J Occup Health 2009; 51: 273–282

Journal of Occupational Health

Field Study

Symptom Prevalence of Musculoskeletal Disorders and the Effects of Prior Acute Injury among Aging Male Steelworkers

Won-Jun CHOI[1], Young-Joong KANG[1], Ji-Young KIM[2] and Sang-Hwan HAN[1]

[1]Department of Occupational & Environmental Medicine, Gachon University Gil Hospital and [2]Seoul National University, Graduate School of Public Health, Korea

Abstract: Symptom Prevalence of Musculoskeletal Disorders and the Effects of Prior Acute Injury among Aging Male Steelworkers: Won-Jun CHOI, *et al.* Department of Occupational & Environmental Medicine, Gachon University Gil Hospital, Korea— **Objectives:** The prevalence of musculoskeletal symptoms and related factors were investigated by a structured questionnaire among male steel workers at a large steel company in Korea including a number of aged employees and workers with prior acute injuries. **Methods:** Of an eligible 2,093 workers, 1,836 responded to the survey. Among 39 job groups, 8 major job groups (1,068 subjects) were selected to evaluate the potential risk factors of musculoskeletal symptoms. **Results:** The prevalence of musculoskeletal symptoms was 19.1% for the upper extremities, 7.6% for the back, and 7.7% for the lower extremities. Regardless of body part, the prevalence was 25.5%. In logistic regression analysis, among workers of 8 major job groups, those who experienced prior acute injuries were more likely to have musculoskeletal symptoms in the same region as that of the injury (for the upper extremities, odds ratio [OR] 2.19, 95% confidence interval [CI] 1.51–3.16; for the back, OR 7.35, 95% CI 4.01–13.48; for the lower extremities, OR 4.20, 95% CI 2.33–7.57), after adjusting for age, duration of employment, and job contents. **Conclusions:** The effect of job contents differed according to the presence of prior acute injury. Among workers with prior injuries, the relationship between job contents and musculoskeletal symptoms was not statistically significant in general. Among workers with no prior injuries, job contents was a significant variable for the musculoskeletal symptoms of the upper extremities and back, after adjusting for age and duration of employment. These findings suggest that prior acute injuries are a potential risk factor for musculoskeletal disorders in the workforce. More detailed and specific strategies for managing musculoskeletal disorders including prevention of musculoskeletal injuries is needed.
(J Occup Health 2009; 51: 273–282)

Key words: Aging, Injury, Musculoskeletal symptoms, Steelworkers

The burden of musculoskeletal disorders is increasing for society. The prevention and management of musculoskeletal disorders are priorities for national health care in a number of countries[1, 2]. Musculoskeletal disorders are one of the most important medical issues in Korea. According to a Korea Occupational Safety and Health Agency (KOSHA) report in 2005, 9,114 employees in Korea received workers' compensation due to occupational illness or work-related disorders. Among these, 6,223 cases (68.3%) were work-related musculoskeletal disorders including 3,612 cases of accident-related back pain[3].

Work-related musculoskeletal disorders (WMSDs) refer to diseases that occur in connection with muscles, tendons, and nerves[4]. Work factors, such as repetitive tasks, awkward posture, heavy physical work, and vibration are known as risk factors for musculoskeletal disorders in the workforce. In addition, individual factors, such as age, gender, smoking habit, and psychosocial factors, are also known to play an important role[5].

Several of the known risk factors of musculoskeletal disorders, e.g., repetitive work, force exertion, and awkward posture, exist in steel manufacturing operations. However, it is not easy to assess these factors using ergonomic evaluation tools since the steel manufacturing industry has a number of non-typical jobs. As a result, studies of musculoskeletal disorders among steel manufacturing employees are relatively scarce.

As society ages overall, an aging workforce becomes an increasingly important issue for society[6, 7]. There are

Received Oct 22, 2008; Accepted Mar 4, 2009
Published online in J-STAGE Apr 17, 2009
Correspondence to: S.-H. Han, Department of Occupational & Environmental Medicine, Gachon University Gil Hospital, 449 28B-1L, Nonhyundong, Namdonggu, Incheon 405-849, Korea (e-mail: hansh@gachon.ac.kr)

differing conclusions on the impact of age on musculoskeletal disorders. Some argue that musculoskeletal disorder prevalence rates are relatively consistent with age in the active workforce[8, 9]; however the interpretation of the relationship between age and working period calls for careful attention since they are mutually confounded by a strong correlation between the two variables[5]. While age appeared to be an important factor determining musculoskeletal disorders in one study, other studies could not confirm the relationship[10–14]. In studies of the relationship between work factors and WMSDs, individual factors, such as age or gender, are often treated as confounders or effect-modifiers[5].

Meanwhile, most studies about WMSDs usually exclude musculoskeletal symptoms from acute injuries such as accidents. However, as expected longevity increases, the chance of experiencing acute injuries has increased in everyday life. In cases of non-fatal injury, it is likely that people will return to their own work. Hence, it is easy to conjecture that musculoskeletal symptoms due to acute injuries are highly likely to become chronic or recur among employees who are exposed to the risk factors of musculoskeletal disorders.

This study investigated the musculoskeletal symptom prevalence among employees at a steel company in Korea, and examined the impact of the characteristics of the workplace, including the number of aged employees and employees with prior acute injuries, on musculoskeletal symptoms. The present study had the following specific objectives; (a) to report the symptom prevalence of musculoskeletal disorders in a large scale steel-manufacturing plant in Korea where the work force is getting older, and (b) to clarify the effect of prior acute injury on musculoskeletal symptoms.

Materials and Methods

Subjects

The study enrolled 2,169 employees at a large steel company in Korea, where 2,093 workers (97.3%) were male production employees. The workers worked 3 shifts at 4 groups in fourteen plants. Of the total, 1,998 employees (95.5%) responded to the survey, from which 162 cases were excluded due to incomplete information. The final number of research subjects was 1,836, a response rate of 87.7%.

The job contents of the research subjects were categorized into 39 groups according to the steel manufacturing process. Among these 39 job contents, we selected the following eight groups as major job contents: rolling, general technology, casting, operation, crane, dissolution, machine maintenance, and electronics maintenance. These eight job contents constitute the main framework of the steel manufacturing process. Tasks of workers in the selected eight major job contents were relatively similar within each group. There were certain ergonomic risk factors for musculoskeletal disorders in these job contents such as awkward posture, repetition or excessive force. Other job contents consisted of quite heterogeneous tasks within each group. Thus the authors judged that the effect of job contents on musculoskeletal symptoms could not be logically explained. In addition, there were more than 110 workers in each of the 8 selected job contents(range from 113 to 189, Table 1), thus significant results could be produced by statistical models, whereas subjects numbers in the other 31 job contents were too small to bring statistical power to the 'job contents' variable(range from 1 to 75, not expressed in tables). Among the research subjects, 1,068 (58.2%) belonged to the eight major job groups.

Research methods

The demographic characteristics, duration of employment, department and job contents, prior injury presence and injury sites, and musculoskeletal symptoms (pain, ache, discomfort, or numbness) during the past 12 mo of the research subjects were surveyed using a structured questionnaire with informed consent. The questionnaire used in this study was the standard questionnaire for studying prevalence of musculoskeletal symptoms, which was developed by the Korea Occupational Safety and Health Agency (KOSHA)[15]. The standard questionnaire classifies workers who have musculoskeletal symptoms using the frequency, duration and severity of symptoms. The questionnaire was distributed in the period of national ergonomic evaluation. The period of investigation was from June 28, 2007 to July 6, 2007 (7 days excluding weekend). In that period, three trained investigators got informed consent from the subjects, and asked them to fill out the questionnaire by themselves within a day. Questionnaires were collected on the very next day.

The respondents were asked to answer questions about the frequency, duration, and severity of the musculoskeletal symptoms that they had experienced during the past 12 mo by body part (neck, shoulder, elbow/arm, wrist/hand, back, and lower extremities). The case definition of musculoskeletal symptoms is as follows: (i) those who felt musculoskeletal symptoms during the past 12 mo in any body part (ii) the symptom lasted over a week or the symptom was observed more than once a month during the past year. In cases where the respondents complained of symptoms in more than one body part among neck, shoulder, elbow/arm, and wrist/hand, these were classified as musculoskeletal symptoms of the "upper extremities" as a region. The case definition of the present study is similar to that of the National Institute of Occupational Safety and Health (NIOSH)[16, 17]. Although the severity of symptoms could be added to the case definition, the authors judged workers of this company to be generally accustomed to

Table 1. Demographic characteristics of subjects

		N (%)	
Age (N=1,836)	<40	469	(25.5)
	40–49	717	(39.1)
	50–	650	(35.4)
Duration of employment (N=1,836)	<5 yr	361	(19.7)
	5–9 yr	458	(24.9)
	10–14 yr	250	(13.6)
	15–19 yr	227	(12.4)
	20 yr	540	(29.4)
Working hours a day (N=1,836)	less than 8 h	41	(2.2)
	8 to less than 10 h	1,692	(92.2)
	10 to less than 12 h	81	(4.4)
	more than 12 h	22	(1.2)
Subjective intensity of current task* (N=1,836)	Fairly good	377	(20.5)
	Bearable	942	(51.3)
	Slightly hard	385	(21.0)
	Unbearable	132	(7.2)
Prior acute injury (N=1,836)	Yes	643	(35.0)
	No	1193	(65.0)
Regular leisure activities† (N=1,836)	Computer-related	490	(26.7)
	Tennis/badminton/squash	143	(7.8)
	Football/basketball/ski	186	(10.1)
	Musical instrument (piano, violin *etc*.)	33	(1.8)
	Calligraphy	5	(0.3)
	No regular leisure activities	979	(53.3)
Job contents (N=1,068)	Rolling	189	(17.7)
	General technology	139	(13.0)
	Casting	136	(12.7)
	Operation	132	(12.4)
	Crane	123	(11.5)
	Dissolution	121	(11.3)
	Machine maintenance	115	(10.8)
	Electronics maintenance	113	(10.6)

*Average working hours of the past month. †Regular leisure activities were defined as continuous activities over 30 min in a time and twice or more per week.

considerable physical discomfort associated with their tasks, and a severity factor was not used in the case definition.

We asked whether workers had previously experienced injuries before experiencing the current musculoskeletal symptoms. The definition of prior acute injury in this study was any injury of the musculoskeletal system which had occurred in the 2 yr prior to the survey date. Causes of injuries included occupational ones such as a fall or an object hitting a worker in the workplace, and non-occupational ones such as motor accidents or sports activities. These injuries had to precede the subjective symptoms by at least 3 mo in order to exclude symptoms in the acute or subacute phase. Consequently, those who had musculoskeletal symptoms with prior injury in this study had injury of the musculoskeletal system 3 mo prior to the reported symptoms in the case definition of musculoskeletal symptoms. To minimize the recall bias, prior acute injuries were limited to occurrences during the past 2 yr. When a response met the case definition of prior injury, we examined the relevant body part. Based on this, the musculoskeletal symptom prevalence of all

the subjects were investigated by body part, as well as by age, duration of employment, and working department, and the presence and site of a prior injury. Potential risk factors that affected the musculoskeletal symptoms were examined using a sample of 1,068 workers in the eight major work groups.

The study procedure was reviewed and approved by the Ethical Committee of Gachon University Gil Hospital.

Analytical methods

We conducted a frequency analysis according to age, duration of employment, prior injury, and job contents, in order to find the distribution of the employees who complained of musculoskeletal symptoms. We conducted a chi-square test or Mantel-Haenszel chi-square test to compare the musculoskeletal symptom prevalence according to each variable.

To examine the impact of a prior injury on the musculoskeletal symptoms at the same site, logistic regression analysis was implemented with age, duration of employment, injury site, and job contents as explanatory variables, and the presence of musculoskeletal symptoms at the previous injury site as a response variable (Model 1). In model 2, we investigated the impact of age, duration of employment, and job contents on the musculoskeletal symptoms according to whether or not there was an injury. We conducted logistic regression analysis after stratifying the data by injury presence.

For statistical analysis, SAS version 9.13 was used. The statistical significance was tested using a standard *p*-value of 0.05.

Results

Demographic characteristics of subjects

Table 1 presents the distribution of the research subjects by age and duration of employment, along with a history of prior injuries. In the total sample, employees over 50 yr old constituted 35.4%, which is relatively high. There were 540 employees who had a working period longer than 20 yr, which constitutes 29.4% of the total sample. Among 1,068 workers in the eight major job groups, 383 (35.9%) had prior acute injury, and this proportion is similar to that of the total sample.

Musculoskeletal symptom prevalence

The musculoskeletal symptom prevalence by body part was 7.1% for the neck, 12.2% for the shoulder, 5.6% for the elbow/arm, 5.8% for the wrist/hand, 7.6% for the back, and 7.7% for the lower extremities (Table 2). The cases of more than one symptom, either in the neck, shoulder, elbow/arm, or wrist/hand, were classified as having musculoskeletal symptoms of the upper extremities, and 19.1% of the subjects complained of musculoskeletal symptoms in this region. The prevalence of those with symptoms at any site, regardless of the body part, was 25.5%. The proportion of the sample with a single symptom complaint was 15.1%, while 10.5% complained of symptoms at more than one site. That is, cases with symptom at a single site were more frequently observed than the cases with symptoms in multiple areas.

Table 2. Prevalence of musculoskeletal symptoms (N=1,836)

	N (%)
Specific body region	
Upper extremities	350 (19.1)
Neck	131 (7.1)
Shoulder	223 (12.2)
Elbow/arm	102 (5.6)
Wrist/hand	106 (5.8)
Back	140 (7.6)
Lower extremities	141 (7.7)
Positive symptom at least 1 body region	469 (25.5)

Table 3 presents musculoskeletal symptom prevalence by body part according to the age, duration of employment, injury presence, and job contents of the subjects. In a univariate analysis, the musculoskeletal symptom prevalence of the back decreased as age increased (p=0.003). The musculoskeletal symptom prevalence of the upper extremities and lower extremities did not show a statistical significance according to age. The musculoskeletal symptom prevalence by body part did not show a statistically significant difference among different durations of employment. In cases of prior injury, the musculoskeletal symptom prevalence was significantly higher than in cases of no injury in any of the upper extremities, back, and lower extremities. The musculoskeletal symptom prevalence in a sample restricted to the eight major job groups was 3.6–27.2%. Upper extremities and back showed a significant difference between different jobs (p=0.01, 0.06, respectively), while lower extremities did not show a statistically significant difference between different jobs (p=0.16).

Logistic regression

We conducted a logistic regression analysis on a sample of employees from the eight major job groups, using age, duration of employment, injury presence, and job contents as independent variables and the musculoskeletal symptoms around the injured site as a dependent variable (Table 4). The age and duration of employment showed a significant positive correlation. The age was regarded as a continuous variable, while the duration of employment was treated as a categorical variable. The neck and shoulders were combined after deciding that the distinction between the two parts was ambiguous.

Table 3. Prevalence of musculoskeletal symptoms by age, duration of employment, prior acute injury and contents of job (N=1,836)

	Upper extremity		Back		Lower extremity	
	n	%	n	%	n	%
Age						
<40	97	20.7	50	10.7	35	7.5
40–49	137	19.1	52	7.3	47	6.6
50–	116	17.9	38	5.9	59	9.1
p for trend*	0.23		0.003		0.25	
Duration of employment						
<5	77	20.9	20	10.5	22	11.5
5–9	68	13.7	20	7.6	15	5.7
10–14	59	27.8	13	8.6	15	9.9
15–19	37	19.1	15	11.0	7	5.2
20–	109	20.5	25	7.7	26	8.0
p for trend*	0.40		0.67		0.29	
Prior injury at the same region†						
Yes	112	34.3	37	29.8	36	18.8
No	238	15.8	103	6.0	105	6.4
p-value‡	<0.0001		<0.0001		<0.0001	
Job contents (n=1,068)						
Rolling	38	20.1	11	5.8	12	6.4
General technology	13	9.4	6	4.3	5	3.6
Casting	37	27.2	17	12.5	10	7.4
Operation	27	20.5	15	11.4	14	10.6
Crane	27	22.0	17	13.8	14	11.4
Dissolution	28	23.1	10	8.3	11	9.1
Machine maintenance	26	22.6	9	7.8	13	11.3
Electronics maintenance	15	13.3	8	7.1	6	5.3
p-value‡	0.01		0.06		0.16	

*Mantel-Haenszel Chi-square test. †Subjects who had prior injury at the same body regions of musculoskeletal symptoms: upper extremity 327, low back 124, lower extremity 192. ‡Chi-square test.

There was no significant relationship between age and musculoskeletal symptoms in the upper extremity and back. On the other hand, a small but significant relationship was found in the lower extremity (odds ratio [OR]=1.04, 95% confidence interval [CI]=1.01–1.08). There was no statistically significant relationship between the duration of employment and musculoskeletal symptoms. After adjusting for age, duration of employment, and job contents, it turned out that a prior injury had a significant impact on the musculoskeletal symptoms at the same site. There was a significant relationship between musculoskeletal symptoms of the upper extremities and prior injuries of the upper extremities (OR=2.19, 95% CI=1.51–3.16). Results of other specific regions in the upper extremity were quite similar (omitted from Table 4). Meanwhile, an injury in the back or lower extremities did not show a significant relationship with musculoskeletal symptoms of the upper extremities. By the same method, OR was calculated as 7.35 for the back (95% CI=4.01–13.48), and 4.20 for the lower extremities (95% CI=2.33–7.57), while injuries in other body parts did not show significant relationships, except upper extremity injuries for back pain (OR=1.89, 95% CI=1.08–3.31). Although there was statistical significance, the magnitude was relatively small and the upper limit was below that of the lower limit for back injury. This result might be partly explained if symptoms of the upper back or scapular region were confused with back symptoms. The effect of job contents showed overall statistical significance in the upper extremity, except electronics maintenance. For the back, three job contents (casting, operation and crane) showed statistical significance, but the 95% confidence intervals were relatively wide. For the lower extremity, only machine maintenance showed statistical significance (OR=3.11, 95% CI=1.01–9.52).

Table 4. Logistic model derived odds ratios for musculoskeletal symptoms by the region of prior injury (N=1,068)

	Musculoskeletal symptoms		
	Upper extremity	Back	Lower extremity
	Odds ratio (95% CI*)	Odds ratio (95% CI)	Odds ratio (95% CI)
Age†	1.0 (0.97, 1.03)	0.99 (0.95, 1.02)	**1.04** (1.01, 1.08)
Duration of employment			
<5	1.0	1.0	1.0
5–9	0.64 (0.37, 1.12)	0.83 (0.40, 1.73)	0.37 (0.17, 0.78)
10–14	1.26 (0.74, 2.15)	0.80 (0.36, 1.75)	0.73 (0.35, 1.53)
15–19	0.84 (0.46, 1.52)	1.14 (0.52, 2.49)	0.31 (0.12, 0.78)
20–	0.96 (0.53, 1.74)	0.72 (0.31, 1.63)	0.35 (0.16, 0.76)
Body region of prior injury			
No prior injury	1.0	1.0	1.0
Upper extremity	**2.19** (1.51, 3.16)	**1.89** (1.08, 3.31)	1.57 (0.87, 2.86)
Back	0.78 (0.39, 1.54)	**7.35** (4.01, 13.48)	1.38 (0.55, 3.45)
Lower extremity	0.88 (0.50, 1.54)	1.16 (0.52, 2.58)	**4.20** (2.33, 7.57)
Job contents			
General technology	1.0	1.0	1.0
Rolling	**2.25** (1.10, 4.61)	1.73 (0.58, 5.14)	1.48 (0.48, 4.54)
Casting	**3.14** (1.53, 6.42)	**3.36** (1.21, 9.34)	1.82 (0.58, 5.72)
Operation	**2.32** (1.10, 4.92)	**3.75** (1.32, 10.64)	2.25 (0.74, 6.86)
Crane	**2.50** (1.15, 5.43)	**5.78** (2.00, 17.01)	3.00 (0.95, 9.36)
Dissolution	**2.45** (1.18, 5.09)	2.41 (0.82, 7.13)	2.69 (0.88, 8.26)
Machine maintenance	**2.32** (1.09, 4.96)	2.21 (0.71, 6.85)	**3.11** (1.01, 9.52)
Electronics maintenance	1.27 (0.56, 2.91)	2.27 (0.71, 7.26)	1.47 (0.41, 5.25)

*95% confidence interval. †Age is treated as a continuous variable.

After stratifying the research subjects according to the occurrence of a prior injury, we conducted a logistic regression model, which showed no statistically significant difference by age or duration of employment in any of the upper extremities, back, or lower extremities (Table 5). A complaint of musculoskeletal symptoms according to job contents showed a different pattern with prior injury occurrence. It turned out that the musculoskeletal symptoms of the upper extremities were not significantly affected by work types except for casting. On the other hand, in the case of no prior injury, tasks such as rolling (OR=2.80, 95% CI=1.21–6.44), casting (OR=2.55, 95% CI=1.07–6.07), operation (OR=3.14, 95% CI=1.33–7.44), crane (OR=3.75, 95% CI=1.53–9.20), and machine maintenance (OR=2.53, 95% CI=1.04–6.17), turned out to have a significant impact on the musculoskeletal symptoms of the upper extremities. In cases of prior back injuries, none of the work types except for machine maintenance had a significant impact on musculoskeletal symptoms in the back. In cases of no prior back injuries, tasks such as casting (OR=3.40, 95% CI=1.12–10.32), operation (OR=3.47, 95% CI=1.11–10.84), and crane (OR=6.36, 95% CI=2.01–20.15) turned out to have a significant impact on the musculoskeletal symptoms of the back. As for the lower extremities, job contents did not show any significance in its relationship with musculoskeletal symptoms of the lower extremities regardless of the presence or absence of prior injury.

Discussion

In this study, we investigated the musculoskeletal symptom prevalence in a sample of employees at a large steel company in Korea, and examined the factors that affected musculoskeletal symptom complaints. The musculoskeletal symptoms were highest in the shoulder area at 12.2%, followed by lower extremities 7.7%, back 7.6%, neck 7.1%, wrist/hand 5.8%, and elbow/arm 5.6%. The percentage of complaints of musculoskeletal symptoms of the upper extremities was 19.1%, which is larger than that of the back (7.6%) or lower extremities (7.7%). When we did not categorize the symptoms by body parts, the percentage of employees who complained about musculoskeletal symptoms at one or more sites was

Table 5. Effects of job contents on MSD symptoms by body region (N=1,068)

Body regions	Job contents	No prior injury in the region	Prior injury in the region
		Odds ratio* (95% CI)	Odds ratio (95% CI)
Upper extremities	General technology	1.00	1.00
	Rolling	**2.80** (1.21, 6.44)	0.97 (0.22, 4.30)
	Casting	**2.55** (1.07, 6.07)	**6.38** (1.56, 26.08)
	Operation	**3.14** (1.33, 7.44)	0.76 (0.16, 3.72)
	Crane	**3.75** (1.53, 9.20)	0.47 (0.08, 2.70)
	Dissolution	2.01 (0.85, 4.75)	3.29 (0.82, 13.11)
	Machine maintenance	**2.53** (1.04, 6.17)	1.52 (0.37, 6.17)
	Electronics maintenance	1.32 (0.48, 3.63)	1.12 (0.25, 5.08)
Back	General technology	1.00	1.00
	Rolling	1.23 (0.36, 4.22)	6.13 (0.49, 77.01)
	Casting	**3.40** (1.12, 10.32)	6.19 (0.54, 70.97)
	Operation	**3.47** (1.11, 10.84)	6.03 (0.49, 74.64)
	Crane	**6.36** (2.01, 20.15)	2.50 (0.10, 61.06)
	Dissolution	1.80 (0.56, 5.82)	9.30 (0.58, 150.05)
	Machine maintenance	0.93 (0.21, 4.44)	**21.33** (1.54, 296.19)
	Electronics maintenance	1.94 (0.54, 6.89)	6.42 (0.36, 115.35)
Lower extremities	General technology	1.00	1.00
	Rolling	0.93 (0.25, 3.44)	7.99 (0.62, 102.54)
	Casting	1.57 (0.43, 5.70)	4.65 (0.36, 60.56)
	Operation	1.98 (0.56, 6.98)	4.93 (0.41, 59.07)
	Crane	3.41 (0.98, 11.85)	1.26 (0.06, 26.36)
	Dissolution	2.32 (0.68, 7.89)	7.82 (0.44, 138.88)
	Machine maintenance	2.80 (0.79, 9.89)	7.73 (0.65, 92.45)
	Electronics maintenance	1.63 (0.40, 6.59)	1.49 (0.07, 30.43)

*Logistic regression analysis, adjusted for age and duration of employment.

as high as 25.5%. A history of prior acute injury showed a significant relationship with musculoskeletal symptoms. In cases of no prior acute injury, the job contents showed a significant relationship with musculoskeletal symptoms.

Roquelaure *et al*., conducted a clinical diagnosis and epidemiological study of the musculoskeletal disorders of the upper extremities among a sample of employees in France, and reported that the prevalence rate of musculoskeletal disorders of the upper extremities among male employees in steel manufacturing was 14.8%, which was the second highest following automobile manufacturing (20.0%)[18]. Moussavi-Najarkola *et al*. examined the upper extremities in terms of musculoskeletal symptoms and diseases among the employees of a steel company in Tehran who were exposed to high force exertion, repetition, and awkward postures, using a standardized Nordic Musculoskeletal Questionnaire and clinical examinations. According to their results, the symptom prevalence was 66–88% and disease prevalence was 5.4–18.7%[19]. No study on musculoskeletal disorders among steel industry employees has so far been conducted in Korea. There is a report that employees with repetitive tasks, such as those found in automobile manufacturing or assembly of electronic components, have symptoms in the neck and shoulder area most frequently, followed by symptoms in the wrist and hand, and elbow and arm. However, the symptom prevalence differs across many studies, according to the evaluation method and case definition of subjective symptoms[20–22]. Han *et al*., who conducted physical examinations and electrophysiological tests on shipyard workers, reported a musculoskeletal disorders prevalence of 29%. According to their study, unlike other manufacturers, shipyard workers are exposed to work tasks that are not standardized, and the ergonomic risk factors, such as awkward posture and high force exertion, play important roles in the development of musculoskeletal symptoms[22].

There are not many studies that have examined the impact of prior injuries on musculoskeletal symptoms. Forde *et al*. investigated the musculoskeletal symptom prevalence in a sample of current and retired construction

workers and reported that the odds ratio of complaints of musculoskeletal symptoms of the upper extremities was 4.6 (95% CI=3.1–6.8), for the back, 6.0 (95% CI=4.2–8.6), and for the lower extremities, 4.9 (95% CI=3.4–7.1) in cases of prior injury[23]. In our study, prior injury sites showed a statistically significant relationship with sites of musculoskeletal symptoms. In many studies on work-related musculoskeletal disorders, cases of previous accidents or injuries were excluded from the research because of low relevance with work. However, Welch *et al*. reported that musculoskeletal injuries often leave chronic symptoms even after treatment, especially among aged employees for whom the symptoms last much longer[24]. In that study, cases where the work conditions were appropriately modified, afterwards, were as low as 25% despite the presence of chronic symptoms after musculoskeletal injuries. Moreover, there is a report that about 40% of employees that have experienced musculoskeletal disorders or accidents actually experienced reinjury after a return to work[25]. Employees can suffer when the musculoskeletal symptoms continue, since they are constantly exposed to ergonomic risk factors after injury. Considering that an epidemiological study of musculoskeletal disorders would provide a surveillance tool for problem solving, we believe that musculoskeletal symptoms due to accidents or injuries should be included in analyses.

In cases of prior acute injuries, the relationship between job contents and musculoskeletal symptoms was not significant overall. On the other hand, in cases of no prior acute injuries, in the upper extremities and back, a significant relationship was observed between several job contents and musculoskeletal symptoms. This is similar to the results of Forde *et al*., who reported that among construction workers, the work type does not show a significant relationship with musculoskeletal symptoms in cases of prior injury, while it shows significant relationship in cases of no prior injury in the upper extremities and back[23]. According to these results, the relationship between musculoskeletal symptoms and job contents, which reflect ergonomic stressors, is not statistically significant for those who have received prior injuries. The authors suggest workers who have received prior injuries should be treated appropriately and have enough rest or rehabilitation before returning to work to reduce residual symptoms, if ergonomic risk factors exist in the workplace. On the other hand, more attention should be paid adjusting working conditions, including job contents or ergonomic stressor, for those who complain of musculoskeletal symptoms irrespective the history of significant physical injuries. This means that we should apply different intervention strategies for reducing musculoskeletal disorders and relevant symptoms. In addition, prevention of occupational injury in the workplace should be emphasized as a part of management of musculoskeletal disorders. The number of WMSDs in the back and lower extremity was too small (3.6–13.8%) to obtain reliable outcomes using a logistic regression model.

Job contents are closely related to ergonomic factors, which is one of the important risk factors for musculoskeletal symptoms. Repetition, awkward posture, high force exertion, vibration, and their combined impacts are known as the risk factors of musculoskeletal disorders. The steel industry has very diverse work types requiring workers to be able to perform various tasks occasionally. Moreover, tasks in different departments are often common. Hence, we could not conduct an ergonomic assessment using a sample containing all the employees in this study. Considering that the variation in ergonomic risk factors among employees in the eight major job groups was not large within the same department, and that the variation was large between different departments, we assessed the ergonomic risk factors for some of the workers. The selected ergonomic evaluation methods were rapid upper limb assessment (RULA), rapid entire body assessment (REBA), and the Ovako working-posture analysis system (OWAS). In the casting process, awkward posture and high force exertion often affected the upper extremities, such as the shoulder, elbow, and wrist, as the workers used long and heavy equipment while collecting samples to measure the temperature of molten iron. In crane work, it was often observed that the employees worked in a fixed posture with an excessively bent neck and back for long periods. There were at least one or more ergonomic risk factors for musculoskeletal disorder of the upper extremity including the neck in all eight major job groups, for which RULA scores exceeded 5, that is grade 3 or 4. If risk factors for back disorder such as lifting or heavy physical work were present, the REBA score exceeded 8, that is grade 3 or 4, which also means high or very high risk. There is little evidence that ergonomic risk factors for the lower extremity were as many as those for the upper extremity or back. These results help to explain the relationship between job contents and musculoskeletal symptoms. Table 4 shows that most of the eight major job groups had significant relationships with musculoskeletal symptoms of the upper extremity but not with the lower extremity (Table 4). Unfortunately, as the ergonomic evaluation was conducted as part of the national regular evaluation, we could not get entire ergonomic information about the selected eight major job groups. Even with a semi-quantitative evaluation with a sample subset of employees, the evaluation result confirms that the dominant ergonomic risk factors varied with the type of task. Such findings support the argument that work type can play a significant role as a risk factor in musculoskeletal symptoms, and this helps explain why symptoms occur in different body parts according to

different job contents[26–28]. Hence, we can say that an effective way to improve the working environment is to consider the work type-specific factors, i.e., ergonomic risk factors.

Psychosocial factors such as job stress seemed to be related to the musculoskeletal disorders. The mechanism may be explained by strain due to job stress becoming a symptom of the musculoskeletal system, or the recovery of inflammation being interrupted by, or the pain threshold being reduced by[5, 29, 30]. Unfortunately, we couldn't find anything in the literature about the relationship between workers with prior injuries and their psychosocial backgrounds. Although the authors fully understand that psychosocial and basic lifestyle factors are important in studies of musculoskeletal disorders, we paid much more attention to other factors such as prior injury to concentrate on the main interest of this study.

In a univariate analysis, age did not show a significant relationship with musculoskeletal symptoms of the upper or lower extremities. However, in cases of back problems, complaints of musculoskeletal symptoms became more frequent as age increased. A study examining work-related musculoskeletal symptoms among active union carpenters showed that the higher the age, the less frequent the prevalence of back disorders, which connotes a possible healthy worker effect[17]. That is, we would interpret this phenomenon as one where those with back musculoskeletal symptoms are transferred to other departments with less ergonomic stress, and as a result, the musculoskeletal symptom prevalence decreased. In our study, a positive correlation between age and duration of employment was proven, while there was no significant relationship between duration of employment and musculoskeletal symptom prevalence in the back. In our study, no significant relationship was found in a univariate analysis between age or duration of employment and musculoskeletal symptoms. However, since age is considered a meaningful biological factor and the duration of employment has been confirmed as a risk factor or effect modifier in prior studies, we adjusted for the age and duration of employment in our final model[17]. According to one follow-up study on the occurrence of musculoskeletal disorders in a sample of 253 employees at a large shoe factory, a larger company is less likely to be affected by the healthy worker effect, since their working population is relatively stable[31].

This study has some limitations. First, since this is a cross-sectional study, it is hard to clarify the temporal relationship between risk factors and musculoskeletal symptoms. Moreover, there is the problem of potential selection bias. Out of all the male employees, 91.1% were included in the final study, showing a high response rate. Even if the possibility of early retirement or work transfer is low, we cannot completely ignore the possibility of selection bias. Prospective studies, such as cohort studies, along with further studies that adjust for severity of injury are required in the future. A second limitation is that since we collected information regarding prior acute injury through a questionnaire, information bias (recall bias) is possible. However, in cases of minor injuries, we consider that adding hospital data would not alter the results much from those of the questionnaire; thus, we consider that there was minimal differential bias, if any, in this study. A third limitation is that, subjects who had symptoms in the back and lower extremity were too small in number to generate reliable outcomes. Although the authors expect the outcome would be similar with that of upper extremity, further studies with a larger number of participants with symptoms in the back and lower extremity will be needed. Another limitation is that, socio-psychological factors, such as job stress, were not measured. We surmise that the relationship between work type and musculoskeletal symptoms would be affected by variables other than ergonomic risk factors. However, considering the ergonomic assessment results of some of the workers, it is more appropriate to interpret the ergonomic factors as risk factors, rather than as confounding variables.

This study investigated the musculoskeletal symptom prevalence of a sample of about 2,000 employees at a large steel company, and examined the factors that affected the musculoskeletal symptoms of 1,068 employees working in eight major job groups in the company. The musculoskeletal symptom prevalence was especially high in the upper extremities, and prior acute injuries had a significant impact on musculoskeletal symptoms. In cases of no prior acute injuries, the job contents turned out to be a significant risk factor that determined musculoskeletal symptoms, implying that it is important to investigate whether or not a research subject has experienced a prior acute injury when conducting an epidemiologic study about musculoskeletal disorders. We expect that a more detailed and specific strategy for managing musculoskeletal disorders can be established, if additional studies confirm that the impact of prior acute injuries varies with the body part or job contents.

References

1) Woolf AD, Akesso K. Understanding the burden of musculoskeletal conditions. BMJ 2001; 322: 1079–80.
2) Spielholz P, Silverstein B, Morgan M, Checkoway H, Kaufman J. Comparison of self-report, video observation and direct measurement methods for upper extremity musculoskeletal disorder physical risk factors. Ergonomics 2001; 44: 588–613.
3) Korea Occupational Safety and Health Agency. Analysis of Occupational Accidents, 2006. [Online]. 2007 [cited 2008 Oct 13]; Available from: URL: http://www.kosha.net/shdb/statistics/main.jsp
4) Hagberg M. WMSDs: Conceptual framework. In:

Kuorinka I, Forcier L, editors. Work related musculoskeletal disorders (WMSDs): A reference book for prevention. London: Tayler & Francis; 1995. p. 5–16.
5) National Institute of Occupational Safety and Health. Musculoskeletal disorders and workplace factors: A critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back. Cincinnati (OH): NIOSH; 1997.
6) Zuhosky JP, Irwin RW, Sable AW, Sullivan WJ, Panagos A, Foye PM. Industrial medicine and acute musculoskeletal rehabilitation —7. Acute industrial musculoskeletal injuries in the aging workforce—. Arch Phys Med Rehabil 2007; 88 (Suppl 1): S34–9.
7) Silverstein M. Meeting the challenges of an aging workforce. Am J Ind Med 2008; 51: 269–80.
8) Guo HR, Tanaka S, Cameron LL, et al. Back pain among workers in the United States: National estimates and workers at high risk. Am J Ind Med 1995; 28: 591–602.
9) Chaffin DB. Manual materials handling the cause of overexertion injury and illness in industry. J Environ Pathol Toxicol 1979; 2: 67–73.
10) English CJ, Maclaren WM, Court-Brown C, Hughes SPF, Porter RW, Wallace WA. Relations between upper limb soft tissue disorders and repetitive movements at work. Am J Ind Med 1995; 27: 75–90.
11) Ohlsson K, Hansson HA, Balogh I, et al. Disorders of the neck and upper limbs in women in the fish processing industry. Occup Environ Med 1994; 51: 826–32.
12) Toomingas A, Hagberg M, Jorulf L, Nilsson T, Burstrom L, Kihlberg S. Outcome of the abduction external rotation test among manual and office workers. Am J Ind Med 1991; 19: 215–27.
13) Punnett L, Robins JM, Wegman DH, Keyserling WM. Soft-tissue disorders in the upper limbs of female assembly workers: Impact of length of employment, work pace, and selection. Scand J Work Environ Health 1985; 11: 417–25.
14) Torrell G, Sanden A, Jarvholm B. Musculoskeletal disorders in shipyard workers. J Soc Occup Med 1988; 38: 109–12.
15) Korea Occupational Safety and Health Agency. Questionnaire for musculoskeletal symptoms. In: Park DY, editor. Guideline for evaluation of risk factors for musculoskeletal disorders. Incheon (Korea): KOSHA; 2003. p.A10–11.
16) Bernard B, Sauter S, Fine L, et al. Job task and psychosocial risk factors for work-related musculoskeletal disorders among newspaper employees. Scand J Work Environ Health 1994; 20: 417–26.
17) Lemasters GK, Atterbury MR, Booth-Jones AD, et al. Prevalence of work related musculoskeletal disorders in active union carpenters. Occup Environ Med 1998; 55: 421–7.
18) Roquelaure Y, Ha C, Leclerc A, et al. Epidemiologic surveillance of upper-extremity musculoskeletal disorders in the working population. Arthritis Rheum 2006; 55: 765–78.
19) Moussavi-Najarkola SA, Khavanin A. Work related musculoskeletal disorders of the upper limbs among steel industry populations. Acta Medica Iranica 2007; 45: 405–14.
20) Yoon CS, Lee SH. Symptom prevalence and related factors of upper limb musculoskeletal symptoms in automobile related job workers. Kor J Occup Environ Med 1999; 11: 439–48 (in Korean).
21) Kim JY, Choi JW, Kim HJ. The relation between work-related musculoskeletal symptoms and rapid upper limb assessment (RULA) among vehicle assembly workers. J Prev Med Public Health 1999; 32: 48–59 (in Korean).
22) Han SH, Paik NJ, Park DH, et al. Cumulative trauma disorders among shipyard workers and application of baseline checklist for risk assessment. Kor J Occp Environ Med 1997; 9: 579–88 (in Korean).
23) Forde MS, Punnett L, Wegman DH. Prevalence of musculoskeletal disorders in union ironworkers. J Occup Environ Hyg 2005; 2: 203–12.
24) Welch LS, Hunting KL, Nessel-Stephens L. Chronic symptoms in construction workers treated for musculoskeletal injuries. Am J Ind Med 1999; 36: 532–40.
25) Pransky G, Benjamin K, Hill-Fotouhi C, et al. Outcomes in work-related upper extremity and low back injuries: Results of a retrospective study. Am J Ind Med 2000; 37: 400–9.
26) van Vuuren BJ, Becker PJ, van Heerden HJ, Zinzen E, Meeusen R. Lower back problems and occupational risk factors in a South African steel industry. Am J Ind Med 2005; 47: 451–7.
27) Hildebrandt VH, Bongers PM, Dul J, van Dijk FJ, Kemper HC. Identification of high-risk groups among maintenance workers in a steel company with respect to musculoskeletal symptoms and workload. Ergonomics 1996; 39: 232–42.
28) Burdorf A, Zondervan H. An epidemiological study of low-back pain in crane operators. Ergonomics 1990; 33: 981–7.
29) Bongers PM, Kompier MAJ, Hidebrandt VH. Psychosocial factors at work and musculoskeletal disese. Scand J Work Environ Health 1993; 19 :297–312.
30) Evanoff BA, Rosenstock L. Psychophysiologic stressors and work organization. In: Rosenstock L, Cullen MR, editors. Textbook of clinical occupational and environmental medicine. Tokyo: WB Saunders Company; 1994. p.717–28.
31) Roquelaure Y, Mariel J, Fanello S, et al. Active epidemiological surveillance of musculoskeletal disorders in a shoe factory. Occup Environ Med 2002; 59: 452–8.