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Original Article

Analysis of Risk Factors for Work-related Musculoskeletal Disorders in Radiological Technologists

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Abstract. [Purpose] The aim of this study was to analyze, through ergonomic analyses, those motions most used by radiological technologists that can cause musculoskeletal disorders. [Subjects and Methods] The subjects were 7 radiological technologists with work experience in hospitals for more than 5 years. For the analysis of working postures, we simulated the work posture of radiological technologists when moving patients, when pushing or pulling an apparatus, when conducting ultrasonography, and when handling a mouse for MRI were analyzed. [Results] In this study, the burdens on the radiological technologists' waists were shown to be high when they were moving patients for a CT scan. During mouse handling for an MRI scan, large burdens were imposed on the neck. In the case of ultrasonography working postures, larger burdens on the leg and neck were found when the patient's examination sites were located further away. The assessment of working postures when pushing a portable radiation apparatus showed that burdens on the musculoskeletal system increased as the weight of the apparatus increased. [Conclusion] The musculoskeletal disorders of radiological technologists occur in various regions of their bodies but occur most frequently in the shoulder and the lumbar region. Therefore, hospitals need to be educated regarding the concept of musculoskeletal disorders.

Key words: Radiological technologists, Musculoskeletal disorder, Ergonomic risk factor

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INTRODUCTION

The work of Korean medical radiological technologists is divided into three areas: diagnosis, treatment, and nuclear medicine[1)]. The department of diagnostic radiology (department of radiology) is in charge of general X-ray examinations, magnetic resonance imaging, ultrasonography, and computerized tomography scans for conducting precise examinations of the inside of the body. The department of radiation oncology deals with cancer treatment, using high energy radiation to kill cancer cells; the department of nuclear medicine uses radioactive isotopes with cutting-edge technologies for diagnosis and treatment of certain cancers[2)]. To perform these responsibilities, radiological technologists are constantly required to perform physical work, such as lifting adult patients who cannot move adequately by themselves, pushing or pulling to move heavy equipment, and continuous work with a computer keyboard or mouse[3, 4)]. During these activities, radiological technologists are sometimes at risk for musculoskeletal disorders[5)]. The acts of moving patients who cannot move well by themselves and pushing and pulling heavy equipment, are known to be major causes of lower back pain, while the repetitive movements performed when utilizing computers for functions, such as use of the picture archiving communication system (PACS) and the order communication system (OCS), are causes of upper extremity musculoskeletal disorders[6)]. In these ways, the exposure of radiological technologists to the risks of work-related musculoskeletal disorders can be said to be increasing. However, because awareness of occupational safety for radiological technologists has been concentrated on exposure to radiation and on the necessary defense against radiation exposure, the issue of safety in relation to work-related musculoskeletal disorders has tended to be neglected.

Because the significance of work-related musculoskeletal disorders has generally come to be recognized, a law was established in Korea in 2005 that aims to prevention and control work-related musculoskeletal disorders. Based on this legislation, physical therapists have worked in different industrial fields to analyze work movements and organize educational programs to prevent work-related musculoskeletal disorders. Thus, the working area of physical therapists has been expanded to include this area[7)]. However, data that can be utilized by physical therapists in analyzing work-related musculoskeletal disorders is rarely reported, because ergonomic assessment is conducted only

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in certain types of jobs where there is high labor intensity. In general, hospitals are special workplaces in which the concept of medical personnel is stronger than the concept of workers, and the concept of medical practice is stronger than the concept of labor or work. However, since hospital workers are also workers who conduct physical activities using their bodies, they are also exposed to the risk of work-related musculoskeletal disorders. In particular, radiological technologists are exposed to higher levels of the risks relating to musculoskeletal disorders because they are forced to use inconvenient working postures due to the nature of their work, such as manually handling adult patients, frequently exceeding 60 kg in weight, without any generalized mechanical assistance. In these situations, they are required to adjust their own postures to accommodate the positions and weights of their patients[8]. Hospital workers are repeatedly exposed to the risk of work-related musculoskeletal disorders, and frequently exacerbate the problem because they do not recognize, or are indifferent to the problem. To prevent and effectively control musculoskeletal disorders, the potential disorders should first be accurately diagnosed and classified, and then their scales should be evaluated[6].

The aim of this study was to analyze, through ergonomic analyses, those motions most used by radiological technologists that can cause musculoskeletal disorders so that the results can be utilized as the basis for diagnosis, classification and prevention of occupational musculoskeletal disorders in radiological technologists.

SUBJECTS AND METHODS

In this study, designed to assess the ergonomic risks of radiological technologists, a field survey was conducted on August 1 and August 2, 2013, at a hospital located in Gangwon-do, Republic of Korea. This was a university hospital in which all three areas of radiological technologists work were performed. The purpose, method, and research process of the study were explained to the general manager of the department of radiology, and the field survey was conducted after getting his consent. The study's objectives and procedure were explained to the study subjects, and their consent was obtained. The study was approved by the ethics committee of the Kangwon National University Hospital institutional review board. The work processes performed by the radiological technologists were then videotaped from the left side, right side, and front so that the movements of their joints were clearly visible. Based on this data, the parts of the videotapes judged to demonstrate working postures that would impose the heaviest burdens on the technologists' bodies were each captured and analyzed three times.

The captured working postures were assessed and analyzed using the following ergonomic assessment methods: the Rapid Entire Body Assessment (REBA), the Rapid Upper Limb Assessment (RULA), the National Institute for Occupational Safety and Health Lifting Equation (NLE), and the Strain Index (SI). Three professors of industrial safety conducted the analysis to preserve the objectivity of the study. The professors assessed the scores through discussion and analyzed the different categories of working posture. REBA was developed for the purpose of analyzing the degree of exposure of the body to physical burden and the risk factors in the service industries, including nursing, cleaning, and other jobs with dynamic and unpredictable work postures. Different factors, including repetition, static work, working postures, and duration of working hours, among others, are evaluated in relation to two groups, Group A (trunk, neck, leg) and Group B (humerus, shoulder, forearm, wrist), using recorded video and direct observation. REBA categorizes the danger levels into 5 stages using a grading system with a 15-point scale and suggests appropriate safety measures[9]. RULA enables convenient and swift assessment of the workload imposed by working postures by focusing on an upper limb analysis, whether in assembly work, service work, meat processing, dental clinic work, or video display terminal tasks, especially those involving the shoulders, wrists, neck, and other upper body parts. It divides the body parts into Group A (upper arm, lower arm, wrist) and Group B (neck, trunk, legs) and assesses them in terms of the number of movements, the static muscle work, force, and working postures as the workload parameters. RULA categorizes the danger levels into 4 stages using a grading system with a 7-point scale and suggests appropriate safety measures[10]. The Ovako Working Posture Analysing System (OWAS) is an assessment technique developed by the Ovako Steel Company to define and assess workers' working postures in relation to their suitability for manual handling of heavy objects in the course of their work. Working postures are considered in relation to four items: the waist, the upper extremities, the lower extremities, and the weight of the object handled. The effects of these factors on the musculoskeletal system are divided into four levels, and the results are recorded[11].

The SI is a method for evaluating jobs to determine whether they expose workers to increased risk of developing musculoskeletal disorders of the distal upper extremity (DUE)[12]. The DUE is defined as the elbow, forearm, wrist, and hand. Musculoskeletal disorders of the DUE include specific diagnoses (e.g., epicondylitis, peritendinitis, tendon entrapment at the wrist or finger, and carpal tunnel syndrome) and less specific symptomatic conditions related to the muscle-tendon units of the DUE. The SI uses six task variables to describe hand exertions: intensity of exertion, duration of exertion, exertions per minute, hand/wrist posture, speed of work (how fast), and duration per day. Among these factors, exertion is evaluated to be the most serious risk factor. An SI higher than 5 indicates the occurrence of potential danger to the upper extremity. An SI below 3 indicates safety, while an SI above 7 is considered very dangerous.

RESULTS

This study was conducted to analyze the working postures of radiological technologists and to utilize the results for the prevention and treatment of their musculoskeletal disorders. Accordingly, their postures when moving patients, when pushing or pulling an apparatus, when conducting ultrasonography, and when handling a mouse for

Table 1. Working postures for patient lifting

Working Posture	Risk Factor	REBA	OWAS	RULA (Rt)	REBA	OWAS	RULA (Lt)
Patient lifting starting point	Waist	5	4	6	5	4	6
	Neck	2	3	3	2	3	3
	Leg	2	5	2	1	4	1
	Shoulder (upper arm)	4	1	4	4	1	4
	Elbow (forearm)	2		3	2		3
	Wrist	2		2	2		2
	Wrist twisting	1		2	0		1
	Load/force	2	3	3	2	3	3
	Handle	3			3		
	Activity	2		1	2		1
	AS	13	4	8	12	4	8
	AR	I	I	I	I	I	I
Patient lifting ending point	Waist	5	4	6	4	4	5
	Neck	2	3	3	2	3	3
	Leg	2	5	2	2	5	2
	Shoulder (upper arm)	4	1	4	4	1	4
	Elbow (forearm)	2		3	2		3
	Wrist	2		2	2		3
	Wrist twisting	1		2	1		2
	Load/force	2	2	3	2	3	3
	Handle	3			3		
	Activity	2		1	2		1
	AS	13	4	8	12	4	8
	AR	I	I	I	I	I	I

REVA, Rapid Entire Body Assessment; OWAS, Ovako Working Posture Analysing System; RULA, Rapid Upper Limb Assessment; AS, Assessment Score; AR, Assessment Rating; I, Improve immediately

MRI were analyzed. Individual postures were assessed and scored according to the waist, neck, leg, shoulder, elbow, wrist, wrist twisting, load, handling, and activity, and the assessment ratings were analyzed.

Moving a patient was divided into a starting point and an ending point, and the postures at each point were assessed. At the starting point, in both the case when the radiological technologist was positioned on the right side of the patient and the case when the radiological technologist was positioned on the left side of the patient, the assessment rating was shown to be "improve immediately" (RULA, OWAS, REBA). Therefore, the work of moving patients was shown to impose great burdens on the musculoskeletal system. Burdens on the waist and shoulder were shown to be high, and of all the assessments, the burden on the waist was shown to be the highest (Table 1).

In assessing the posture during mouse handling for MRI, the right hand and left hand were assessed separately. The assessment ratings for both the left and right hands were commonly shown to be "improve soon" (REBA) or "improve immediately" (RULA). The mouse work required for MRI was shown to impose large burdens on the neck, the shoulder, and the wrist (Table 2). The SIs indicated that continuously handling a mouse with the right hand placed the hand in a little in danger and that the level of risk for the left hand was uncertain. In the case of the left hand, work done with severe flexion of the wrist and without any support was shown to be particularly problematic (Table 3). Ultrasonography work postures were assessed after dividing them into three levels, from cases in which the distance between the radiology technologist and patient was the shortest to cases in which the distance was the longest. The assessment ratings for REBA were shown to be "should be improved" and "improve soon" and that for RULA was shown to be "improve immediately". The results showed that when the distance between the radiology technologist and the patient was longer, the burden on the neck and shoulder was greater (Table 4). The apparatus pushing work posture assessed was the radiological technologist's posture when pushing a heavy portable radiation apparatus to move it. The REBA

showed an assessment rating of "should be improved" and the RULA showed an assessment rating of "improve immediately". The load/force burdens were shown to be high (Table 5).

DISCUSSION

This study was conducted to analyze the working postures of radiological technologists so that the results can be utilized for the prevention and treatment of musculoskeletal disorders. In this study, burdens on radiological technologists' waists were shown to be high when they were moving patients for a CT scan. This result is supported by studies indicating that the lower back pain of radiological technologists is closely related to the frequency with which they assist in moving patients[13]. The table for a CT scanner is just wide enough for a patient to lie on and is positioned at a height that is close to the hip joints of the radiological technologists. Therefore, when moving patients, they use force after bending substantially at their waists and stretching their arms out far. As the trunk is bent forward, the load on the lumbar region increases markedly[14]. In addition, since the movements are made in the limited space of the CT scan room and the height of the table is fixed, the radiological

Table 2. Mouse handling work posture

Working Postures	Risk Factor	Right hand		Left hand	
		REBA	RULA	REBA	RULA
Mouse handling	Waist	3	4	3	4
	Neck	3	5	3	5
	Leg	1	1	1	1
	Shoulder (upper arm)	4	4	4	4
	Elbow (forearm)	2	3	2	3
	Wrist	2	3	3	4
	Wrist twisting	1	2	1	2
	Load/force	0	0	0	0
	Handle	1		1	
	Activity	2	1	2	1
	AS	10	8	10	8
	AR	S	I	S	I

REVA, Rapid Entire Body Assessment; OWAS, Ovako Working Posture Analysing System; RULA, Rapid Upper Limb Assessment; AS, Assessment Score; AR, Assessment Rating; I, Improve immediately; S, Improve soon.

Table 3. Mouse handling work posture strain index

Working Posture	Hand Side	Intensity of Exertion	Duration of Exertion (% of Cycle)	Efforts Per Minute	Hand / Wrist Posture	Speed of Work	Duration of Task Per Day (Hours)	SI Score
Mouse handling	Right	3.0	0.5	1.5	1.5	1.5	1.0	5.06 A little dangerous
	Left	3.0	0.5	1.0	2.0	1.0	1.0	3.00 Uncertain

Table 4. Ultrasonography work posture

Working Postures	Risk Factor	Posture 1		Posture 2		Posture 3	
		REBA	RULA	REBA	RULA	REBA	RULA
Posture 1 (Close to the patient)	Waist	2	1	2	1	3	3
	Neck	2	4	2	4	3	6
	Leg	3	1	3	5	3	1
	Shoulder (upper arm)	3	3	3	1	3	3
	Elbow (forearm)	1	2	1	2	2	3
Posture 2 (Middle)	Wrist	1	2	2	2	2	3
	Wrist twisting	1	2	1	2	1	2
	Load/force	0	0	0	0	0	0
	Handle	1	-	1	-	1	-
Posture 3 (Patients with distant)	Activity	1	1	1	1	1	1
	AS	6	8	9	8	10	8
	AR	Should be improved	4. I	4. S	4. I	4. S	4. I

REVA, Rapid Entire Body Assessment; OWAS, Ovako Working Posture Analysing System; RULA, Rapid Upper Limb Assessment; AS, Assessment Score; AR, Assessment Rating; I, Improve immediately; S, Improve soon.

Table 5. Apparatus pushing working posture

Working Posture	Risk Factor	REBA	RULA
Pushing apparatus	Waist	2	2
	Neck	1	1
	Leg	2	2
	Shoulder (upper arm)	2	2
	Elbow (forearm)	2	2
	Wrist	1	1
	Wrist twisting	0	1
	Load/force	2	3
	Handle	0	-
	Activity	1	1
	Assessment score	7	8
	Assessment rating	Should be improved	Improve immediately

technologist cannot take up a position that would distribute his or her weight to the lower extremities. Therefore, these movements can be understood to impose large burdens on the waist. As a measure to prevent the musculoskeletal disorders that can occur when moving patients, making the height of the table that the patient lies on adjustable so that the radiological technologists can also use their lower extremities when moving heavy patients and thereby distribute the force to their lower extremities is recommended. Although there are diverse causes of lower back pain, manual transporting work, such as pushing, pulling, transporting, loading, and unloading, is an important cause[15]. Workers who are to engage in handling heavy objects should be adequately educated and trained in correct methods for lifting heavy objects, methods for lowering, methods for moving, methods for loading, working postures, exercises to prevent lower back pain, and other working methods before they are assigned to work in order to prevent lower back pain[16]. This education and training should also be provided to radiological technologists to prevent lower back pain in them. In addition, habituation to the use of movement assistance systems, such as the easy-trans used when moving from sitting postures on a wheelchair or chair to a bed or when moving from a bed to a wheelchair, can also be a good way to reduce the burden on the waist and lower back.

The assessment of postures during mouse handling for an MRI scan showed that large burdens were imposed on the neck, shoulder, and wrist. Repetitive keyboard entries, continuous movements in fixed postures (static posture), inappropriate working postures, and prolonged periods of work cause pain in the neck, shoulder, elbow, wrist, and fingers, together with health hazards, such as numbness and tingling. Among hospital workers, radiological technologists show a high incidence of VDT syndrome, thereby supporting this study result. Therefore, to prevent not only VDT syndrome[2] but also musculoskeletal disorders, a mouse pad with a wrist rest should be used for the right hand, and a support should be prepared for the left arm.

In the case of ultrasonography working postures, larger burdens on the leg and neck were found when the patient's examination sites were located further away and the radiological technologist's upper extremities and arms were stretched further out. While maintaining a constant pressure, the radiological technologist is required to stretch his upper extremities out far while watching the computer monitor of the ultrasonography equipment. Due to this position, when the patient's examination sites are located further away, the neck and trunk must be twisted further, thereby increasing the burden on the neck. Therefore, the location of both the ultrasonography equipment and the patient should be arranged appropriately, and the computer monitor for the ultrasonography equipment should be situated at an appropriate level. The assessment of working postures when pushing a portable radiation apparatus showed that burdens on the musculoskeletal system increased as the weight of the apparatus being pushed by the radiological technologist increased. Therefore, measures to reduce the weight of portable radiation apparatuses should be sought. Among the radiological technologists in the department of diagnostic radiology, 30.8% reported pain. The largest number of them reported pain in the lower extremity, followed by pain in the shoulder, hand, wrist, waist, neck, and elbow in order of precedence, and a higher ratio of females reported symptoms compared with males[17]. In a study conducted by Lee Jin et al., symptoms appeared most frequently in the shoulder, followed by the waist, neck, and leg/foot in order of precedence, and a slightly higher degree of fatigue was shown. The present study also showed that risks to the shoulder and waist were high, while the risks to the wrist and leg appeared to be highest, as was shown in the study of Lee[13]. Although some differences were shown between the present study and a study conducted by Kim, the differences are considered attributable to the fact that the study conducted by Kim was limited to radiological technologists.

Radiological technologists are stressed due to the high tension of their work, and the muscles, blood vessels, and nerve tissues in their necks, shoulders, arms, hands, waists, legs, and knees are damaged or affected by their hard physical work, such as standing for most of their working hours, repetitive movements including waist flexion, and helping patients to move, together with static motions[4]. Although the musculoskeletal disorders of radiological technologists occur in various regions of their bodies, they occur most frequently in the shoulder and the lumbar region. However, as the issue of occupational safety of radiological technologists has been focused on possible exposure to radiation and defense against radiation exposure, the issue of safety in relation to work-related musculoskeletal disorders has been neglected, and education and interest regarding the prevention of musculoskeletal disorders has been insufficient. Therefore, hospitals need to be educated regarding the concept of musculoskeletal disorders, and this needs to followed by education regarding prevention through use of correct working postures, exercise methods for radiological technologists.

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