

Relationship between Wearing a Lead Apron and Work-related Musculoskeletal Disorders: A Questionnaire Survey of Japanese Radiological Technologists

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The purpose of this study was to conduct a self-reported questionnaire survey of work-related musculoskeletal disorders (WMSDs) among Japanese radiological technologists (RTs) and to report on the relationship between wearing a lead apron and WMSDs. Between February and April of 2021, RTs in Okayama Prefecture, Japan, were surveyed by mail and through a website. Information on individual characteristics, physical factors at work, and the presence of WMSDs were collected. All participants were also asked whether they frequently wore lead aprons. A multiple logistic regression analysis was used to assess the relationship between wearing a lead apron and WMSDs. The model was adjusted for age, sex, body mass index (BMI), and working hours. Of the 123 participants, 67 (54.5%) had WMSDs. Multiple logistic regression analysis revealed that WMSDs were significantly associated with wearing a lead apron. Compared to the “Never wear” group, the odds ratios for the “Always/Frequently wear” and “Sometimes/Rarely wear” groups were 7.87 (95% confidence interval [CI] = 1.28-48.46; $p=0.026$) and 7.80 (95% CI = 1.43-42.44; $p=0.017$), respectively. Our analysis suggests that wearing a lead apron is associated with WMSDs, and thus design modifications in lead aprons may improve the occupational health management of RTs.

Key words: work-related musculoskeletal disorders, radiological technologists, lead apron, questionnaire survey, multiple logistic regression analysis

Work-related musculoskeletal disorders (WMSDs) are defined as symptoms caused or aggravated by occupational risk factors, including discomfort, and damage or persistent pain in body structures, such as the muscles, joints, tendons, ligaments, nerves, bones, or circulatory system [1-4]. Collectively, they are among the most prevalent occupational diseases in working populations in modern society. WMSDs have been reported not only in industry but also in the medical field, especially among medical professionals such

as nurses, and occupational and physical therapists [5-9]. Various activities, such as lifting and transferring patients, tiring positions, and awkward postures, are associated with WMSDs. There have been numerous previous studies on the prevalence of WMSDs in the medical profession. Bae *et al.* report that 745 (94.5%) of 788 respondents complained of WMSDs in at least one body site on a self-administered questionnaire survey of 855 physical therapists in South Korea [10]. Similarly, Park *et al.* conducted a questionnaire survey of 150 occupational therapists in South Korea and report that

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110 (85.9%) of 128 respondents complained of WMSDs in at least one body site [7]. Krishnan *et al.* report that 295 (97.4%) of the 303 nurses in a Malaysian survey complained of having had WMSDs within the previous 12 months [11].

Radiological technologists (RTs) often perform tasks that involve high physical loads, such as equipment handling and patient positioning, however, there have been few studies assessing WMSDs in RTs [12, 13]. RTs are often required to wear proper radiation protective equipment to prevent or minimize radiation exposure. A lead apron with 0.25- to 0.5-mm lead equivalent is commonly used as an effective shield from primary and secondary radiation. However, such lead aprons are heavy (2-5 kg) and uncomfortable when worn for long periods. Therefore, the physical load of lead aprons is expected to accumulate and be associated with WMSDs among RTs. In recent years, the development of diagnostic and therapeutic radiology equipment has been remarkable, and diagnostic and therapeutic techniques using this equipment have become more diverse. As a result, both radiologists and RTs are often required to work long hours while wearing lead aprons. Although the incidence of WMSDs among RTs is expected to be high, it remains largely unexplored. There have been few studies to date on the development of WMSDs in interventional physicians related to wearing a lead apron [14]. In the present study, we conducted a questionnaire survey of WMSDs among Japanese RTs and report on the relationship between wearing a lead apron and WMSDs.

Materials and Methods

Participants and survey method. Our 735 participants were all members of the Okayama Association of Radiological Technologists in Japan. This was a cross-sectional study using questionnaires. With the approval of the Board of Directors of the Okayama Association of Radiological Technologists, the questionnaire was sent to RTs by mail and through a website. The purpose of this study was explained in writing on paper and online, and it was clearly stated that answering the questionnaire constituted the respondents' agreement to participate in the study. Under the postal method, participants completed the questionnaire on paper and returned it by mail. On the website, participants completed the questionnaire on a Google Form.

The survey period was from February to April of 2021. This study was conducted with the approval of the Ethics Review Committee of Okayama Healthcare Professional University (No. 0023).

Questionnaire. The survey items included respondent characteristics (age, sex, body mass index [BMI], work hours/day, *etc.*), the presence or absence of WMSDs in the previous year (most painful region), and content related to work conditions (use of a lead apron). The frequency of use of a lead apron was surveyed using a 5-point Likert scale: "Always," "Frequently," "Sometimes," "Rarely" or "Never."

Statistical analysis. Multiple logistic regression analysis was performed to examine the effect of lead apron use on WMSDs, with the presence of WMSDs as the dependent variable and the wearing status of a lead apron as the explanatory variable. For the analysis, we classified the wearing status of a lead apron into three groups: "Always/Frequently wear," "Sometimes/Rarely wear," and "Never wear." The model was adjusted for age, sex, BMI, and working hours. STATA Ver. 16 (Stata Statistical Software: Release 16; StataCorp LLC, Texas, USA) was used for statistical analysis, and all significance levels were set at $p < 5\%$.

Results

Of the 735 RTs invited to participate in the study, 123 responded (88 male and 35 females; response rate 16.7%). Twenty-four responded by mail and 99 online. The respondents' characteristics are presented in Table 1. Sixty-seven responders (54.5%) reported WMSDs, including 41 (61.2%) in the lumbar region, 8 (11.9%) in the shoulder, 6 (9.0%) in the knee, 5 (7.5%) in the neck, 4 (6.0%) in the hands and fingers, and 3 (4.5%) in other locations (Fig. 1).

In multiple logistic regression analysis, the wearing status of a lead apron was extracted as significant factor of WMSDs. Compared to the "Never wear" group, the odds ratios for the "Always/Frequently wear" and "Sometimes/Rarely wear" groups were 7.87 (95% confidence interval [CI] = 1.28-48.46; $p = 0.026$) and 7.80 (95% CI = 1.43-42.44; $p = 0.017$), respectively (Table 2).

Discussion

The results of our questionnaire showed that 54.5% of the RTs who responded had WMSDs, with back pain

Table 1 Participant characteristics

	WMSDs (n=67)	Non-WMSDs (n=56)
Age, Years	45.5 ± 11.8	43.2 ± 13.8
Male	43 (64%)	45 (80%)
BMI		
< 18.5	2 (3%)	4 (7%)
18.5–25.0	48 (72%)	46 (82%)
25.0 <	17 (25%)	6 (11%)
Work hours/day		
< 4	17 (25%)	15 (27%)
4–8	38 (57%)	35 (62%)
8–9	12 (18%)	6 (11%)

WMSDs, work-related musculoskeletal disorders; BMI, body mass index.

Age data are presented as a mean ± standard deviation.

Other data are presented as number (%).

being the most frequent complaint. The prevalence of WMSDs in RTs was consistent with that in a previous study [15], but not high compared to other recent studies on medical professionals such as physical therapists, occupational therapists, and nurses [7,10,11]. The reason for the relatively low prevalence may be the difference in the physical workloads of different professionals. For example, RTs may not perform as many patient processing tasks as other healthcare professionals analyzed in previous studies. The high proportion of WMSDs in RTs associated with the lower back compared to other parts of the body may be due to the weight of the lead apron.

The present multiple logistic regression analysis results suggest that the wearing status of a lead apron has an effect on WMSDs in RTs. In recent years, new procedures such as interventional radiology (IVR), which involves a high risk of radiation exposure, have been implemented in addition to conventional radio-

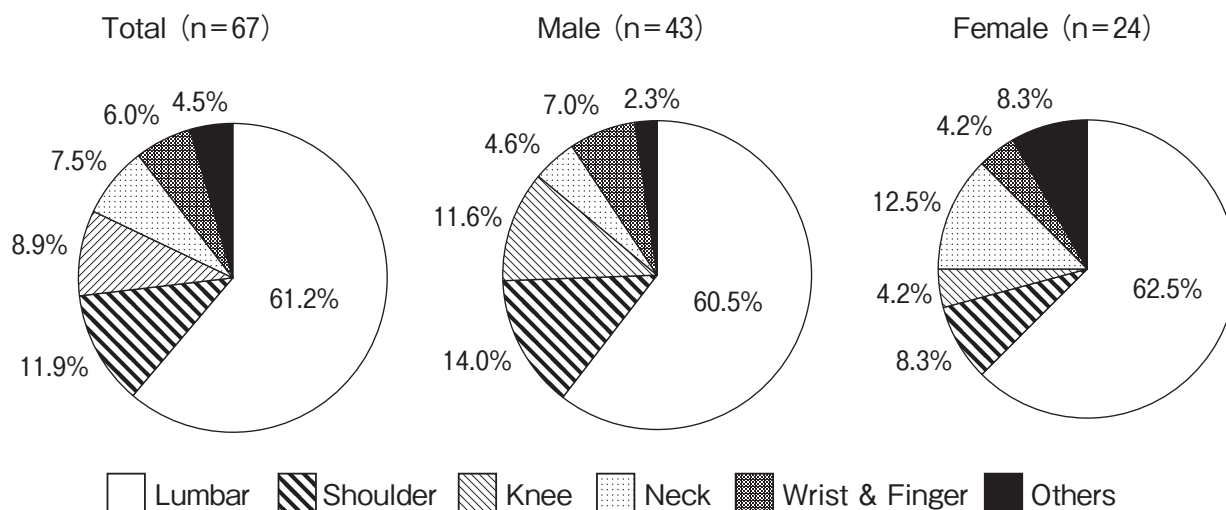


Fig. 1 Body parts breakdown of WMSDs.

Table 2 Relationship between wearing status of a lead apron and WMSDs (Logistic regression analysis*)

Variable	Odds Ratio	95% Confidence interval		P-value	
		Lower	Upper		
Wearing status of a lead apron	Always/Frequently	7.87	1.28	48.46	0.026
	Sometimes/Rarely	7.80	1.43	42.44	0.017
	Never	1			

*Model was adjusted for age, sex, BMI (<18.5, 18.5–25.0, 25.0<), and working hours (<4, 4–8, 8–9).

logical diagnostic and therapeutic procedures. As a result, there has been an increase in the use of lead aprons. Morrison *et al.* surveyed radiologists involved in IVR treatment in Scandinavia and report that approximately 60% reported WMSDs, 60% of which involved lumbar symptoms [15]. This is consistent with our results. They also speculate that this was due to the heavy load placed on the body by the weight of the radiation protective gear [15]. However, their study did not show that wearing a lead apron was necessarily associated with WMSDs such as back pain. A similar result was reported by Andrew *et al.*, who surveyed the staff of a general hospital in the UK [16]. In addition, the earliest study, 1992, of WMSDs in interventional radiologists found no correlation between the prevalence of back pain and the duration of lead apron use [17].

The Guidelines for the Prevention of Low Back Pain in the Workplace issued by the Ministry of Health, Labor and Welfare specify weight restrictions for lifting activities. <<https://www.mhlw.go.jp/stf/shingi/2r9852000002shqgatt/2r9852000002shvs.pdf>. (update September 6, 1994; accessed October 1, 2021.)> However, there are no clear guidelines regarding weight to be worn on the body, as in the case of lead aprons. Patients who suffer from back pain due to the cumulative effect of even a small physical load are often encountered in clinical situations. Therefore, it is crucial to take ergonomic measures to prevent musculoskeletal disorders, including back pain prevention.

The strength of the present study is that we conducted a survey of the actual workplace situation of RTs, and addressed a focused question about the relationship between wearing a lead apron and WMSDs. The results of this study highlight the fact that lead aprons are a critical physical factor in the occupational health management of RTs. However, this study has some limitations. First, the response rate of the questionnaire was low, and the number of participants was small. The reason for this is not clear, but it is possible that potential participants were not thoroughly informed of the questionnaire. It will be necessary to increase the number of RTs surveyed. Second, the analysis was semi-quantitative based on three approximate categories of lead apron use. A more quantitative analysis of the relationship between wearing a lead apron and WMSDs would be possible if the exact duration and frequency of wearing a lead apron were collected. Third, the results

of this study were based on a single analysis of only physical factors. It has been reported that musculoskeletal disorders are also affected by various non-physical factors, such as social and psychological factors [10, 18, 19]. We will conduct further analysis from various perspectives in our next study.

In conclusion, we performed a questionnaire survey on WMSDs among Japanese RTs. WMSDs were found in 54.5% of RTs who responded, and approximately 60% had lower back pain. Our analysis suggests that wearing a lead apron is associated with WMSDs, and thus design modifications in lead aprons may improve the occupational health management of RTs.

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References

1. Barboza MC, Milbrath VM, Bielemann VM and de Siqueira HC: Work-related musculoskeletal disorders and their association with occupational nursing. *Rev Gaucha Enferm* (2008) 29: 633–638.
2. Cherry NM, Meyer JD, Chen Y, Holt DL and McDonald JC: The reported incidence of work-related musculoskeletal disease in the UK: MOSS 1997–2000. *Occup Med (Lond)* (2001) 51: 450–455.
3. Kee D and Seo SR: Musculoskeletal disorders among nursing personnel in Korea. *Int J Ind Ergon* (2007) 37: 207–212.
4. Trinkoff AM, Lipscomb JA, Geiger-Brown J and Brady B: Musculoskeletal problems of the neck, shoulder, and back and functional consequences in nurses. *Am J Ind Med* (2002) 41: 170–178.
5. Darragh AR, Huddleston W and King P: Work-related musculoskeletal injuries and disorders among occupational and physical therapists. *Am J Occup Ther* (2009) 63: 351–362.
6. Vieira ER, Schneider P, Guidera C, Gadotti IC and Brunt D: Work-related musculoskeletal disorders among physical therapists: A systematic review. *J Back Musculoskelet Rehabil* (2016) 29: 417–428.
7. Park JH and Park JH: Association among Work-Related Musculoskeletal Disorders, Job Stress, and Job Attitude of Occupational Therapists. *Occup Ther Health Care* (2017) 31: 34–43.
8. Takahashi M, Iwakiri K, Sotoyama M, Hirata M and Hisanaga N: Musculoskeletal pain and night-shift naps in nursing home care workers. *Occup Med (Lond)* (2009) 59: 197–200.
9. Kox JHAM, Bakker EJM, Bierma-Zeinstra S, Runhaar J, Miedema HS and Roelofs PDDM: Effective interventions for preventing work related physical health complaints in nursing students and novice nurses: A systematic review. *Nurse Educ Pract* (2020) 44: 102772.
10. Bae YH and Min KS: Associations between work-related musculoskeletal disorders, quality of life, and workplace stress in physical therapists. *Ind Health* (2016) 54: 347–353.
11. Krishnan KS, Raju G and Shawkataly O: Prevalence of Work-Related Musculoskeletal Disorders: Psychological and Physical

- Risk Factors. *Int J Environ Res Public Health* (2021) 18: 9361.
12. Lorusso A, Bruno S and L'Abbate N: Musculoskeletal complaints among Italian X-ray technologists. *Ind Health* (2007) 45: 705–708.
 13. Lorusso A, Vimercati L and L'abbate N: Musculoskeletal complaints among Italian X-ray technology students: a cross-sectional questionnaire survey. *BMC Res Notes* (2010) 24: 114.
 14. Monaco MGL, Carta A, Tamhid T and Porru S: Anti-X Apron Wearing and Musculoskeletal Problems Among Healthcare Workers: A Systematic Scoping Review. *Int J Environ Res Public Health* (2020) 17: 5877.
 15. Morrison JJ, Jiao A, Robinson S, Jahangiri Y and Kaufman JA: Prevalence of Musculoskeletal Symptoms in Interventional Radiologists. *J Vasc Interv Radiol* (2020) 31: 1308–1314.
 16. Andrew S, Abdelmonem MR, Kohli S and Dabke H: Evaluation of Back Pain and Lead Apron Use Among Staff at a District General Hospital. *Cureus* (2021) 13: e18859.
 17. Moore B, vanSonnenberg E, Casola G and Novelline RA: The relationship between back pain and lead apron use in radiologists. *AJR Am J Roentgenol* (1992) 158: 191–193.
 18. Anderson S, Stuckey R and Oakman J: Work-related musculoskeletal injuries in prosthetists and orthotists in Australia. *Int J Occup Saf Ergon* (2021) 27: 708–713.
 19. Akodu AK and Ashalejo ZO: Work-related musculoskeletal disorders and work ability among hospital nurses. *J Taibah Univ Med Sci* (2019) 14: 252–261.