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Musculoskeletal Symptoms Amongst Clinical Radiologists and the Implications of Reporting Environment Ergonomics—A Multicentre Questionnaire Study

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Abstract This multicentre study aimed to assess compliance of the reporting environment with best ergonomic practice and to determine the prevalence of musculoskeletal symptoms related to working as a radiologist. All 148 radiology trainees and consultants in 10 hospitals across the region were invited to complete a musculoskeletal symptoms and reporting ergonomics questionnaire. Best ergonomic reporting practice was defined, following literature review, as being able to alter the following: monitor, desk, chair and armrest height, chair back support, ambient light, and temperature. The frequency that these facilities were available and how often they were used was determined. One hundred and twenty-three out of 148 (83 %) radiologists responded, and 38 % reported radiology-associated occupational injury. Lower back discomfort was the commonest radiology associated musculoskeletal symptom (41 %). Only 13 % of those with occupational injury sought the advice of occupational health. No reporting environments conformed completely to best ergonomic practice. Where certain facilities were available, less than a third of radiologists made personal ergonomic adjustments prior to starting a reporting session. Radiologists who had good self-assessed knowledge of best ergonomic practice had significantly less back discomfort than those with poor self-assessed knowledge ($P < 0.005$). We demonstrated high prevalence of musculoskeletal symptoms amongst radiologists. Poor compliance of the reporting environment with best ergonomic practice, in combination with our other findings of a low level of ergonomic awareness, low rates of making ergonomic adjustments and seeking appropriate help, may be implicated. We hope this study raises awareness of this issue and helps prevent long-term occupational injury amongst radiologists from poor ergonomic practice.

Keywords Ergonomics · Musculoskeletal pain · Occupational health · Occupational injury · Radiology

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Introduction

Clinical radiologists encounter ergonomic challenges daily; be it whilst reporting at workstations or when performing diagnostic or interventional procedures. In the era of picture archiving and communications systems (PACS), the computer workstation is a crucial component of diagnostic radiology. The Health and Safety (Display Screen Equipment) Regulations 1992 define display screen equipment as "any alphanumeric or graphic display screen" and a user as "an employee who habitually uses display screen equipment as a significant part

of his normal work" [1]. The definition of a workstation also incorporates "the immediate work environment around the display screen equipment" [1]. Visual display unit (VDU) users who do not adhere to good ergonomic practice may decrease their efficiency and productivity, as well as increasing their risk of repetitive stress injury, eye strain, backache, shoulder and neck pain [2]. Such symptoms can potentially progress to long-term morbidity. For example, the inappropriate use of a computer mouse and keyboard has been linked with the development of carpal and cubital tunnel syndrome symptoms [3]. Poor ergonomic practice may also have repercussions for patients. Workstations that are not optimised for personal use result in eyestrain and fatigue. Prabhu et al. speculate that tired eyes and brains commit more errors and that by implementing certain ergonomic measures, eye fatigue can be reduced, efficiency increased and error rates in reporting minimised [4].

Regular and prolonged computer use subjects the human body to unique strains [5, 6]. Review of the literature regarding ergonomic practice reveals several facilities that should be at the disposal of the reporting radiologist in order to reduce the impact of these stresses. Eye fatigue and strain on neck muscles amongst computer users can be reduced by gazing downwards at an angle of 14° or more [4]. Consequently, the top of the visual display unit should not be above the level of the user's eyes. To achieve this, monitors and desk height should be adjustable to the user's height [7]. Computer-friendly chairs are important to maximise comfort and efficiency. Specifically, the chair and armrest heights should be adjustable to reduce upper limb symptoms, as fixed armrests are generally too low [4]. Where adjustable chair height is not available, a foot rest can facilitate good posture and reduce back pain [3]. Adjustable lumbar support on a reporting chair can also reduce the incidence of lower back pain [7].

The most comfortable temperature for sedentary work is between 20 and 24 °C (68–75 °F), with a relative humidity between 40 and 60 % [4]. However, the comfort range of temperature varies with the season. Computer workstations and monitors generate heat and raise the ambient temperature within a reporting room. The radiologist should be able to control ambient temperature and humidity with air conditioning. The relative balance between monitor light output and background reporting room lighting is an important factor in determining the degree of radiologist fatigue, as well as efficiency and accuracy [8]. Reiner et al. assessed the impact of luminance in interpreting radiographs and found a subjective increase in the observed level of confidence of interpretation as monitor brightness increased [9]. Furthermore, monitor brightness was inversely proportional to reporter fatigue [9]. On-off light switches should be located near each workstation, ideally with individual dimmers to enable users to adjust the lighting depending on the task being performed [3]. Consideration should also be given to screen shields that reduce screen glare, especially on older monitors [2].

Prabhakar et al. surveyed the prevalence of musculoskeletal symptoms and working practices amongst 28 radiologists at a single American institution [10]. Siegel et al. conducted a multicentre study of seven sites from around the world regarding radiologists' opinions on factors that promote radiology productivity in the soft-copy reporting environment [11]. Boiselle et al. looked at repetitive stress symptoms amongst radiologists in a single American institution [12]. However, to date, no study has quantified the adherence of the reporting environment in routine clinical practice with best ergonomic practice or explored the types of advice radiologists sought for the treatment of occupational-related musculoskeletal symptoms. We aim to address these issues in our multicentre cross-sectional study.

Methods

Participants

Ethical approval was not necessary for this questionnaire-based survey [13]. The paper-based questionnaire was distributed to all clinical radiologists; both consultants (faculty and senior radiologists) as well as registrars and fellows, working in the following ten teaching and district general hospitals in the Severn Deanery: Bristol Children's Hospital, Bristol Royal Infirmary, Cheltenham General Hospital, Frenchay Hospital (Bristol), Gloucester Royal Hospital, Great Western Hospital (Swindon), Musgrove Park Hospital (Taunton), Royal United Hospital (Bath), Southmead Hospital (Bristol) and Weston General Hospital. Eligible participants were all radiologists (consultants and trainees) working at the time of the survey.

Questionnaire

A paper-based questionnaire was devised following review of the literature and scrutiny of established and validated questionnaires for the analysis of musculoskeletal symptoms, including The Nordic pain questionnaire [14] and the Saskatchewan Health and Back Pain Survey [15]. The questionnaire was piloted amongst radiologists at Southmead Hospital. The questionnaire was amended and then distributed to all radiologists working in the institutions within the Severn Deanery. The questionnaire was broadly divided into three components as follows: (a) background demographic information, (b) personal musculoskeletal symptoms/occupational injury resulting from working as a radiologist and the type of treatment sought for these ailments, and finally (c) compliance of reporting environments with best ergonomic practice. The survey was conducted over a 2-month period between June and July 2011. A covering letter attached to the questionnaire instructed respondents to only report musculoskeletal symptoms that they felt were directly attributable to working as a radiologist (e.g. to exclude symptoms relating to previous

injuries sustained outside of the radiology workplace and include symptoms that occur or worsen during the working week and symptoms that resolve during holidays).

Statistical Analysis

Data from the survey were entered into Microsoft Excel (Microsoft Corp., Seattle, WA, USA). Statistical analysis by unpaired two-tailed chi-squared test was performed using GraphPad Prism (GraphPad Software, San Diego, CA, USA). Significant levels were set at $P<0.05$.

Results

Of the 148 subjects who were invited to participate, 123 (83 %) responses were received. The majority of respondents were male (68 %), consultants, aged between 36 and 45 years and worked full time (Table 1).

Prevalence of Musculoskeletal Symptoms

Forty-six out of 120 (38 %) respondents considered themselves to suffer or have suffered from an occupational injury that they attributed to working as a radiologist, and 8/46 (17 %) of those respondents who had suffered an occupational injury required time off work due to the injury. The length of time off work ranged from 1 day to 6 months. Three respondents required surgical invention for their injury (two microdiscectomies and one subacromial shoulder decompression). The most common occupational injury symptom caused by working as a radiologist was lower back pain, present in 51/123 (41 %) respondents (Table 2).

Significantly fewer respondents aged <55 years suffer/have suffered with neck pain from working as a radiologist, compared with those aged >56 years (24/106 (23 %) vs. 5/12 (42 %), $P<0.001$).

Table 1 Descriptive statistics for survey group

Characteristic	Value n (%)	Characteristic	Value n (%)
Gender		Work pattern	
Male	84 (68 %)	Full time	104 (86 %)
Female	37 (30 %)	Part time	19 (14 %)
No response	2 (2 %)	No response	0 (0 %)
Age		Experience	
24–35	30 (24 %)	1st year trainee	10 (8 %)
36–45	40 (33 %)	2nd year trainee	6 (5 %)
46–55	36 (29 %)	3rd year trainee	4 (3 %)
56–65	12 (10 %)	4th year trainee	6 (5 %)
>65	0 (0 %)	5th year trainee	4 (3 %)
No response	5 (4 %)	Fellow	0 (0 %)
		Consultant	93 (76 %)

Table 2 Prevalence of occupational injury symptoms ($n=123$)

Symptom(s) induced by working as a radiologist	%
Eye sensitivity to glare	14
Eye discomfort	17
Neck discomfort	25
Lower back discomfort	41
Shoulder discomfort	27
Elbow discomfort	7
Wrist discomfort	20
Hand discomfort	12

Sources of Advice/Treatment for Work-Related Musculoskeletal Symptoms

Of those who had suffered an injury, 6/46 (13 %) consulted occupational health and 11/46 (24 %) sought no help or advice. The sources of help and the frequencies at which they were consulted are detailed in Table 3.

Of the 74/120 (62 %) who did not classify themselves as having suffered with an occupational injury, 41/74 (55 %) suffer or had suffered with at least one symptom which they attributed to working as a radiologist and 6/74 (8 %) had sought advice from a healthcare professional regarding their occupation-induced symptoms.

Compliance with Best Ergonomic Practice

Seventeen out of 122 (14 %) felt they have received formal training on making ergonomic adjustments to their working

Table 3 Frequency of consultation of sources of help for those respondents with occupational injury. Some individuals sought the advice of multiple 'other' sources ($n=46$)

Source of help	%
Occupational health doctor	13
No help	24
Other	
General practitioner	20
Orthopaedic surgeon	9
National Health Service physiotherapist	20
Private sector physiotherapist	13
Private sector chiropractor	11
Radiology colleague	24
Self-help (e.g. internet research)	22
Miscellaneous	11

environment. When asked to score their level of agreement with the statement "I understand what best ergonomic practice is" on a seven-point Likert scale (where 1=strongly disagree and 7=strongly agree), the mean response was 3.9 (mode=5, median=4; $n=118$).

Subgroup analysis of respondents who had not suffered an occupation injury was conducted to assess the impact of ergonomic knowledge on musculoskeletal symptoms. Respondents with prior occupational injury were excluded as their ergonomic knowledge may have been affected by subsequent occupational health input. Those respondents who scored 6 or 7 where defined as having good ergonomic knowledge. Those who responded who gave a score of 0 or 1 were defined as having poor ergonomic knowledge. Comparison of the prevalence of musculoskeletal symptoms amongst these cohorts is described in Table 4.

Fifty-seven out of 123 (46 %) of respondents work on average 1–2 h at a PACS workstation without a break, and 65/122 (53 %) had worked in excess of 3 h at a workstation without a break within the last month (Table 5).

The compliance of the working environment with best ergonomic practice is detailed in Table 6. The ability to alter chair height (98 %) and ambient light (83 %) were the most common ergonomic facilities at the radiologist's disposal. The other facilities were not as widely available. No workstation complied completely with best ergonomic practice. Where certain ergonomic facilities were available, adjustments were only routinely made to ambient light (73 %), ambient temperature (79 %) and chair height to a lesser degree (58 %). Ninety-two out of 119 (77 %) felt that an annual ergonomic review with occupational health should be available for radiologists.

Discussion

In this multicentre study, we have quantified the prevalence of musculoskeletal injury amongst consultant and trainee radiologists, explored the types of help sought for such symptoms and determined the adherence of reporting environments to best ergonomic practice. We found that occupational injury was self-reported in 38 % of respondents. Boiselle et al. noted a prevalence of 58 % of repetitive stress symptoms amongst faculty members, fellows and residents in a single American radiology department [12]. Their response rate was 68 % (73/107) compared to our 83 % (123/148).

The prevalence of occupational injury in our cohort may be underestimated, as 55 % of those respondents who did not classify themselves as formally having or having had an occupational injury did describe musculoskeletal symptoms which

Table 4 The prevalence of musculoskeletal symptoms in respondents with good ergonomic knowledge ($n=7$) compared with those with poor ergonomic knowledge ($n=7$)

Musculoskeletal symptom	Ergonomic knowledge % Good	% Poor	*P* value
Neck discomfort	14	14	=1.0
Back discomfort	0	71	<0.005
Shoulder discomfort	0	14	=0.3370
Elbow discomfort	0	14	=0.3370
Wrist discomfort	0	14	=0.3370

Table 5 Average and maximum uninterrupted reporting time at a PACS workstation

Time spent reporting at PACS station without a break (hours)	%
Average time ($n=123$)	
<0.5 h	3
0.5–1 h	16
1–2 h	46
2–3 h	25
>3 h	10
Maximum time within last month ($n=122$)	
1–2 h	21
2–3 h	26
>3 h	53

Table 6 Compliance with best ergonomic practice

Best ergonomic practice	% Yes
At my workstation, there is the option to alter:	
Computer monitor height ($n=121$)	55
Desk height ($n=121$)	2
Chair height ($n=121$)	98
Chair back support ($n=121$)	61
Chair armrest height ($n=121$)	25
Ambient light ($n=121$)	83
Ambient temperature ($n=121$)	60
When available, I routinely alter:	
Computer monitor height ($n=67$)	19
Desk height ($n=3$)	67
Chair height ($n=118$)	58
Chair back support ($n=74$)	28
Chair armrest height ($n=30$)	13
Ambient light ($n=101$)	73
Ambient temperature ($n=72$)	79
The following are at my disposal:	
Computer screen shield ($n=122$)	4
Foot rest ($n=122$)	3
Wrist support mouse mat ($n=122$)	23
Hands-free dictation ($n=122$)	32

they attributed to working as a radiologist. This may be because of lack of insight into the fact that their symptoms constituted an occupational injury. Such lack of recognition has previously been described amongst visual display unit users by Robertson et al. [16]. Raising awareness of the issue, followed by ergonomic training, significantly reduced self-reported musculoskeletal pain in this study [16].

Lower back discomfort was the most common symptom amongst our cohort, occurring in 41 %. However, lower back discomfort is a very common musculoskeletal symptom. The lack of a suitable age- and sex-matched control group of individuals who are not in employment for comparison means that we cannot conclude that working as a radiologist has a direct causal effect on the prevalence of the musculoskeletal symptoms documented. Furthermore, direct comparison of our results with other general musculoskeletal symptom data in the published literature is difficult due to the lack of consistency in definitions of symptoms, as well as different prevalence endpoints for musculoskeletal symptoms, e.g. point, annual or life time prevalence, between studies. In addition, we assessed for musculoskeletal symptoms that respondents attributed directly to working as a radiologist which represents a discrete prevalence subset, separate to lifetime prevalence. Nevertheless, our results are in keeping with a study from Prabhakar et al. who found similar results, with lower back pain described in 39 % in a survey of American radiologists [10].

It is important to realise that whilst lower back discomfort was the most commonly reported symptom, several serious work-related injuries were also described by the cohort. Seventeen percent of respondents who had suffered an occupational injury required time off work as a consequence. The length of time off work ranged from 1 day to 6 months, with some serious injuries requiring surgical treatment. Such sick leave has cost implications to radiology departments and may impact on workflow. Any potential short-term costs incurred to improve reporting environments ergonomics must be weighed against the potential costs of long-term radiologist sick leave resulting from poor ergonomic reporting practice.

Those aged under 55 years were significantly less likely to suffer from neck pain compared to their colleagues older than 55 years. A potential explanation might be the previous practice of continually changing films during hard copy reporting sessions by the older generation of radiologists. However, the fact that the majority of those surveyed (57 %) were aged less than 45 years and several junior trainees had suffered occupational injury despite only working as radiologists for a short duration is important. If this issue is not dealt with, there is a strong possibility of recurring problems during their radiology careers.

Of those with radiology-induced occupational injury symptoms, only 13 % sought the advice of occupational health. Other sources of help such as radiology colleagues and the internet were consulted with greater frequency. This could lead to inappropriate management. Yet, the vast majority of respondents (77 %) agreed that an annual occupational health review should be at the disposal of all radiologists. This opportunity may abrogate both the issues of not recognising the symptoms as occupational-related injuries and ensuring appropriate individualised workplace modifications are made to reduce the burden of occupational injury.

The majority of radiologists worked for longer than 1 h at a PACS workstation without a break, and 53 % had worked continuously for longer than 3 h at a PACS workstation in the last month. This finding is important as it has been documented that the main factor determining visual fatigue in a PACS user is the amount of time spent viewing display units [4]. We found that nearly half (46 %) of respondents work without a break at a PACS workstation for 1–2 h, which is in keeping with work by Siegel et al. who found that the median time spent at a workstation without taking a break in an American study was 1.5 h [11]. Boiselle et al. report that 68 % of radiologists worked for more than 8 h per day at a personal computer or PACS monitor [12]. It is recommended that people working at computer monitors should get up and stretch at least every half an hour [4]. Alternatively, it has been suggested that PACS users should look 20 ft away from their computer screen for 20 s every 20 min [3]. However, this would equate to 8 min of lost reporting time per day per radiologist, assuming they report for 8 h a day, or the equivalent of 2 h and 40 min lost reporting time in a Department of 20 radiologists.

We found that no working environments conformed completely to best ergonomic practice, in terms of being able to alter the monitor, desk, chair and armrest height, chair back support and ambient light and temperature. These shortcomings may contribute to the high prevalence of musculoskeletal symptoms amongst radiologists in our study. However, even where certain ergonomic facilities were at the radiologist's disposal, adjustments prior to reporting were made infrequently, with the exception of adjusting ambient light and temperature. The ability to alter desk height was only at the disposal of three radiologists; one routinely reported standing up, one optimised desk height for reporting sitting down and the other did not routinely make use of this facility. The user interface of computer mouse and keyboard is a key element; only 3 % of respondents (4/123) had personalised equipment in this regard, e.g. tracker ball mouse or optimised smaller keyboard.

The low level of awareness of radiologists regarding best ergonomic practice and the apparent lack of training of how to make ergonomic adjustments in 86 % may be important in this regard. Robertson et al. demonstrated that self-reported musculoskeletal pain and discomfort can be significantly reduced with ergonomic training amongst VDU users [16]. Awareness is the important first step and appears to be lacking amongst our cohort, and we hope this study will raise the awareness of this issue amongst other radiologists. In our study, the fact that the respondents with good self-assessed ergonomic

knowledge suffered with significantly less lower back discomfort than those with poor knowledge supports this notion.

There are some limitations of our observational study. This was a cross-sectional study and, as previously alluded to, we cannot definitively comment on causal relationships between the musculoskeletal symptoms and reporting environment ergonomic facilities, or lack thereof. A potentially confounding issue is whether respondents had any prior medical problems predisposing them to musculoskeletal symptoms. Detailed questions in this regard were considered for the questionnaire. However, the feedback received from our pilot study was that such questions were too intrusive and would dissuade people from participating in the survey. The decision was taken to remove these questions but reiterate, on both the questionnaire and an accompanying covering letter, we were looking for respondents to only disclose symptoms that they attributed to working as a radiologist. Furthermore, detailed studies of prevalence of musculoskeletal symptoms have previously been conducted and published. We wanted to ensure as good a response rate as possible to assess compliance of reporting environments with best ergonomic practice and the types of advice for occupational injury that are being sought, which have not been reported before to the best of our knowledge. We subsequently achieved an impressive response rate of 83 %. Ultimately, regardless of whether the musculoskeletal symptom(s) experienced are a de novo work-related phenomenon or an exacerbation of a pre-existing injury, they should be addressed in the same manner at work with appropriate ergonomic interventions. In fact, if a radiologist were to suffer from a potential pre-existing injury that could be aggravated by poor ergonomic practice, there would be even more reason to ensure their reporting environment complies with best ergonomic practice.

Finally, the study population was confined to a region of the UK. However, we believe the radiological practice sampled broadly reflects current modern radiology practice. Nevertheless, responder bias within our cohort is still possible. In particular, those who have suffered occupational injury may have felt more compelled to complete the questionnaire than the 17 % who did not. An argument could be made that our self-reported data are subject to perceptive error, and that different data may have been gathered from occupational health records. However, very few respondents actually sought occupational health advice; furthermore, previous questionnaire studies have demonstrated good agreement between self-reported and documented illness [17]. We have relied upon the respondents' reports of the ergonomic facilities at their disposal, which may also be subject to recall bias.

Conclusion

In this multicentre study, we found a high prevalence of self-reported musculoskeletal symptoms and occupational injury amongst radiologists and poor compliance of the reporting environment with best ergonomic practice. Whilst it is impossible to be categorical on the basis of a cross-sectional study, our results imply that the aetiology of occupational injury is likely to be multi-factorial including paucity of ergonomic facilities, not personalising those facilities available, lack of training, long reporting sessions and not recognising symptoms as occupational injuries. Poor ergonomic practice impacts directly on radiologists by causing injury. It may also have implications for patients, and it is postulated that reporting under poor ergonomic conditions increases radiologist fatigue and causes more reporting error. Although further work is still required in this area, we hope our study raises awareness of this important issue amongst radiologists in order to recognise musculoskeletal symptoms as potentially associated with their work and to seek advice through the appropriate occupational health channels to ensure that optimal ergonomic improvements are made to their reporting environment.

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