applied sciences

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A Cross-Sectional Descriptive Study of Musculoskeletal Disorders (MSDs) of Male Shipbuilding Workers and Factors Associated the Neck, Shoulder, Elbow, Low Back, or Knee MSDs

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Abstract: This study investigates the cross-sectional descriptive characteristics of male shipbuilding workers' musculoskeletal disorders (MSDs) and factors associated with MSDs in the neck, shoulders, elbows, low back, or knees. From the national compensation data confirmed as MSDs during three years between 2015 and 2017, 985 male workers were analyzed in terms of age, work experience, occupations, company size, and MSD type according to each body region. In the analysis of frequency and severity according to 'occupation–body region–MSD type', 'Electrician/plumber–low back–herniated disc' (6.9%) was the form of MSDs with the highest frequency among total MSDs, and 'Crane–neck–herniated disc' (500.5 days) was the highest mean of sick leave days. The low back MSDs (28.9%) were the highest frequency, followed by shoulders (27.7%) and knees (16.2%). The herniated disc was frequent in the neck and lumbar region, and the mean of sick leave days of the neck herniated disc (402.2 days) was greater than that of the low back herniated disc (321.1 days). While a rupture was frequent in the shoulder or knee region, the mean of sick leave days for shoulder rupture (335.1 days) was greater than that of the knee rupture (318.8 days). In the binary logistic regression analysis, age was positively associated with MSDs in the neck, shoulder, or elbow regions, while the low back MSDs category was not positively associated with age. Large companies with >1000 employees were highly associated with neck MSDs, while small companies with <30 employees were related to the low back MSDs. This study derives the characteristics for frequency and sick leave days of MSDs in the neck, shoulders, elbows, low back, or knees to prioritize MSD prevention information. The results of this study can be used as primary data for establishing MSD prevention policy.

Keywords: shipyard; sick leave days; compensation; logistic regression analysis

Citation: Kim, W.-J.; Park, H.-J.; Jeong, B.-Y. A Cross-Sectional Descriptive Study of Musculoskeletal Disorders (MSDs) of Male Shipbuilding Workers and Factors Associated the Neck, Shoulder, Elbow, Low Back, or Knee MSDs. *Appl. Sci.* **2022**, *12*, 3346. https://doi.org/10.3390/app12073346

Academic Editor: Nicola Magnavita

Received: 22 January 2022
Accepted: 24 March 2022
Published: 25 March 2022

1. Introduction

Musculoskeletal disorders (MSDs) are related to the tendons, muscles, joints, nerves, and circulatory systems that can affect body regions such as the neck, upper limbs, and back [1]. Prevention of MSDs is a major concern for individuals, organizations, and governments because these disorders significantly impact workers' health and productivity [2]. Among the various populations, MSDs are common in shipbuilding workers [3]. Shipyard work is ergonomically hazardous, commonly requiring repetitive handling of heavy or bulky materials, uncomfortable postures, and frequent bending and twisting work [4–6].

Shipbuilding is a complicated business involving construction, mechanical engineering, electrical engineering, naval architecture, and ocean engineering [4,7]. Shipyard work consists of cutting, welding, grinding, painting, outfitting, installing, and testing [8]. Shipyard workers contact various hazards during hectic and strenuous work [7]. They perform a broad range of physical work and spend most of their time standing, walking, bending,

and twisting parts of their body [3]. They often work in uneven ground, confined spaces, heights, and outdoors [5,9]. Previous research on the shipbuilding industry has focused on occupational injuries [4,5,7,10]. Several results have emphasized age, work experience, occupation, and company size as factors of occupational injuries and illnesses [5,7,10,11].

Korea's shipbuilding industry has developed it into a powerful shipbuilding country, but the industry has a lot of occupational injuries and illnesses [5]. In the shipbuilding industry of South Korea in 2015, out of 233,730 workers working at 8438 shipbuilding workplaces, 1940 were confirmed as having accidents by the Industrial Accident Compensation Act [12]. The occupational injury and illness rate of shipbuilding work per 1000 workers was 8.30, which was 1.279 times higher than that of 6.49 in the whole manufacturing industry [12]. In particular, due to the shipbuilding industry's recession in 2017, the number of workers in shipbuilding workshops decreased to 198,328. However, the number of accidents confirmed by the Industrial Accident Compensation Act increased to 1953 [13]. As a result, the accident rate per 1000 persons accounted for 9.85, which was 2035 times higher than that of the whole industry [13]. In the nationwide data confirmed in the shipbuilding industry, 5804 workers were confirmed as having work-related injuries and illnesses during the three years between 2015 and 2017, and 1165 were MSDs [12,13].

MSDs studies can be classified into questionnaire surveys using workers' subjective pain or symptoms and actual MSDs studies using work-related injuries and illnesses compensation data. Studies using actual MSDs based on occupational injuries and illnesses compensation data have limitations in the type of the variable and the number of items because analysis must be performed only within the compensation database [2,5]. Additionally, MSDs that are weaker than the number of sick leaves of compensation criterion (4 days in South Korea) are not included. Therefore, it can be underestimated in the frequency of occurrence.

It is essential to understand the descriptive characteristics of types of MSDs according to occupation to prevent MSDs. However, there is a lack of descriptive studies on MSDs using actual work-related compensation databases in the shipbuilding industry [3,5]. This descriptive study uses cross-sectional MSDs data confirmed in the shipbuilding industry for 3 years. First, this study intends to derive the characteristics of MSDs by type of occupation using actual MSDs data. Additionally, this study attempts to find out the features of sick leave days according to types of occupation.

To effectively prevent MSDs, it is essential to investigate the distribution of MSDs and sick leave days by factors associated with MSDs according to the body region. Occupational injuries in the shipbuilding industry were associated with occupation, age, work experience, and company size [3,5,7]. Second, this study investigates the descriptive characteristics and sick leave days on types of MSDs, occupation, age, work experience, and company size according to the body region of MSDs.

Finally, this study intends to derive which factors are related to MSDs in the specific body region and which conditions of the related factors have a relatively significant effect on the occurrence of MSDs within the particular body region. This study uses a (binary) logistic regression model and odds ratio to obtain the relationships.

2. Materials and Methods

2.1. Data Collection

In the Republic of Korea, employers have to offer workers' compensation insurance under the Industrial Safety and Health Act [2,3,5]. The compensation data for occupational injuries and illnesses were approved by the 'procedure for review of award on workers' compensation insurance eligibility' under the Industrial Safety and Health Act [14]. These compensation data were compiled and maintained by the Ministry of Labor.

According to the national work-related compensation database, 1165 workers were confirmed as work-related MSDs in the shipbuilding industry between 2015 and 2017 [12,13]. Among shipbuilding workers with MSDs, 92.5% were male. Additionally, 28.9% had low back (lumbar) disorders, followed by shoulder disorders (27.7%), knee disorders (16.2%),

neck disorders (11.3%), elbow disorders (7.2%), hand/wrist/finger disorders (5.1%), and leg/ankle/toe disorders (3.5%). MSDs with low back, shoulder, knee, neck, and elbow disorders accounted for more than 90% of MSDs. This study investigates the characteristics of shipbuilding male workers' MSDs, excluding MSDs with hand/wrist/finger or leg/ankle/toe. After excluding females and MSDs with hand/wrist/finger or leg/ankle/toe, 985 MSDs were extracted as study subjects. Among 985 MSDs, the body sites most vulnerable to MSDs were low back (323, 32.8%), followed by the shoulder (298, 30.3%), knee (162, 16.4%), neck (122, 12.4%), and elbow (80, 8.1%). The distributions of 985 MSDs were derived according to occupation, age, MSD type, work experience, company size, and body region.

2.2. Distribution and Severity of MSDs According to Occupation and Body Region

This study investigates the distribution and sick leave of MSDs to understand basic information for prioritizing MSD prevention policies. First, this study attempts to derive the relative frequency and severity of occupation-related MSDs. The occupation-related MSDs is an occupation–body region–MSD type combination representing a set of MSDs having the same occupation and nature of MSDs in the shipbuilding industry. For example, the 'welder–low back–herniated disc' combination is the herniated disc set that occurred in the low back of welders. The relative frequency of each combination is used for the likelihood. The severity of the MSDs was represented by the mean and SD (standard deviation) of sick leave days.

Second, this study describes the distributions of total MSDs and each body region's MSDs, and the mean and SD (standard deviation) of sick leaves according to workers' company size, occupation, age, MSD type, or work experience. The worker's occupation is classified as the main work that the worker performs. Work experience means years of service of workers, and company size represents the number of employees in the company of workers. A Chi-square test was used to compare distributions of total MSDs and each body region's MSDs.

2.3. Logistic Regression Analysis on the Neck, Shoulder, Elbow, Low Back, or Knee MSDs

The binary logistic regression model used the backward stepwise (Wald) method to predict the relationship between a binary outcome variable (1 = specific body region's MSDs, 0 = other regions' MSDs) and the five predictors. This study selected occupation, age, career, company size, and MSD type as predictors [3,5]. The five predictors of occupation, age, MSD type, experience, and company size are all in the form of a nominal scale. In this study, reference was set based on occupation as a welder, age as under 40 years, MSD type as a sprain, work experience as less than one year, and company size as less than 30 employees.

The sample of this study is a group of workers that all had MSDs. There are no subjects that did not have MSDs. The concept of odds of this study is not of getting that injury (compared to no injury) but compared to another injury. Odds relate to a binary outcome where the outcome occurs (1) or does not occur (0). The odds ratio (OR) between the odds of the comparison condition and the odds of reference condition quantifies the relationship between the two conditions. Consequently, the odds ratio indicates the likelihood that MSDs at a specific body site in the comparison condition will occur compared to MSDs at a particular body site in the reference condition. For example, in the case of neck MSDs and occupation, the odds ratio indicates the likelihood that neck MSDs of a specific occupation will occur compared to neck MSDs of the welder (reference occupation).

The binary logistic regression model for specific MSDs forms a model by selecting which factors are associated with the MSDs among the five predictors and indicates whether the conditions of the derived factors have a significant likelihood relationship compared to the reference. Reliability analysis for the binary logistic regression model was performed to confirm the reliability of the independent variable for the dependent variable. The ability of the binary logistic regression model is evaluated with the correct classification table

value. The goodness of fit of a model was assessed through the Hosmer–Lemeshow test, and the explanatory power of the dependent variable was assessed by the Nalgelkerke R^2. The statistics were used to identify the OR and the 95% confidence interval (95% CI). SPSS 18.0 was used for statistical analysis, and a significance level of 0.05 was applied.

3. Results

3.1. Distribution and Sick Leave Days of MSDs According to Occupation–Body Region–MSD Type

Table 1 presents the distribution and sick leave days of the MSDs according to occupation–body region–MSD type. 'Electrician/plumber–low back–herniated disc' (6.9%) was the form of MSDs with the highest frequency among total MSDs, followed by 'welder–low back–herniated disc' (6.4%), 'fitter–shoulder–rupture' (6.3%), and 'electrician/plumber–shoulder–rupture' (6.2%).

Table 1. Distribution and sick leave days of the MSDs according to occupation–body region–MSD type.

Occupation	Body Region	MSD Type	Frequency		Sick Leave Days	
			N	%	Mean	SD
			985	100%	318.9	222.1
Welder	Neck	Herniated disc	18	1.8%	416.6	388.3
	Low back	Herniated disc	63	6.4%	319.7	131.4
	Low back	Sprain	10	1.0%	105.1	60.1
	Knee	Rupture	21	2.1%	397.7	475.5
	Shoulder	Rupture	47	4.8%	365.2	173.1
	Elbow	Sprain	10	1.0%	317.7	106.9
Fitter	Neck	Herniated disc	17	1.7%	307.2	141.0
	Low back	Herniated disc	46	4.7%	305.1	146.5
	Knee	Rupture	32	3.2%	281.1	115.3
	Shoulder	Rupture	62	6.3%	315.7	127.0
	Shoulder	Sprain	12	1.2%	287.5	142.4
Electrician/plumber	Neck	Herniated disc	34	3.5%	404.3	265.3
	Low back	Herniated disc	68	6.9%	314.0	178.1
	Low back	Sprain	21	2.1%	107.8	99.4
	Knee	Rupture	31	3.1%	365.8	274.5
	Shoulder	Rupture	61	6.2%	350.6	209.1
	Shoulder	Sprain	12	1.2%	329.4	163.9
	Elbow	Sprain	22	2.2%	266.7	160.7
Painter	Neck	Herniated disc	13	1.3%	368.1	252.7
	Low back	Herniated disc	17	1.7%	352.0	165.1
	Knee	Rupture	12	1.2%	367.2	166.6
	Shoulder	Rupture	30	3.0%	308.3	105.8
	Elbow	Sprain	12	1.2%	193.5	131.7
Grinding operator	Knee	Rupture	10	1.0%	298.0	175.3
	Shoulder	Rupture	12	1.2%	332.2	157.9
Crane operator	Neck	Herniated disc	19	1.9%	500.5	334.3
	Low back	Herniated disc	12	1.2%	310.8	163.1
Installer	Neck	Herniated disc	15	1.5%	337.4	169.4
	Low back	Herniated disc	46	4.7%	351.1	229.2
	Low back	Sprain	19	1.9%	72.7	44.3
	Knee	Rupture	24	2.4%	252.7	129.8
	Shoulder	Rupture	31	3.1%	301.8	113.9
	Elbow	Sprain	13	1.3%	252.0	104.9

% = N/985, SD = standard deviation, Note: Items with % of less than 1% are ignored.

'Crane–neck–herniated disc' (500.5 days) represents the highest mean work-loss days, followed by 'welder–neck–herniated disc' (416.6 days) and 'electrician/plumber–neck–herniated disc rupture' (404.3 days).

3.2. Distribution and Sick Leave Days of Neck MSDs and Factors Associated Neck MSDs

Table 2 shows the distributions of total MSDs and neck MSDs and the mean and SD (standard deviation) of sick leave days by workers' company size, occupation, age, MSD type, and work experience.

Table 2. Distribution and sick leave days of neck MSDs and factors associated with neck MSDs.

Variable	Total MSDs		Neck MSDs			Sick Leave Days		Logistic Regression on Neck			
	N	*N*/985	*n*	%	*n*/*N*	Mean	SD	OR	[95% CI]		*p*
	985	100%	122	100%	12.4%	402.2	277.5				
Occupation											0.010 *
Welder (Ref)	183	18.6%	18	14.8%	9.8%	416.6	388.3				
Fitter	189	19.2%	17	13.9%	9.0%	307.2	141.0	1.428	0.648	3.149	0.377
Electrician/plumber	259	26.3%	34	27.9%	13.1%	404.3	265.3	1.758	0.885	3.492	0.107
Painter	100	10.2%	13	10.7%	13.0%	368.1	252.7	2.455	0.978	6.162	0.056
Grinding worker	43	4.4%	6	4.9%	14.0%	541.3	283.5	2.973	0.812	10.880	0.100
Crane operator	54	5.5%	19	15.6%	35.2%	500.5	334.3	5.473	2.179	13.745	0.001 *
Installer	157	15.9%	15	12.3%	9.6%	337.4	169.4	1.179	0.527	2.636	0.688
		$\chi^2 = 30.389$, $p < 0.001$ *									
Age (years)											0.001 *
<40 (Ref)	238	24.2%	27	22.1%	11.3%	319.4	197.6				
40–49	267	27.1%	31	25.4%	11.6%	399.3	263.9	1.417	0.773	2.597	0.260
50–59	289	29.3%	46	37.7%	15.9%	450.5	337.3	3.549	1.938	6.497	0.001 *
≥60	191	19.4%	18	14.8%	9.4%	408.2	217.4	2.985	1.371	6.501	0.006 *
		$\chi^2 = 5.250$, $p = 0.154$									
MSD type											
Sprain (Ref)	209	21.2%	0	0%	0.0%						
Herniated disc	380	38.6%	122	100%	32.1%	402.2	277.5				
Rupture	396	40.2%	0	0%	0.0%						
		$\chi^2 = 221.696$, $p < 0.001$ *									
Work experience											
<1 (Ref)	157	15.9%	15	12.3%	9.6%	415.9	385.8				
1–4	154	15.6%	15	12.3%	9.7%	364.1	249.7				
5–9	145	14.7%	24	19.7%	16.6%	310.4	200.1				
10–19	153	15.5%	22	18.0%	14.4%	558.5	316.5				
≥20 (years)	376	38.2%	46	37.7%	12.2%	383.3	238.4				
		$\chi^2 = 5.040$, $p = 0.283$									
Company size											
<30 (Ref)	91	9.2%	7	5.7%	7.7%	483.4	468.8				
30–99	97	9.8%	9	7.4%	9.3%	277.3	117.7				
100–999	175	17.8%	20	16.4%	11.4%	441.5	306.1				
≥1000	622	63.1%	86	70.5%	13.8%	399.6	263.3				
		$\chi^2 = 4.048$, $p = 0.256$									
Constant								0.000			0.993

* $p < 0.05$. Note: N = total number of MSDs; n = number of neck MSDs; % = $n/122$; SD = standard deviation; OR = odds ratio; CI = confidence interval; Ref = reference.

In the case of total MSDs according to occupations, electrician or plumber workers were most prevalent (259, 26.3%), followed by fitters (189, 19.2%), welders (183, 18.6%), installers (157, 15.9%), and painters (100, 10.2%). There was a significant difference in frequency distributions between neck MSDs and the other MSDs ($\chi^2 = 30.389$, $p < 0.001$). The ratio of neck MSDs was the highest in the crane operator (35.2%), followed by grinding workers (14.0%). The mean of sick leave days for neck MSDs was the highest in grinding workers (541.3 days), followed by crane operators (500.5 days). The crane operator and grinding worker had a small share of total MSDs, but the incidence of neck MSDs and the mean of sick leave days were high.

In the case of total MSDs according to worker's age, workers in their 50s had a large portion (29.3%), followed by 40s (27.1%). The ratio of neck MSDs was the highest in workers in their 50s (15.9%). According to age, there was no difference in frequency distributions between neck MSDs and the other MSDs ($\chi^2 = 5.250$, $p = 0.154$). The mean of sick leave days for neck MSDs was the highest in workers in their 50s (450.5 days), followed by workers in ≥60 (408.2 days). In their 50s, the overall share of MSDs and the incidence of neck MSDs were high, and the average number of sick leave days was also high.

In the case of total MSDs according to MSD type, a rupture was the most prevalent type of injury (40.2%), followed by a herniated disc (38.6%) and sprain (21.2%). There was a significant difference in frequency distributions between neck MSDs and the other MSDs according to MSD type (χ^2 = 221.696, $p < 0.001$). The neck MSDs only experienced herniated disc, and the mean of sick leave days was 402.2 days.

In the case of total MSDs according to the worker's work experience, workers with ≥20 years of work experience had a large portion (38.2%). There was no difference in frequency distributions between neck MSDs and the other MSDs according to work experience (χ^2 = 5.040, p = 0.283). The mean of sick leave days for neck MSDs was the highest in workers with 10–19 years of work experience (558.5 days).

In the case of total MSDs according to company size, companies with ≥1000 workers were the most frequent (63.1%), followed by companies with 100–999 workers (17.8%). The ratio of neck MSDs was the highest at companies with ≥1000 workers (13.8%), followed by companies with 100–999 workers (11.4%). According to company size, there was no difference in frequency distributions between neck MSDs and the other MSDs (χ^2 = 4.048, p = 0.256). The larger the company size, the more MSDs occurred. The ratio of neck MSDs also showed a higher trend as the company size increased. The mean of sick leave days for neck MSDs was the highest at companies with <30 workers (483.4 days).

Table 2 also shows the binary logistic regression analysis result on neck MSDs with five predictors: company size, occupations, age, MSD type, and work experience. The factors significantly related to neck MSDs were occupation and age (classification table value = 88.6%). The logistic regression model was tested by the G value of the model coefficient (χ^2 = 302.760, $p < 0.001$). The explanatory power of the dependent variable was the Nagelkerke value (0.502), and the fitness test for the variable was Hosmer and Lemeshow (χ^2 = 0.062, p = 0.999 > 0.05). Therefore, it was found that the model and explanatory power were suitable.

In Table 2, the OR and confidence interval (CI) describe the factors associated with the neck MSDs. Looking at the confirmed MSDs by occupation type, the likelihood that the crane operator will be confirmed as having a neck MSD is 5.473 times (95% CI = (2.179, 13.754)) higher than that of the welder.

In terms of age, the likelihood that workers with ≥60 years old (OR = 2.985, 95% CI = (1.371, 6.501)) or 50–59 years (OR = 3.549, 95% CI = (1.938, 6.497)) will be confirmed as a neck MSD is higher than that of workers with <40 years.

3.3. Distribution and Sick Leave Days of Low Back MSDs and Factors Associated with Low Back MSDs

Table 3 shows the distributions of total MSDs and low back MSDs and the mean and SD of sick leave days by workers' occupation, age, MSD type, work experience, and company size.

According to occupations, there was a significant difference in frequency distributions between low back MSDs and the other MSDs (χ^2 = 23.845, $p < 0.001$). The most prevalent occupation in low back MSDs was electricians or plumber workers (27.6%), followed by welders (22.6%) and installers (20.1%). The ratio of low back MSDs among total MSDs was the highest in installers (41.4%), followed by welders (39.9%) and electricians or plumber workers (34.4%). The mean of sick leave days for low back MSDs was the highest in grinding workers (330.1 days).

Table 3. Distribution and sick leave days of low back MSDs and factors associated with low back MSDs.

Variable	Total MSDs	Low Back MSDs			Sick Leave Days		Logistic Regression on Low Back			
	N	*n*	%	*n*/*N*	Mean	SD	OR	[95% CI]		*p*
	985	323	100%	32.8%	279.5	186.7				
Occupation										0.014 *
Welder (Ref)	183	73	22.6%	39.9%	290.3	144.4				
Fitter	189	50	15.5%	26.5%	287.1	154.3	0.624	0.327	1.191	0.153
Electrician/plumber	259	89	27.6%	34.4%	265.4	184.8	0.662	0.379	1.155	0.147
Painter	100	22	6.8%	22.0%	281.6	196.1	0.402	0.186	0.867	0.020 *
Grinding worker	43	7	2.2%	16.3%	330.1	273.1	0.236	0.075	0.737	0.013 *
Crane operator	54	17	5.3%	31.5%	298.0	223.0	0.336	0.145	0.779	0.011 *
Installer	157	65	20.1%	41.4%	269.7	231.9	0.988	0.523	1.867	0.971
		$\chi^2 = 23.845$, $p = 0.001$ *								
Age (years)										0.001 *
<40 (Ref)	238	140	43.3%	58.8%	244.0	159.2				
40–49	267	98	30.3%	36.7%	297.6	160.1	0.351	0.214	0.573	0.001 *
50–59	289	56	17.3%	19.4%	305.8	258.5	0.190	0.112	0.322	0.001 *
≥60	191	29	9.0%	15.2%	338.6	206.1	0.195	0.104	0.366	0.001 *
		$\chi^2 = 125.504$, $p < 0.001$ *								
MSD type										0.001 *
Sprain (Ref)	209	65	20.1%	31.1%	114.4	154.8				
Herniated disc	380	258	79.9%	67.9%	321.1	170.5	5.299	3.522	7.971	0.001 *
Rupture	396	0	0.0%	0%					.	
		$\chi^2 = 405.947$, $p < 0.001$ *								
Work experience (years)										
<1 (Ref)	157	69	21.4%	43.9%	216.8	147.0				
1–4	154	63	19.5%	40.9%	308.9	209.2				
5–9	145	66	20.4%	45.5%	239.0	151.3				
10–19	153	55	17.0%	35.9%	335.1	180.3				
≥20	376	70	21.7%	18.6%	309.2	213.1				
		$\chi^2 = 59.097$, $p < 0.001$ *								
Company size										0.001 *
<30 (Ref)	91	44	13.6%	48.4%	228.5	137.2				
30–99	97	33	10.2%	34.0%	318.4	207.5	0.541	0.225	1.302	0.170
100–999	175	70	21.7%	40.0%	301.4	209.3	0.623	0.286	1.357	0.233
≥1000	622	176	54.5%	28.3%	276.2	182.3	0.318	0.162	0.624	0.001 *
		$\chi^2 = 19.894$, $p < 0.001$ *								
Constant							3.911			0.002

* $p < 0.05$. Note: *N* = total number of MSDs; *n* = number of low back MSDs; % = *n*/323; SD = standard deviation; OR = odds ratio; CI = confidence interval; Ref = reference.

According to workers' age, there was a significant difference in frequency distributions between low back MSDs and the other MSDs ($\chi^2 = 125.504$, $p < 0.001$). Workers < 40 years had a large portion in low back MSDs (43.3%), and the ratio of low back MSDs among total MSDs was the highest in workers < 40 years (58.8%). However, the mean of sick leave days for low back MSDs was the highest in workers ≥ 60 years (338.6 days). Low back MSDs occur most frequently in workers under 40 years of age and decrease with age. However, it was found that the average number of sick leave days due to low back MSDs increased with age.

There was a significant difference in frequency distributions between low back MSDs and the other MSDs according to MSD type ($\chi^2 = 405.947$, $p < 0.001$). In the case of low back MSDs, a herniated disc was the most prevalent type of injury, followed by a sprain. The average number of sick leave days of the herniated disc was 321.1 days.

There was a significant difference in frequency distributions between low back MSDs and the other MSDs according to workers' work experience ($\chi^2 = 59.097$, $p < 0.001$). The ratio of low back MSDs among total MSDs was high in those with less than 10 years of work experience and decreased after that. However, the average number of sick leave days due to low back MSDs was high in 10–19 years of service.

According to company size, companies with ≥1000 workers had the most frequent low back MSDs (54.5%), followed by companies with 100–999 workers (21.7%). According to company size, there was a significant difference in frequency distributions between low back MSDs and the other MSDs (χ^2 = 19.894, $p < 0.001$). The ratio of low back MSDs among total MSDs was the highest at companies with <30 workers (48.4%). The mean of sick leave days for low back MSDs was the highest at companies with 30–99 workers (318.4 days). The share of low back MSDs is high as the share of total MSDs of large companies, but the ratio of low back MSDs is the highest in small companies with <30 workers.

Table 3 also shows the result of the binary logistic regression analysis on the low back. The factors significantly associated with low back MSDs were company size, occupations, age, and MSD type (classification table value = 83.7%). The logistic regression model was tested by the G value of the model coefficient (χ^2 = 598.731, $p < 0.001$). The explanatory power of the dependent variable was the Nagelkerke value (0.634), and the fitness test for the variable was the Hosmer and Lemeshow value (χ^2 = 8.224, $p = 0.412 > 0.05$). Therefore, it was found that the model and explanatory power were suitable.

Looking at the occupation type, the possibility that the welders will be confirmed as having low back MSDs is higher than that of the grinding workers (4.237 times, 95% CI = (1.357, 13.333)), crane operators (2.979 times, 95% CI = (1.284, 6.897)), or painters (2.488 times, 95% CI = (1.153, 5.376)).

In terms of age, the likelihood that workers <40 years will be confirmed as having a low back MSD is higher than that of workers ≥ 60 years old (5.128 times, 95% CI = (2.732, 9.615)), 50–59 years (5.263 times, 95% CI = (3.106, 8.929)), or 40–49 years (2.849 times, 95% CI = (1.745, 4.673)).

In terms of MSD type, the possibility that a herniated disc will be confirmed as a low back MSD is 5.299 times (95% CI = (3.522, 7.971)) higher than that of a sprain.

In views of company size, the possibility that workers worked in a small company with <30 employees will be confirmed as having a low back MSD is 3.148 (=1/0.318) times (95% CI = (1.603, 6.173)) higher than that of workers worked in a large company with ≥1000 employees.

3.4. Distribution and Sick Leave Days of Shoulder MSDs and Factors Associated with Shoulder MSDs

Table 4 shows the distributions of total MSDs and shoulder MSDs and the mean and SD of sick leave days by workers' occupation, age, MSD type, work experience, and company size.

According to occupations, there was a significant difference in frequency distributions between shoulder MSDs and the other MSDs (χ^2 = 15.595, p = 0.016). Fitters (24.8%) and electrician or plumber workers (24.5%) had prevalent shoulders MSDs. The ratio of shoulder MSDs among total MSDs was the highest in fitters (39.2%), followed by painters (35.0%). However, the mean of sick leave days for shoulder MSDs was the highest in crane operators (412.7 days).

According to the worker's age, there was a significant difference in frequency distributions between shoulder MSDs and the other MSDs (χ^2 = 84.840, $p < 0.001$). Workers of 50–59 years had a large portion in shoulder MSDs (39.6%), and the ratio of shoulder MSDs among total MSDs was the highest in workers ≥ 60 years (47.1%). However, the mean of sick leave days for shoulder MSDs was the highest in workers of 50–59 years (357.0 days). In summary, the proportion of total shoulder MSDs and the ratio of shoulder MSDs among the total MSDs were higher in the 50 years and older.

Table 4. Distribution and sick leave days of shoulder MSDs and factors associated with shoulder MSDs.

Variable	Total MSDs	Shoulder MSDs			Sick Leave Days		Logistic Regression on Shoulder			
	N	*n*	%	*n*/*N*	Mean	SD	OR	[95% CI]		*p*
	985	298	100%	30.3%	330.9	158.1				
Occupation										
Welder (Ref)	183	55	18.5%	30.1%	348.9	167.4				
Fitter	189	74	24.8%	39.2%	311.1	129.0				
Electrician/plumber	259	73	24.5%	28.2%	347.1	201.5				
Painter	100	35	11.7%	35.0%	300.5	103.4				
Grinding worker	43	13	4.4%	30.2%	332.2	151.2				
Crane operator	54	9	3.0%	16.7%	412.7	79.0				
Installer	157	39	13.1%	24.8%	320.5	155.6				
		$\chi^2 = 15.595$, $p = 0.016$ *								
Age (years)										0.001 *
<40 (Ref)	238	29	9.7%	12.2%	325.1	298.0				
40–49	267	61	20.5%	22.8%	293.8	123.4	1.786	1.008	3.166	0.047
50–59	289	118	39.6%	40.8%	357.0	158.7	3.149	1.824	5.437	0.001 *
≥60	191	90	30.2%	47.1%	323.6	100.9	3.438	1.939	6.096	0.001 *
		$\chi^2 = 84.840$, $p < 0.001$ *								
MSD type										0.001 *
Sprain (Ref)	209	47	15.8%	22.5%	308.5	160.2				
Herniated disc	380	0	0%	0%						
Rupture	396	251	84.2%	63.4%	335.1	157.7	5.301	3.579	7.851	0.001 *
		$\chi^2 = 376.792$, $p < 0.001$ *								
Work experience (years)										
<1 (Ref)	157	37	12.4%	23.6%	303.7	164.8				
1–4	154	37	12.4%	24.0%	345.7	260.0				
5–9	145	27	9.1%	18.6%	303.6	139.1				
10–19	153	35	11.7%	22.9%	286.8	112.6				
≥20	376	162	54.4%	43.1%	347.7	134.4				
		$\chi^2 = 48.742$, $p < 0.001$ *								
Company size										
<30 (Ref)	91	23	7.7%	25.3%	284.2	134.7				
30–99	97	28	9.4%	28.9%	284.9	130.5				
100–999	175	43	14.4%	24.6%	351.3	137.7				
≥1000	622	204	68.5%	32.8%	338.1	166.5				
		$\chi^2 = 5.743$, $p = 0.125$								
Constant							0.136			0.001 *

* $p < 0.05$. Note: *N* = total number of MSDs; *n* = number of shoulder MSDs; % = *n*/298; SD = standard deviation; OR = odds ratio; CI = confidence interval; Ref = reference.

There was a significant difference in frequency distributions between shoulder MSDs and the other MSDs according to MSD type ($\chi^2 = 376.792$, $p < 0.001$). In the case of shoulder MSDs, a rupture was the most prevalent type of injury (84.2%), followed by sprain (15.8%). The average number of sick leave days of rupture was 335.1 days.

There was a significant difference in frequency distributions between shoulder MSDs and the other MSDs according to workers' work experience ($\chi^2 = 48.742$, $p < 0.001$). The proportion of total shoulder MSDs and the ratio of shoulder MSDs among the total MSDs were higher in those with ≥20 years of work experience, and the average number of sick leave days was also higher in those with ≥20 years of work experience.

According to company size, there was a significant difference in frequency distributions between shoulder MSDs and the other MSDs ($\chi^2 = 5.743$, $p = 0.125$). Companies with ≥1000 workers had the most frequent shoulder MSDs (68.5%), and the possibility of shoulder MSDs among total MSDs was also the highest at companies with ≥1000 workers (32.8%). The mean of sick leave days for shoulder MSDs was the highest at companies with 100–999 workers (351.3 days).

Table 4 also shows the result of the binary logistic regression analysis on shoulder MSDs. The factors significantly associated with shoulder MSDs were age and MSD type (classification table value = 81.1%). The logistic regression model was tested by the G value

of the model coefficient (χ^2 = 489.584, $p < 0.001$). The explanatory power of the dependent variable was the Nagelkerke value (0.554), and the fitness test for the variable was the Hosmer and Lemeshow value (χ^2 = 4.495, $p = 0.721 > 0.05$). Therefore, it was found that the model and explanatory power were suitable.

In terms of age, the likelihood that workers ≥60 years old (3.438 times, 95% CI = (1.939, 6.096)), 50–59 years (3.149 times, 95% CI = (1.824, 5.437)), or 40–49 years (1.786 times, 95% CI = (1.008, 3.166)) will be confirmed as having a shoulder MSD is higher than that of workers < 40 years.

In terms of MSD type, the possibility that a rupture will be confirmed as a shoulder MSD is 5.301 times (95% CI = (3.579, 7.851)) higher than that of a sprain.

3.5. Distribution and Sick Leave Days of Elbow MSDs and Factors Associated with Elbow MSDs

Table 5 shows the distributions of total MSDs and elbow MSDs and the mean and SD of sick leave days by workers' occupation, age, MSD type, work experience, and company size.

Table 5. Distribution and sick leave days of elbow MSDs and factors associated with elbow MSDs.

Variable	Total MSDs	Elbow MSDs			Sick Leave Days		Logistic Regression on Elbow			
	N	*n*	%	*n*/*N*	Mean	SD	OR	[95% CI]		*p*
	985	80	100%	8.1%	278.7	149.0				
Occupation										0.008 *
Welder (Ref)	183	11	13.8%	6.0%	315.3	101.7				
Fitter	189	9	11.3%	4.8%	401.8	236.4	0.772	0.267	2.230	0.632
Electrician/plumber	259	24	30.0%	9.3%	263.1	154.3	1.313	0.538	3.205	0.549
Painter	100	16	20.0%	16.0%	211.8	117.6	3.952	1.385	11.276	0.010 *
Grinding worker	43	5	6.3%	11.6%	319.2	124.9	7.612	1.702	34.041	0.008 *
Crane operator	54	2	2.5%	3.7%	320.5	62.9	0.464	0.080	2.672	0.390
Installer	157	13	16.3%	8.3%	252.0	104.9	1.386	0.506	3.796	0.526
		χ^2 = 14.850, p = 0.021 *								
Age (years)										0.013 *
<40 (Ref)	238	13	16.3%	5.5%	321.0	226.6				
40–49	267	33	41.3%	12.4%	248.7	143.1	3.233	1.438	7.269	0.005 *
50–59	289	15	18.8%	5.2%	320.9	105.4	1.148	0.470	2.804	0.762
≥60	191	19	23.8%	9.9%	268.7	116.8	2.089	0.860	5.072	0.104
		χ^2 = 12.863, p = 0.005 *								
MSD type										0.001 *
Sprain (Ref)	209	71	88.8%	34.0%	281.7	157.1				
Herniated disc	380	0	0%	0%						
Rupture	396	9	11.3%	2.3%	255.4	50.9	0.037	0.017	0.079	0.001 *
		χ^2 = 238.894, p < 0.001 *								
Work experience (years)										
<1 (Ref)	157	11	13.8%	7.0%	316.5	183.2				
1–4	154	7	8.8%	4.5%	373.3	308.4				
5–9	145	14	17.5%	9.7%	225.9	87.0				
10–19	153	17	21.3%	11.1%	266.2	132.3				
≥20	376	31	38.8%	8.2%	274.7	107.8				
		χ^2 = 5.198, p = 0.268								
Company size										0.027 *
<30 (Ref)	91	7	8.8%	7.7%	302.7	224.4				
30–99	97	7	8.8%	7.2%	258.6	124.1	1.025	0.272	3.863	0.970
100–999	175	7	8.8%	4.0%	459.3	269.1	0.482	0.133	1.748	0.267
≥1000	622	59	73.8%	9.5%	256.9	106.8	2.057	0.774	5.465	0.148
		χ^2 = 5.663, p = 0.129								
Constant							0.139			0.004

* $p < 0.05$. Note: N = total number of MSDs; n = number of elbow MSDs; % = n/80; SD = standard deviation; OR = odds ratio; CI = confidence interval; Ref = reference.

According to occupations, there was a significant difference in frequency distributions between elbow MSDs and the other MSDs (χ^2 = 15.595, p = 0.016). Electricians or plumber workers (30.0%) were the most prevalent elbow MSDs, followed by the painters (20.0%)

and installers (16.3%). The ratio of elbow MSDs among total MSDs was the highest in painters (16.0%). However, the mean of sick leave days for elbow MSDs was the highest in fitters (401.8 days).

According to workers' age, there was a significant difference in frequency distributions between elbow MSDs and the other MSDs (χ^2 = 12.863, p = 0.005). The proportion of total elbow MSDs and the ratio of elbow MSDs among the total MSDs were higher in workers of 40–49 years. However, the mean of sick leave days for elbow MSDs was the highest in workers < 40 years (321.0 days).

There was a significant difference in frequency distributions between elbow MSDs and the other MSDs according to MSD type (χ^2 = 238.894, p < 0.001). In the case of elbow MSDs, a sprain was the most prevalent type of injury (88.8%), followed by rupture (11.3%). The average number of sick leave days of sprain was 281.7 days.

There was a significant difference in frequency distributions between elbow MSDs and the other MSDs according to workers' work experience (χ^2 = 5.198, p = 0.268). The proportion of total elbow MSDs was higher in those with ≥20 years of work experience (38.8%). The ratio of elbow MSDs among the total MSDs was higher in those with 10–19 years of work experience. The average number of sick leave days was higher in those with 1–4 years of work experience (373.3 days).

According to company size, there was a significant difference in frequency distributions between elbow MSDs and the other MSDs (χ^2 = 5.663, p = 0.129). Companies with ≥1000 workers had the most frequent elbow MSDs (73.8%), and the possibility of elbow MSDs among total MSDs was also the highest at companies with ≥1000 workers (9.5%). The mean of sick leave days for shoulder MSDs was the highest at companies with 100–999 workers (459.3 days).

Table 5 also shows the result of the binary logistic regression analysis on elbow MSDs. The factors significantly associated with elbow MSDs were company size, occupation, age, and MSD type (classification table value = 92.8%). The logistic regression model was tested by the G value of the model coefficient (χ^2 = 234.238, p < 0.001). The explanatory power of the dependent variable was the Nagelkerke value (0.491), and the fitness test for the variable was the Hosmer and Lemeshow value (χ^2 = 320.780, p = 0.491 > 0.05). Therefore, it was found that the model and explanatory power were suitable.

Looking at occupation type, the possibility that grinding workers (7.612 times, 95% CI = (1.702, 34.041)) or painters (3.952 times, 95% CI = (1.385, 11.276)) will be confirmed as having elbow MSDs is higher than that of welders. In terms of age, the likelihood that workers with 40–49 years will be confirmed as having elbow MSD is 3.233 times (95% CI = (1.438, 7.269)) higher than that of workers with <40 years. In terms of MSD type, the possibility that a sprain will be confirmed as the elbow MSD is 27.027 times (95% CI = (12.658, 58.823)) higher than that of a rupture.

3.6. Distribution and Sick Leave Days of Knee MSDs and Factors Associated with Knee MSDs

Table 6 shows the distributions of total MSDs and knee MSDs and the mean and SD of sick leave days by workers' company size, occupation, age, MSD type, and work experience. According to occupations, there was a significant difference in frequency distributions between knee MSDs and the other MSDs (χ^2 = 8.497, p = 0.204). Fitters (24.1%) and electricians or plumber workers (24.1%) had prevalent knee MSDs. The ratio of knee MSDs among total MSDs was the highest in grinding workers (27.9%), followed by fitters (20.6%). However, the mean of sick leave days for knee MSDs was the highest in electricians or plumber workers (413.8 days).

Table 6. Distribution and sick leave days of knee MSDs and factors associated with knee MSDs.

Variable	Total MSDs	Knee MSDs			Sick Leave Days		Logistic Regression on Knees			
	N	*n*	%	*n*/*N*	Mean	SD	OR	[95% CI]		*p*
	985	162	100%	16.4%	332.6	327.4				
Occupation										
Welder (Ref)	183	26	16.0%	14.2%	384.8	432.8				
Fitter	189	39	24.1%	20.6%	296.5	120.4				
Electrician/plumber	259	39	24.1%	15.1%	413.8	517.3				
Painter	100	14	8.6%	14.0%	358.4	166.3				
Grinding worker	43	12	7.4%	27.9%	288.5	166.5				
Crane operator	54	7	4.3%	13.0%	184.9	119.0				
Installer	157	25	15.4%	15.9%	256.1	128.2				
		$\chi^2 = 8.497$, $p = 0.204$								
Age (years)										
<40 (Ref)	238	29	17.9%	12.2%	242.3	129.8				
40–49	267	44	27.2%	16.5%	281.0	141.1				
50–59	289	54	33.3%	18.7%	435.0	521.0				
≥60	191	35	21.6%	18.3%	314.3	134.4				
		$\chi^2 = 4.690$, $p = 0.196$								
MSD type										0.001 *
Sprain (Ref)	209	26	16.0%	12.4%	405.1	579.6				
Herniated disc	380	0	0%	0%						
Rupture	396	136	84.0%	34.3%	318.8	253.8	3.699	2.327	5.878	0.001 *
		$\chi^2 = 169.541$, $p < 0.001$ *								
Work experience (years)										
<1 (Ref)	157	25	15.4%	15.9%	262.3	161.4				
1–4	154	32	19.8%	20.8%	272.7	156.3				
5–9	145	14	8.6%	9.7%	288.5	108.5				
10–19	153	24	14.8%	15.7%	284.3	93.6				
≥20	376	67	41.4%	17.8%	414.0	472.8				
		$\chi^2 = 7.582$, $p = 0.108$								
Company size										0.053
<30 (Ref)	91	10	6.2%	11.0%	235.6	89.1				
30–99	97	20	12.3%	20.6%	301.1	195.8	2.060	0.839	5.053	0.115
100–999	175	35	21.6%	20.0%	284.6	139.0	2.269	0.995	5.174	0.052
≥1000	622	97	59.9%	15.6%	366.5	401.7	1.289	0.613	2.710	0.504
		$\chi^2 = 5.137$, $p = 0.162$								
Constant							0.139			0.004

* $p < 0.05$. Note: N = total number of MSDs; n = number of knee MSDs; % = $n/162$; SD = standard deviation; OR = odds ratio; CI = confidence interval; Ref = reference.

According to the workers' age, there was a significant difference in frequency distributions between knee MSDs and the other MSDs ($\chi^2 = 4.690$, $p = 0.196$). The proportion of total knee MSDs and the ratio of knee MSDs among the total MSDs were higher in workers of 50–59 years. The mean of sick leave days for knee MSDs was also the highest in workers of 50–59 years (435.0 days).

There was a significant difference in frequency distributions between knee MSDs and the other MSDs according to MSD type ($\chi^2 = 169.541$, $p < 0.001$). In the case of knee MSDs, a rupture was the most prevalent type of injury (84.0%), followed by sprain (16.0%). The average number of sick leave days of sprain was 405.1 days.

There was a significant difference in frequency distributions between knee MSDs and the other MSDs according to the worker's work experience ($\chi^2 = 7.582$, $p = 0.108$). The proportion of total knee MSDs was higher in those with ≥20 years of work experience (41.4%), and the average number of sick leave days was also higher in those with ≥20 years of work experience (414.0 days).

According to company size, there was a significant difference in frequency distributions between knee MSDs and the other MSDs ($\chi^2 = 5.137$, $p = 0.162$). Companies with ≥1000 workers had the most frequent knee MSDs (59.9%), and the possibility of knee MSDs among total MSDs was also high in companies with 30–99 workers (20.6%) or companies

with 100–999 workers (20.0%). The mean of sick leave days for knee MSDs was the highest at companies with ≥1000 workers (366.5 days).

Table 6 also shows the result of the binary logistic regression analysis on knee MSDs. The factor most significantly associated with knee MSDs was the MSD type (classification table value = 83.6%). The logistic regression model was tested by the G value of the model coefficient (χ^2 = 221.724, $p < 0.001$). The explanatory power of the dependent variable was the Nagelkerke value (0.341), and the fitness test for the variable was the Hosmer and Lemeshow test (χ^2 = 0.522, $p = 0.991 > 0.05$). Therefore, it was found that the model and explanatory power were suitable.

In terms of MSD type, the possibility that a rupture will be confirmed as a knee MSD is 3.699 times (95% CI = (2.327, 5.878)) higher than that of a sprain.

4. Discussions

This study examined the factors associated with musculoskeletal disorders (MSDs) according to body region and analyzed the frequency and sick leaves of MSDs for prioritizing MSD prevention information.

This study showed that low back MSDs (28.9%) were the most common in shipbuilding workers. Heavy physical work, excessive force, and bending and twisting were associated with low back disorders [1,15,16]. Shipyard workers, such as welders, electricians/plumbers, installers, and fitters, have ergonomically hazardous jobs, commonly requiring repetitive handling of heavy materials, frequent bending and twisting work, and excessive force [6,17]. Awkward work postures are often caused by restrictions in vertical or lateral spaces, such as the work of electricians/plumbers or installers. These prolonged stooping or kneeling postures increase severe low back pain [18]. Low back MSDs were common in electricians or plumbers, followed by welders or installers.

The shoulder MSDs were the second most common injury (27.7%) in shipbuilding workers approved by work-related compensation insurance. Previous studies implicated working with arms above shoulder level as one of the predisposing factors of shoulder MSDs [19,20]. Other studies indicate that the risk factors include working with awkward postures, repetitive forceful movements of the upper limbs, conducting the same activity for a prolonged period, carrying loads supported by the shoulder, and hand–arm vibrations [8,21]. Shoulder disorders were common in shipyard welders [22]. Shipbuilding workers, such as fitters, electricians/plumbers, welders, grinding workers, and painters, have jobs that involve repetitive forceful movements of the upper limbs, heavy lifting, the prolonged elevation of the arms above the shoulders, and overhead work with outstretched arms [17,22].

In logistic regression analyses, age was associated with MSDs in the neck, low back, shoulder, and elbow regions. Previous findings indicated that age increased the risk of MSDs [23,24]. However, in a questionnaire study based on self-reported symptoms, there was a 'survivor bias' with no positive correlation between MSD risk and aging [7,25]. In this study, the neck or shoulder MSDs was increased with age. This result is consistent with findings [15] that neck and shoulder MSDs are more common in skilled workers. For neck MSDs, only the herniated disc was covered by industrial accident insurance, and the likelihood that a herniated disc will be confirmed as a low back MSD is 5.299 times higher than that of a sprain. The mean of sick leave days was 402.2 days for herniated neck disc and 321.1 days for the low back herniated disc. In contrast, the likelihood that a rupture will be confirmed as a shoulder MSD or knee MSD is higher than that of a sprain. The mean of sick leave days was 335.1 days for shoulder rupture, 318.8 days for knee rupture, and 255.4 days for elbow rupture. In summary, the mean of sick leave days in the neck or shoulder was large, which is in line with the result [26] that older workers who have performed excessive and repetitive activities for a long time may experience more severe MSDs.

However, the likelihood of low back MSDs did not increase with age in this study, which is in line with the NIOSH results [1]. The likelihood that workers < 40 years will be

confirmed as having a low back MSD is higher than workers ≥ 60 years. The likelihood of confirmation of workers who worked in a small company with <30 employees is also higher than that of workers in a large company with ≥1000 employees. The results of this study can be explained by previous results [15] that ergonomic risks and manual workers are the major work-related risk factors for lower back injuries. Large companies have not been hiring young workers due to the recession in the shipbuilding industry. On the other hand, because the workers' retirement age is guaranteed, the average age is over 40 years. Because large shipbuilding companies have improved in manual material handling, the incidence of low back MSDs is relatively small. However, there are frequent neck or shoulder MSDs in older workers, because of performing overhead work or working with arms above shoulder level for more than 20 years. Older workers are exposed to long-term risk factors, resulting in long work-loss days. On the other hand, small subcontracting companies, with relatively poor working conditions, are frequently exposed to low back MSDs. This means that efforts to improve the working environment should be made continuously in the small-sized companies.

In the frequency analysis of the MSDs according to occupation–body region–MSD type, 'electrician/plumber–low back–herniated disc' (6.9%) was the form of MSD with the highest frequency among total MSDs, followed by 'welder–low back–herniated disc' (6.4%), 'fitter–shoulder–rupture' (6.3%), and 'electrician/plumber–shoulder–rupture' (6.2%). While 'crane–neck–herniated disc' (500.5 days) had the highest mean sick leave days, followed by 'welder–neck–herniated disc' (414.0 days) and 'welder–neck–herniated disc' (404.3 days).

The MSDs problem of older workers is a critical issue to be solved in the shipbuilding industry in terms of the quality of life of the worker and the cost of compensation for industrial accidents, and systematic measures are required. There should be continuous efforts to expand the current notion of 'universal design', which regards ease of life for the elderly, into 'universal safety and design', which allows elderly workers to do their job in comfort and safety [27,28]. It makes sense to maintain health and prevent MSDs in older workers who are still physically and mentally fit from the social perspective since they are a primary source of the workforce in the era of an aged population.

This study has some limitations. First, this study analyzed only the MSDs of male shipbuilding workers. Therefore, there may be differences in the characteristics of the MSDs incurred by female workers. Second, the MSDs reported in this study resulted in more than 4 days of absence from work, and MSDs with sick leave of less than 3 days or pains were not included in the analysis. Hence, the results may be lower than other countries' MSDs rates. Third, there is a limitation of not considering various factors associated with MSDs, such as exposure to ergonomic hazard factors and psychological factors, because it is a retrospective study. Therefore, further research is expected that reflects more research into various other factors. Fourth, the sample of this study is a group of workers that all had MSDs. Thus, the concept of odds of this study is not of getting an injury (compared to no injury) but compared to getting one injury over another injury. Additionally, the result of the binary logistic regression model may vary depending on the choice of predictors and reference scales. Since it is different from the typical outcome, it is necessary to be careful about the interpretation of the odds and OR.

5. Conclusions

This study identified the characteristics of MSDs in the shipbuilding industry. The low back MSDs (28.9%) were the most common, followed by shoulder MSDs (27.7%), knee MSDs (16.2%), neck MSDs (11.3%), and elbow MSDs (7.2%).

The ratio of low back MSDs to total MSDs was highest in welders (39.9%), those under 40 years, or those in a company with less than 30 employees. The ratio of shoulder MSDs to total MSDs was high in fitters (39.2%) and painters (35.0%) and was high in those aged 60 years or older (47.1%), those with rupture (63.4), or those with more than 20 years of work experience (43.1%). Crane operators had the highest neck MSDs compared to total

MSDs, and all approved neck MSDs were herniated discs. The ratio of knee MSDs to total MSDs was highest in grinding workers (27.9%) and the highest in rupture injuries (34.3%).

In the occupation-related MSDs, 'electrician/plumber–lumbar–disc' was the highest frequency, followed by 'welder–lumbar–disc', 'fitter–shoulder–rupture', 'electrician/plumber–shoulder–rupture', and 'welder–shoulder–rupture'. 'Crane–neck–disc' represents the highest average of sick leave days, followed by 'welder–neck–disc' and 'electrician/plumber–neck–disc'.

In the logistic regression analysis, age was positively associated with MSDs in the neck, shoulder, or elbow regions, while low back MSDs were not positively associated with age. Large companies with >1000 employees were highly associated with neck MSDs, while small companies with <30 employees were related to the low back MSDs.

Author Contributions: Conceptualization, W.-J.K., H.-J.P. and B.-Y.J.; methodology, W.-J.K., H.-J.P. and B.-Y.J.; data collection and analysis, W.-J.K. and H.-J.P.; resources, H.-J.P. and B.-Y.J.; data curation, W.-J.K. and B.-Y.J.; writing—original draft preparation, H.-J.P. and B.-Y.J.; writing—review and editing, W.-J.K. and B.-Y.J.; supervision, B.-Y.J.; funding acquisition, B.-Y.J. All authors have read and agreed to the published version of the manuscript.

Funding: This research was financially supported by Hansung University.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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