days prior to completing the survey. For those reporting issues, 58% attributed the symptoms to work-related activities. Lower back (61%), neck (56%), and shoulder (46%) complaints were the most common. Medical attention was sought by 48% of respondents, and 27% reported use of medications more than once per week for treatment. Among those with musculoskeletal symptoms during the previous 12 months, symptoms prevented 21% from doing their normal work. Negative effects upon their ability to perform interventional radiologist duties was reported by 26% of respondents, whereas negative effects on life outside of interventional radiologist was reported by 65%.

Table 2. Answers to the Questions about Musculoskeletal Problems in the General Study Population and Subjects Who Reported Any Musculoskeletal Problems during the Previous 12 Months

Question	Subjects with Symptoms (n = 560)
Did the pain prevent you from working?	
Yes	119 (21.2)
No	441 (78.8)
Any musculoskeletal issues during the last week?	
Yes	427 (76.2)
No	133 (23.8)
Any effect on job function?	
Yes	146 (26.1)
No	414 (73.9)
Any effect on personal life?	
Yes	363 (64.8)
No	197 (35.2)
Do you see a doctor for this problem?	
Yes	268 (47.7)
No	293 (52.3)
Used medication for this problem during the last week?	
Yes	152 (27.1)
No	408 (72.9)
Is it work-related?	
Yes	324 (57.9)
No	236 (42.1)

Note–Values are n (%).

The mean symptom severity score was 7.3 ± 5.2, with a maximum value of 23. Uni- and multivariate analyses of risk factors for moderate-to-severe symptoms is shown in Table 3. In the multivariate model, females (odds ratio [OR], 3.35; $P < .0001$) who were overweight (BMI ≥25 kg/m^2; OR, 1.63; $P = .004$) and who had practiced for 10 years or more (OR, 2.15; $P < .0001$) were associated with a higher risk of moderate-to-severe symptoms. Use of radiation protection in 100% of practice time (OR, 0.59; $P = .017$) was associated with a lower risk of more severe symptoms.

Among personal protective equipment, a thyroid shield (88%), a 2-piece garment with posterior coverage (74%), and nonprescription leaded glasses without lateral protection (25%) and with lateral protection (23%) were the devices most often used. Thickness of protective shielding was unknown for 48% of respondents. Of the remainder, 37% were using 0.5-mm or greater lead or lead-equivalent shields, and 15% were using shields with less than 0.5 mm of lead. Among responders, 522 (82%) reported using some kind of radiation protection equipment in 100% of their practice time; 48 (8%) reported using protection in 80%–99% of their practice time; and 70 respondents (11%) reported using protective devices less than 80% of their practice time.

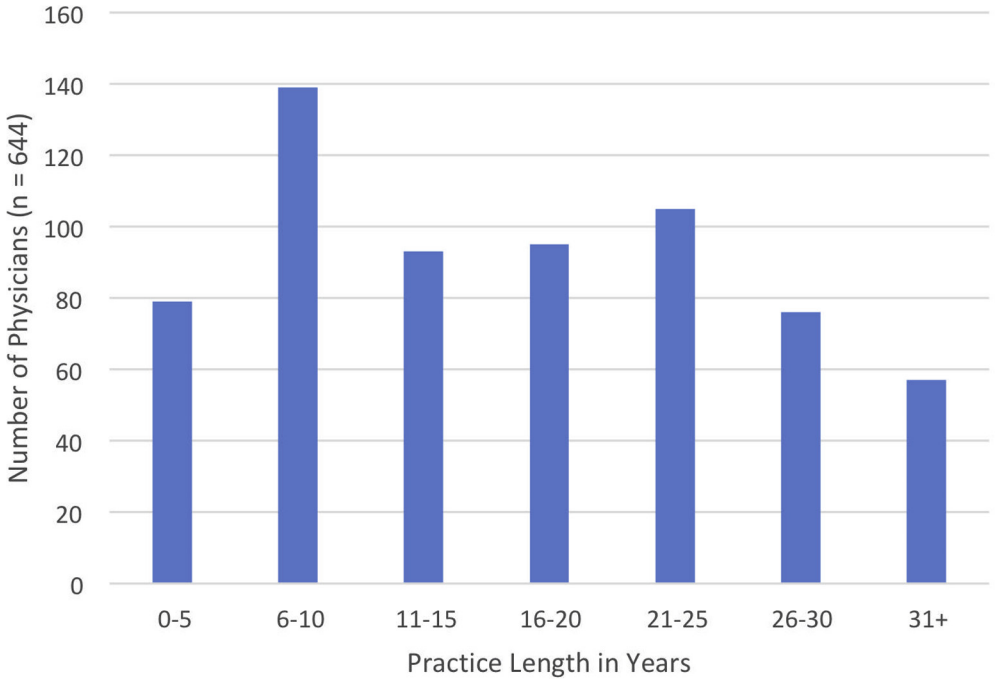

Figure 1. Number of survey responses compared to years in practice (including residency and fellowship).

Table 3. Univariate and Multivariate Regression Analyses of Factors Associated with Moderate-to-Severe Musculoskeletal Injuries

	Univariate Model		Multivariate Model	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Age, ≥50 y	1.26 (0.92–1.72)	.149		
Females	**2.72 (1.56–4.72)**	**<.0001**	**3.35 (1.87–5.97)**	**<.0001**
BMI, ≥25 kg/cm^2	**1.57 (1.15–2.14)**	**.005**	**1.63 (1.17–2.26)**	**.004**
Dexterity vs. Right				
Left	0.81 (0.39–1.70)	.584		
Ambidextrous	1.08 (0.62–1.89)	.789		
Nationality (non-US vs. US)	1.72 (0.88–3.38)	.114		
Position (vs. attending)				
Fellow	0.53 (0.25–1.15)	.110		
Resident	0.66 (0.38–1.14)	.137		
Practice type (nonacademic vs. academic)	1.34 (0.98–1.83)	.070		
Practice length, ≥10 y	**2.15 (1.50–3.06)**	**<.0001**	**2.15 (1.48–3.11)**	**<.0001**
Working days, ≥4 days/week	0.93 (0.68–1.28)	0.679		
Apron lead thickness, ≥2 mm	0.94 (0.69–1.28)	0.676		
Percentage of time wearing lead	**0.58 (0.38–0.87)**	**.009**	**0.59 (0.39–0.91)**	**.017**
Routine exercise	0.97 (0.67–1.42)	0.898		
Exercise time, ≥3 hours/week	1.00 (0.72–1.38)	0.980		

Note–Significant associations are shown in bold.
CI = confidence interval; OR = odds ratio.

Age, sex, and training level data of the survey respondents were comparable to those recorded for the general membership within 3 months of the closing of the survey. The percentage of female members in SIR was 10% compared to 11% in the survey sample, and the mean age for SIR membership was 47 years old (± 10) compared to a mean age of 47.5 years old (± 10.2) for respondents. Attending physicians made up the majority of both respondents (87%) and SIR members (79%). The differences between the 2 groups can be attributed to a lower proportional participation by resident members. In addition, individuals with a variety of practice lengths responded,

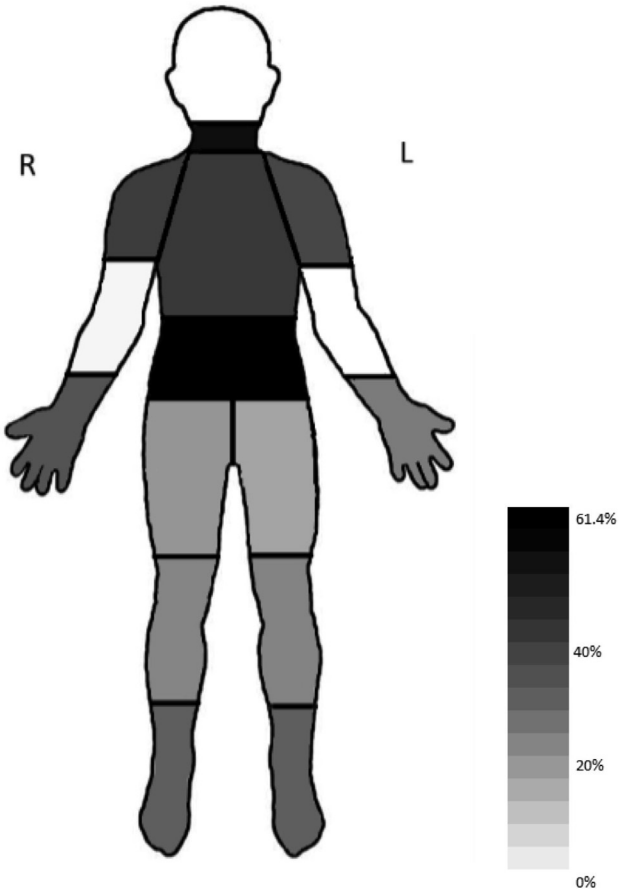

Figure 2. Heatmap of injury prevalence by body region in the previous 12 months among interventional radiologists.

confirming the inclusion of a broad and relatively evenly distributed range of interventional radiologist physicians (Fig 1). Respondents were geographically diverse across the United States (only Hawaii, Wyoming, and Alaska were not represented) along with 39 international responses.

DISCUSSION

There is a high prevalence of musculoskeletal symptoms among practicing interventional radiologists, the majority of which (58%) were attributed to work-related activities. Prevalence of symptoms over the previous 12 months by body region was lowest in the elbows and highest in the lower back (Fig 2). Most respondents also reported symptoms within 7 days of completing the survey. Symptoms affected their ability to perform job functions in most respondents; however, 26% is an alarming proportion of people experiencing negative effects on their job performance. Of equal concern is the fact that symptoms prevented 21% of respondents from performing normal work duties, and 65% reported a negative impact on life outside of work. Compared to a prior study, the 88% prevalence of musculoskeletal symptoms and the 26% prevalence of survey respondents who experienced effects on performance of their interventional radiologist duties due to symptoms are similar rates to those measured in 2001 (10). This suggests that little progress has been made in the intervening years to mitigate the musculoskeletal challenges inherent in interventional radiology practice.

The symptom severity score analysis revealed several factors associated with an increased risk for moderate-to-severe symptoms: females, above-normal BMI, and practice length greater than 10 years. Females were highly correlated with risk of musculoskeletal symptoms (OR, 3.35). This result is interpreted with some caution as females do have a higher baseline prevalence for back pain (13). In addition, gender as a risk factor for symptoms on the multivariate regression analysis may be amplified by the relatively small number of female respondents; nevertheless, female colleagues should be alerted to their higher risk.

A BMI equal to or greater than 25 was correlated with a significantly higher chance of moderate-to-severe symptoms than those with a BMI less than 25. This finding parallels previous research linking BMI with chronic back pain and indicates the importance of maintaining a healthy BMI (14). The mean BMI for survey respondents was 25.5 $\pm$ 3.9, which falls into the "overweight" category, despite 79% of those surveyed reporting regular exercise. Mean exercise time reported by respondents was 3.4 $\pm$ 2.6 hours per week. Cardiovascular exercise (86%) followed by weight training (49%) and core strengthening (41%) exercises were the most popular. Routine exercise was not found to have an association with musculoskeletal symptoms, positive or negative, although it is possible that the effects were diminished in an overweight population.

Physician age was not associated with a higher risk of symptoms. However, interventional radiologists in practice for more than 10 years have an increased risk of experiencing moderate-to-severe musculoskeletal symptoms (OR, 2.15; $P < .0001$). This is consistent with the theory of the additive effects of long-term musculoskeletal wear and tear (2). Although age alone may not be a risk factor, increased age and number of years in practice are inseparable. The risk of pain accompanied by limitations of activity does increase with age, and this may account for the risk of more severe symptoms after 10 years in practice (15).

Respondents who reported spending 100% of time using radiation protective equipment had a lower risk of moderate-to-severe symptoms than colleagues who use equipment during a smaller proportion of daily practice. This may suggest that the increased risk comes from activities unrelated to procedures involving radiation protection. Alternatively, individuals with musculoskeletal symptoms may avoid procedures involving the use of lead aprons as this could exacerbate their symptoms. It is also possible that physicians who perform procedures using radiation protection less frequently may not have customized equipment or familiarity with injury avoidance strategies, thus increasing their risk of symptoms. Ultimately, ambiguity of the survey question "What percentage (0%–100%) of the time do you use radiation protective equipment?" may have led to variable interpretations by survey respondents. Given the counterintuitive nature of this finding, future investigations

Table 4. Prevalence of Shoulder, Neck, and Lower Back Symptoms Compared to Systematic Reviews of Physicians and General Population

	% of Interventional Radiologists	% of Interventional Radiologists in Oude Hengel et al (16)	% of Interventional Radiologists in Epstein et al (17)	General Population
Shoulder	46	17	43–61 (52)	4.7–46.7%*
Neck	56	9–28	47–72 (60)	4.8–79.5 (25.8)†
Lower Back	61	33–68	36–62 (49)	14.3–64.8% (38)‡

Note–Prevalence is shown as range (mean), as available in the reference systematic reviews.
*Luime et al (19).
†Hoy et al (18).
‡Hoy et al (13).

should more carefully stratify the use of protective equipment to better evaluate the associated risks.

The presence or severity of musculoskeletal symptoms was not associated with the type of radiation protective gear worn or the use of supportive devices. A 2-piece leaded apron with posterior coverage was the protection option favored by 73% of respondents. A single-piece garment without posterior coverage was second at 20%. Use of zero-gravity suspended protection devices was reported by 15% of respondents, but the percentage of time using suspended protection devices was not collected by the survey, limiting the analysis in this subcohort. Almost one-half of respondents (48%) were uncertain of the lead-equivalent thickness of their aprons. The majority of respondents (69%) wore leaded eye protection. Orthotic or specialty shoes and compression stockings were the devices most commonly used to protect against injury, although use of supportive equipment and devices was reported by a minority (34%) of those surveyed.

Two systematic reviews established a 1-year prevalence of neck, shoulder, and lower back pain and work-related musculoskeletal disorders in physician populations (16,17). Similarly, systematic reviews have been performed to evaluate 1-year prevalence of neck (18), shoulder (19), and lower back pain (13) in the general population (**Table 4**). Oude Hengel et al (11) reviewed 8 studies of hospital physicians, which included 4 surveys of surgeons, 3 studies of all doctors, and 1 study of urologists. Epstein et al (17) performed both a systematic review and meta-analyses for work-related musculoskeletal disorders specifically in surgeons and interventionalists. Twenty-one articles were included, but only 1 study was similar to that by Oude Hengel (11). Physician specialties included interventional cardiology, plastic surgery, otolaryngology, orthopedic surgery, obstetrics and gynecology, general surgery, dermatology, and urology. Not surprisingly, the 1-year prevalence rates for shoulder, neck, and lower back symptoms for interventional radiologists are more closely aligned with those of surgeons and other interventionalists. Compared to the general population, interventional radiologists exhibit 1-year prevalence rates at the high end of the range for shoulder and lower back symptoms and double the mean for neck symptoms.

Previous studies have described strategies to mitigate occupational musculoskeletal pain with guidance toward safer practice (1,3). A review of all studies of the prevalence of lower back and neck pain among interventional physicians concluded that much of the neck and back pain experienced by interventionalists is "the result of a combination of the chronic effect of wearing protective garments, standing for long periods of time, and maintaining awkward, ergonomically unsound positions" (1). To combat these risk factors, interventionalists should use techniques such as sleeping on the side rather than on the back, maintain a healthy BMI, use good posture while operating, take breaks during long procedures, use freestanding and suspended shields when possible, and work to maintain the operator's body in a neutral position (1,3). Room design and procedural setup are key to the neutral positioning for the interventional radiologist, with careful consideration to table height, monitor location, C-arm orientation, and clear floor space to allow physicians to freely change position (1,3). Through these measures, the environment becomes less of a barrier for interventional radiologists to practice safely. Prevention also extends to the behavior of operators as they perform procedures, including awareness of what actions cause pain and ceasing such activity to interrupt the cycle of pain (1).

This study has limitations. Response rate was low at 16%, despite use of strategies to improve participation, including 3 rounds of reminder emails to nonresponders and a financial incentive (20,21). Previous studies of SIR membership by Reddy et al (22) in 2006 and Prince et al (23) in 2007 used similar Web-based surveys with email invitations and successfully recruited a higher number of respondents (35% and 48%, respectively). In contrast, Grant et al (24) surveyed Australian surgeons, and Ho et al (25) surveyed American otolaryngologists, using an emailed NMQ Web-based survey invitation format with response rates of 16% and 12.5%, respectively. This suggests that the low response rate might have been due to factors related to the subject matter. As with any voluntary survey, there is an inherent

risk of response and selection bias. Response bias was mitigated by using the standardized NMQ survey tool, which has been shown to have high reliability and validity for the epidemiological assessment of musculoskeletal disorders (26). Sampling bias is present as only interventional radiologists who were members of the SIR were invited to participate. In addition, enrollment emails included an explanation of the purpose of the study, possibly leading to a self-selection bias with a higher proportion of positive responses. There is the potential of nonresponse bias as well, although prior studies have shown that physician surveys carry a lower risk of nonresponse bias due to the underlying similarities of the study population (27). Ambiguities of questions regarding time spent performing procedures, wearing radioprotective equipment, and using different types of equipment (such as zero-gravity systems) limited the analysis and conclusions that could be drawn from any association with protective gear.

Interventional radiologists reported a high prevalence of musculoskeletal symptoms. Most of these symptoms were attributed to work-related activities. Identification of the neck, shoulders, and lower back as principal foci for symptoms should focus efforts on minimizing stress on those areas. Increasing awareness of the risks associated with interventional radiology practice may aid in early identification of detrimental effects and promote adoption of mitigation strategies to prevent long-term musculoskeletal symptoms or disability.

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