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Complete List of Authors:	Kim, Yeong-Kwang; Institute of occupational health, Yonsei University College of Medicine Ahn, Yeon-Soon; Dongguk University , Department of Occupational and Environmental Medicine Kim, Kyoo; Korea Occupational Safety and Health Agency, Incheon, Korea Yoon, Jiin-Ha; Department of Preventive Medicine and Public Health, Yonsei University College of Medicine, Seoul, Korea
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Association between job stress and occupational injuries among Korean firefighters

Authors

Yeong-Kwang Kim[1, 2], Yeon-Soon Ahn[3], Kyoo-Sang Kim[4], Jin-Ha Yoon[1, 2]*

Affiliations

[1]The Institute for Occupational Health, Yonsei University College of Medicine, Seoul, Korea

[2]Department of Preventive Medicine, Yonsei University College of Medicine, Seoul, Korea

[3]Department of Occupational and Environmental Medicine, Dongguk University Ilsan Hospital, Goyang, Korea

[4]Department of Occupational and Environmental Medicine, Seoul Medical Center

*Correspondence to this work

Jin-Ha Yoon, MD.

The Institute for Occupational Health, Department of Preventive Medicine,

Yonsei University College of Medicine

50 Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea.

Tel: +82.2-361-5375, Fax: +82.2-392-8622

Email: flyinyou@gmail.com

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ABSTRACT

Objective: Firefighters belong to an occupation with a high risk of injury and are exposed to physical and psychological stress. Until now, only a few systematic approaches to the association between job stress and occupational injury among firefighters exist.

Methods: A survey was conducted among 30,630 firefighters; 91.1% responded to our questionnaire. Individuals with less than 12 months of current job experience were excluded, and 24,265 firefighters were analyzed. To investigate the association between job stress and occupational injuries, we used the following statistical methods: the chi-square test, Cochran-Armitage trend test, negative binomial model.

Results: Among all firefighters, high job demands (odds ratio [OR] 2.15, 95% confidence interval [CI] 1.91–2.41) and of low job control (OR 1.27, 95% CI 1.12–1.43) were associated with an increased risk of occupational injury. In fire suppression personnel, subjects with high job demands (OR 2.01, 95% CI 1.72–2.42) and low job control (OR 1.50, 95% CI 1.24–1.81) have a higher risk of occupational injury. In EMS workers, high job demands (OR 1.74, 95% CI 1.44–2.09) was related to increased risk of occupational injuries, but job control did not show a statistically significant difference (OR 1.11, 95% CI 0.92–1.34). Among officers, high job demands (OR 3.63, 95% CI 2.68–4.94) was associated with a high-risk of occupational injury, but low job control (OR 1.31, 95% CI 0.96–1.78) did not show a statistically significant difference (Table 4).

Conclusion: Excessive job stress due to high job demands and low job control are closely related to occupational injury.

Strengths and limitation of this study

This is a nationwide study involving the entire firefighters of Korea.

There have been only a few systematic approaches to the association between job stress and occupational injury among firefighters.

Major limitation is that our study is cross-sectional study based on self-reported survey.

Potential confounders such as working pattern were not included in this study.

Introduction

Firefighters are responsible for the safety of citizens, and perform functions that include fire suppression and emergency medical services (EMS). As such, firefighters are exposed to physical or chemical hazards that are leading causes of high rates of occupational injuries [1-3]. According to a report of the National Fire Protection Association (NFPA), 18,500 cases of exposure to hazards were reported, and 63,350 firefighter injuries occurred in the line of duty in 2014 at the United States [4]. According to another report, firefighters responsible for fire suppression had a 1.4–7.4 fold higher risk of non-fatal injury than did other industries [5].

Many studies on factors affecting occupational injury have been conducted to reduce the injury rates among firefighters. A study by Fabio et al. showed that occupational injuries among firefighters were influenced by work environments such as the number of alarms, grades of fire, number of structural stories at the scene, work intensity, civilian injury, time of incident, and number of pumpers [6]. Other researchers reported that long working hours [7] and shift work [8 9] could increase the risk of occupational injury. Yet another study examined the impact of individual characteristics such as obesity [10-12], moderate or heavy alcohol drinking [13 14], daytime sleepiness [15 16], sleep habits and insomnia [17 18], and obstructive sleep apnea [19] on workers' risk for occupational injuries.

Separately, other researchers also examined whether psychological factors such as negative affectivity [20], depression symptoms [21], and mental illness [22] were risk factors for occupational injuries. As working conditions or psychological factors can influence occupational injury, recent studies have shown that occupational injury is associated with excessive workload, high cognitive demands, and low job satisfaction [23], as well as low decision latitude, conflicts with the supervisor or colleagues, and high emotional demands [24].

Although many studies to date have investigated of a variety of occupations, there have been a few systematic approaches to the association between job stress and occupational injury among firefighters. In this study, which is based on a survey of all Korean firefighters, we aimed to address this very issue in Korea.

Methods

Study subjects and methods

This cross-sectional study was conducted via a survey targeting firefighters in South Korea between July and November 2007. A questionnaire was mailed to 30,630 total firefighters; 27,895 (91.1%) responded, although respondents with less than 12 months of current job experience were excluded (n = 3,630). These self-reporting structured questionnaires were used to investigate characteristics of subjects, frequency of occupational injury, and job stress. Basic characteristics included age group, marital status, smoking status, alcohol consumption, frequency of exercise, education, current job categories, and current job experience. This study was approved by the Institutional Review Board (IRB) of Dongguk University Ilsan Hospital (2014-82). All authors got written informed consents for their participation.

Occupational characteristics and injury

In the current survey, the number of injuries during the previous 12 months was reported. Recorded injuries were restricted only to events that were related to the firefighter's duties. Furthermore, minor injuries; i.e., those that did not require medical care, were excluded. Firefighters included all workers who worked for a fire department and its related-services: fire suppression, paramedics, rescuer workers, special investigators, informatics training officers, and others [25]. These jobs were categorized into fire suppression, EMS (includes paramedics and rescue), and officers (including administrators, fire source investigators, and communicational and informational system operators).

Job stress

Job stress was identified through the short form of the Korean Occupational Stress Scale (KOSS) [26]. Using KOSS, the job demands (4 items) and low job control (4 items) were assessed. Each of the items allowed 4 possible responses: 'strongly disagree', 'disagree', 'agree', or 'strongly agree'. The possible range of these subscales was 0–100, and the total job stress score was calculated as the average of the 2 subscales. Participants with a score above the 50th percentile of each job stress scale for Korean employees were defined as having high job stress, and considered as having low job stress with a score below the median [26] (Table 1).

Table 1. Reference values and contents of KOSS-26

Job stress scale	Number of items	Range of score	Median (male)	Median (female)	Contents	Questions
Job demands	4	0 - 100	50.1	58.4	Time pressure	Due to many things to do, I always feel time pressure
					Increasing workload	My job has become increasingly overloading
					Excessive work	My work requires a long lasting concentration
					Multiple functioning	I have to do various jobs simultaneously
Job control[a]	4	0 - 100	50.1	58.4	Noncreative work	My work requires creativity.
					Skill underutilization	My work requires a high level of skill or knowledge
					Little or no decision-making	I can make my own decision in my job and give influence over the work
					Low control	I can control my work pace and time schedule

[a]Reverse score

Other confounding variables

Smoking habit was categorized as current smoker, ex-smoker, and never smoker. Alcohol consumption was categorized into drinker vs. non-drinker. Regular physical activity was defined as either <3 times or ≥3 times of exercise per week. Education levels were categorized into <12 years of schooling vs. ≥12 years (high school or above). Marital status was categorized into married and living with a spouse vs. other (never married, divorced, etc.).

Statistical Methods

All study subjects were divided into 2 groups: those that have experienced occupational injury during the previous 12 months and those that had not. Injuries according to occupational and demographic characteristics were compared by using the chi-square test and Cochran-Armitage trend test. Differences in the numbers of injuries during the previous 12 months according to job stress were analyzed using the chi-square test. Job demands and job control were used for analyzing job stress. This analysis was conducted by stratifying the jobs of firefighters as fire suppression, EMS, and officers as mentioned above.

We performed an alpha calculation to select the regression model. All of the estimated alpha values calculated in this study had a 95% confidence interval (CI) that did not include zero, indicating that the negative binomial model was more appropriate than the Poisson model [27]. Because the Bayesian information criteria of the negative binomial model were smaller than that of the zero inflated negative binomial model, we used the negative binomial model for analyzing the impact of job stress on occupational injury [28]. These models were used to analyze the impact of job stress on occupational injury. The odds ratio (OR) and 95% CI were calculated by adjusting all confounding variables that affect

occupational injury on univariate analysis: sex, age group, marital status, smoking status, current job, and current job experience (years). The interaction of job demands with level of job control was also analyzed by dividing workers into 4 groups: those who have high job demands and low job control, those who have high job demands and high job control, those who have low job demands and low job control, and those who have low job demands and high job control. P values below 0.05 were considered statistically significant. Statistical analysis was performed using the SAS 9.2 software (SAS Institute Inc., Cary, NC, USA.)

Result

General characteristics

Over 12 months, 2,669 (11.00%) subjects experienced occupational injury. Young firefighters had a greater rate of injury (12.75% in those younger than 30 years vs. 7.52% in those older than 50 years, P for trend < 0.001). Former smokers experienced more injuries than current and never smokers (13.75% vs. 10.81%, and 10.81%, respectively, P < 0.001). No differences in rates of occupational injury according to sex, alcohol consumption, exercise, and education were observed. EMS workers showed the highest injury prevalence (16.34%), followed by fire suppression personnel (10.95%) and officers (6.01%) (P < 0.001). In general, subjects with longer experience of current job had a greater rate of injury (P for trend = 0.020) (Table 2).

Table 2. General characteristics of subjects stratified by occupational injury

Characteristics		Not injured	Injured[a]	p-value[b]
Number of subjects		21596 (89.00)	2669 (11.00)	
Sex	Male	20540 (88.92)	2559 (11.08)	0.08
	Female	1056 (90.57)	110 (9.43)	
Age group	less than 30	1670 (87.25)	244 (12.75)	<0.001[c]
(years)	30 to 39	9065 (87.33)	131 (12.67)	
	40 to 49	8377 (90.22)	908 (9.78)	
	50 and over	2484 (92.48)	202 (7.52)	
Marriage status	with spouse	18427 (89.36)	2195 (10.64)	<0.001
	others	3169 (86.99)	474 (13.01)	
Smoking status	Current smokers	7651 (89.19)	927 (10.81)	<0.001
	Former smokers	1555 (86.25)	248 (13.75)	
	Never smokers	11271 (89.19)	1366 (10.81)	
Alcohol consumption	Drinker	19218 (89.04)	2365 (10.96)	0.556
	Non-drinker	2378 (88.67)	304 (11.33)	
Frequency of exercise	<3	12779 (89.28)	1534 (10.72)	0.092
(times/week)	≥3	8817 (88.60)	1135 (11.40)	
Education (years)	≤12	8221 (89.16)	1000 (10.84)	0.547
	>12	13375 (88.91)	1669 (11.09)	
Current job	Fire suppression	9974 (89.05)	1226 (10.95)	<0.001
	EMS	5323 (83.66)	1040 (16.34)	
	Officer	6299 (93.99)	403 (6.01)	
Current job experience	1 to 4	11706 (89.85)	1323 (10.15)	<0.020[c]
(years)	5 to 9	3357 (87.33)	487 (12.67)	
	10 to 14	3500 (87.13)	517 (12.87)	
	15 and over	3033 (89.87)	342 (10.13)	

[a]Cases that undergo medical treatment due to the occupational injury for last 12 months

[b]p values that calculated by chi-square test

[c]p values for trend that calculated by cochran-Armitage trend test

Relationship of job stress and number of injuries

In terms of job stress, those individuals with a high job demands experienced more occupational injuries among all firefighters ($P < 0.001$). Likewise, the group with a low job control experienced a higher number of the injuries ($P < 0.05$). Stratified by job categories, more occupational injuries occurred in the high job demands group than in all other job categories. In the low job control group, only firefighters working as fire suppression personnel experienced more occupational injuries, whereas EMS workers and officer did not (Table 3).

Table 3. Distribution of number of injuries according to job stress

Occupational stress scale		Number of injuries[a] 0	1	2	3	4 or more	p-value[b]
Total firefighters							
Job demand	Low risk	9947 (92.12)	466 (4.32)	139 (1.29)	97 (0.90)	149 (1.38)	<0.001
	High risk	11645 (86.50)	832 (6.18)	399 (2.96)	186 (1.38)	400 (2.97)	
Insufficient job control	Low risk	14388 (89.33)	861 (5.35)	341 (2.12)	183 (1.14)	334 (2.07)	0.03
	High risk	7204 (88.36)	437 (5.36)	197 (2.42)	100 (1.23)	214 (2.64)	
Fire suppression							
Job demand	Low risk	4392 (91.98)	217 (4.54)	62 (1.30)	37 (0.77)	67 (1.40)	<0.001
	High risk	5580 (86.88)	414 (6.45)	163 (2.54)	97 (1.51)	169 (2.63)	
Insufficient job control	Low risk	7320 (89.56)	462 (5.65)	156 (1.91)	88 (1.08)	147 (1.80)	<0.001
	High risk	2652 (87.67)	169 (5.59)	69 (2.28)	46 (1.52)	89 (2.94)	
EMS							
Job demand	Low risk	2292 (87.25)	167 (6.36)	57 (2.17)	45 (1.71)	66 (2.51)	<0.001
	High risk	3030 (81.15)	285 (7.63)	185 (4.95)	69 (1.85)	165 (4.42)	
Insufficient job control	Low risk	3417 (84.37)	275 (6.79)	140 (3.46)	75 (1.85)	143 (3.53)	0.178
	High risk	1905 (82.43)	177 (7.66)	102 (4.41)	39 (1.69)	88 (3.81)	
Officer							
Job demand	Low risk	3263 (96.08)	82 (2.41)	20 (0.30)	15 (0.22)	16 (0.24)	<0.001
	High risk	3035 (91.83)	133 (4.02)	51 (1.54)	20 (0.61)	66 (2.00)	
Insufficient job control	Low risk	3651 (94.00)	124 (3.19)	45 (1.16)	20 (0.51)	44 (1.13)	0.827
	High risk	2647 (93.97)	91 (3.23)	26 (0.92)	15 (0.53)	38 (1.35)	

[a]Cases that undergo medical treatment due to the occupational injury for last 12 months

[b]p values that calculated by chi-square test

Analysis of occupational injury according to job stress by negative binomial model

The odds of occupational injury were calculated by comparing subjects with high job stress to low job stress; we adjusted for all confounding variables. In all firefighters, high job demands (OR 2.15, 95% CI 1.91–2.41) and low job control (OR 1.27, 95% CI 1.12–1.43) were associated with the increased risk of occupational injury. In fire suppression personnel, subjects with high job demand (OR 2.01, 95% CI 1.72–2.42) and low job control (OR 1.50, 95% CI 1.24–1.81) have a higher risk of occupational injury. In EMS workers, high job demands (OR 1.74, 95% CI 1.44–2.09) was related to increased risk of occupational injuries, but job control did not show a statistically significant difference (OR 1.11, 95% CI 0.92–1.34). Among officers, high job demands (OR 3.63, 95% CI 2.68–4.94) was associated with a high-risk of occupational injury, but low job control (OR 1.31, 95% CI 0.96–1.78) did not show a statistically significant difference (Table 4).

Table 4. The relationship between occupational stress and risk of occupational injury

Occupational stress scale[a]		Odds ratio[b]	95% Confidence interval
Total firefighters			
Job demand	Low risk	1.00	
	High risk	2.15	1.91 - 2.41
Insufficient job control	Low risk	1.00	
	High risk	1.27	1.12 - 1.43
Fire suppression			
Job demand	Low risk	1.00	
	High risk	2.01	1.72 - 2.42
Insufficient job control	Low risk	1.00	
	High risk	1.50	1.24 - 1.81
Emergency medical services			
Job demand	Low risk	1.00	
	High risk	1.74	1.44 - 2.09
Insufficient job control	Low risk	1.00	
	High risk	1.11	0.92 - 1.34
Officer			
Job demand	Low risk	1.00	
	High risk	3.63	2.68 - 4.94
Insufficient job control	Low risk	1.00	
	High risk	1.31	0.96 - 1.78

[a]All high risk group of occupational stress scale were compared to low risk group

[b]OR and 95% CI calculated from negative binomial regression model adjusted for sex, age group, marriage status, smoking status, current job, current job experience (years)

Interaction of job demands and insufficient job control

When subjects had high job demands and low job control, all firefighters had the highest risk of occupational injuries. However, there was no statistically significant interaction between job demands and job control. Differences in the odds of the high job stress vs. low job stress were higher with respect to job demands (Figure 1).

Discussion

This study showed that excessive stress due to high job demands and low job control is related to occupational injuries in Korean fighters. In fire suppression personnel, high job demands and low job control were associated with high-risk of occupational injury. Among EMS workers and officers, high job demands was associated with increased risk of occupational injury, but low job control didn't show a statistically significant difference.

Many recent studies investigated occupational injury due to physical and chemical exposure, as well as psychological factors including job stress. However, the association of job stress and occupational injury among firefighters has rarely been examined. Our study is meaningful because it is a nationwide survey involving the entire firefighter force of Korea, and reveals the association between job stress and occupational injury of firefighters after adjusting for confounding variables.

Some studies report different impacts of job demands and insufficient job control on occupational injury according to occupation and gender. In a study of Korean small-to-medium sized manufacturing enterprises, male workers with highly demanding jobs had a higher risk of occupational injury (OR 1.71, 95% CI 1.13–2.59). However, insufficient job control did not increase the risk of occupational injury in male workers (OR 1.08, CI 0.72–1.63). In female workers, high job demands was associated with a high-risk of occupational injury (OR 2.11, 95% CI 1.18–3.78), as was insufficient job control (OR 1.80, CI 1.02–3.17) [29]. A study from Japan showed that high quantitative workloads (OR 1.55, 95% CI 1.24–1.98), high variance in workload (OR 1.70, 95% CI 1.32–2.17), high cognitive demands (OR 1.31, 95% CI 1.03–1.67), and low job security (OR 1.35, 95% CI 1.05–1.72) were associated with occupational injury in males working in small-to-medium sized manufacturing enterprises. Among female workers, high quantitative workload (OR 1.62, 95% CI 1.07–2.44), high cognitive demands (OR 1.53, 95% CI

1.02–2.31), low job control (OR 2.04, 95% CI 1.30–3.18), and high rates of intragroup conflicts in the workplace (OR 1.66, 95% CI 1.08–2.55) were related to a high-risk of occupational workplace injury [23]. High job demands is related to increased risk of occupational injury in various occupation and both genders. However, the effect of excessive stress as it relates to job control increases the risk of occupational injury among female workers of other occupations, but the impact of job control on male workers is not clear. In our study, because there were a small number of female firefighters, we did not stratify the data by gender. Nevertheless, male firefighters with insufficient job control have increased risk of occupational injuries, which differ from some studies about other occupation. Occupation and location of work are representative job-related factor affecting the risk of occupational injuries[30]. Therefore, association between job stress and risk of occupational injuries can be affected by worker's job. Among firefighters, EMS personnel and officers can communicate with each other when they are faced with a challenging situation. In contrast, fire suppression personnel can face situations where co-worker communication is severed because the job of tackling a fire may sometimes become unpredictable, and firefighters are often isolated in such situations; this environment can be hazardous and lead to occupational injuries.

Elements that make up the Job stress is a very diverse, and many researchers have defined a variety of job stressor. Karasek presented Job-Demand-Control model, and put the job demands and job control as precedence factor of job stress[31]. On the basis of this model, Impacts of job demands and control on physical and psychological health have been identified by many studies[32 33]. Furthermore, it is revealed that the relevance of the elements was associated with safety in the workplace such as safety performance and accident[34 35]. Therefore, in this study, we set the job demands and control to important elements of the job stress, and focused on figuring out the association between job stress and occupational injury.

Our study had 3 limitations as follows. First, because the study was conducted using a self-reported survey, recall or reporting bias may have occurred. However, because severe cases of injuries are generally more easily remembered, the fact that our study design surveyed only injuries that required medical care may minimize recall bias. Self-reported survey methods also carry the limitation that the characteristics of non-respondents, and their effect on our results, could not be determined. Moreover, since deceased workers cannot response to the survey, a bias towards healthy workers may have occurred. If this study included non-respondents, it is possible that our final results would be different. Second, confounding variables such as working patterns, hours of duty, and number of alarms were not included, although these may have an influence on the relationship between job stress and occupational injuries. Third, because the study design was cross-sectional, we could not establish a causal relationship, and were only able to identify the association between job stress and injury. However, the advantage of this study is that it was nationwide and included the entire firefighter force in Korea.

In summary, our study revealed that excessive job stress due to high job demands and low job control is related to increased risk of occupational injuries. To prevent such injuries among firefighters, controlling job stress by screening individuals and establishing systems for the care and well-being can be effective.

Contributors

Y-KK designed the study, analyzed and interpreted the data, and drafted and revised the manuscript. Y-SA interpreted the data and revised the manuscript. K-SK suggested the study design and revised the manuscript. J-HY suggested the study design, interpreted the data, and reviewed the manuscript.

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Competing interest

None declared.

Ethic approval

The Institutional Review Board (IRB) of Dongguk University Ilsan Hospital

Provenance and peer review

Not commissioned; externally peer reviewed.

Data sharing statement

No additional data are available.

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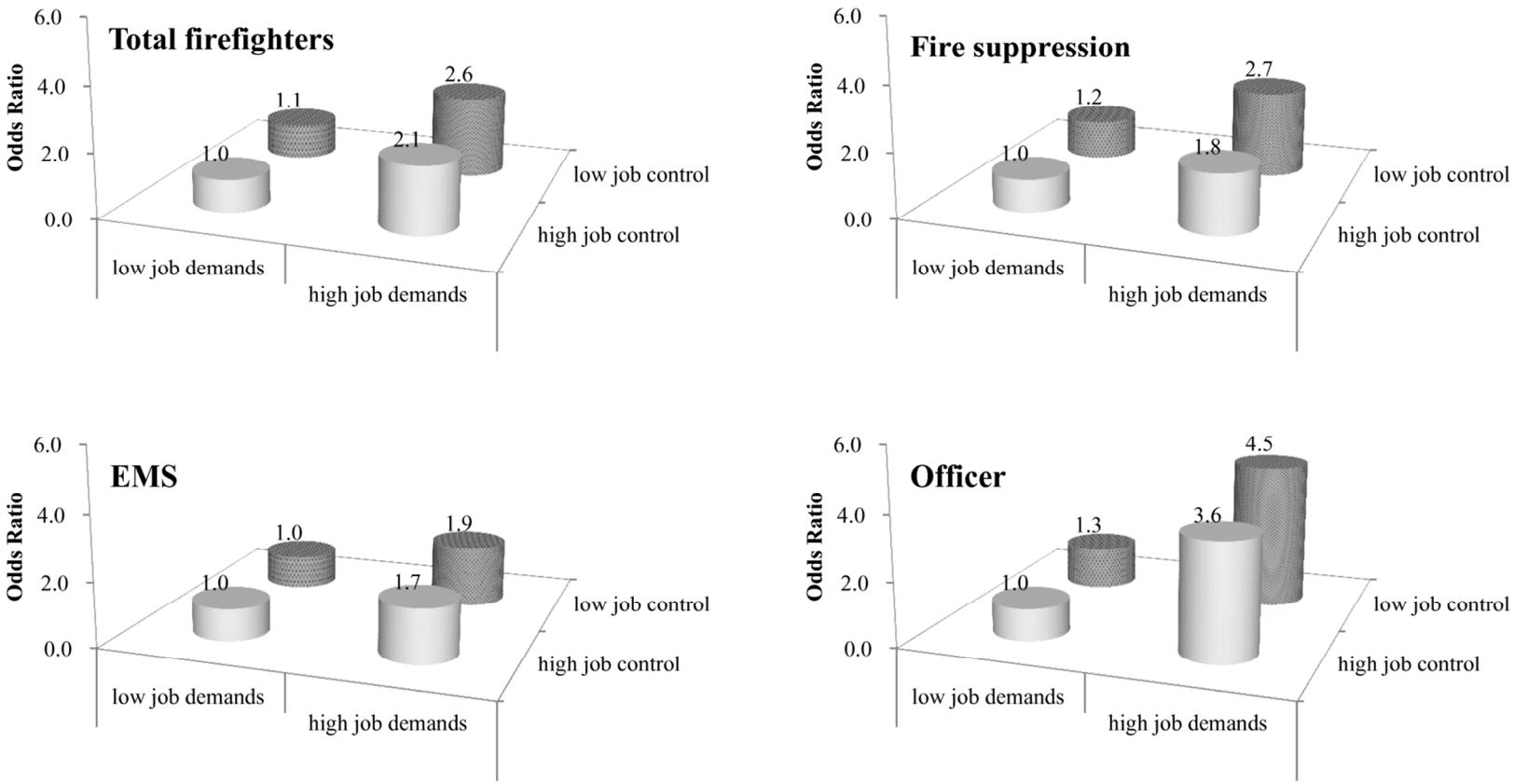
<Figure legends>

Figure 1. Adjusted ORs of occupational injury obtained from negative binomial regression model by categories of job demands and insufficient job control



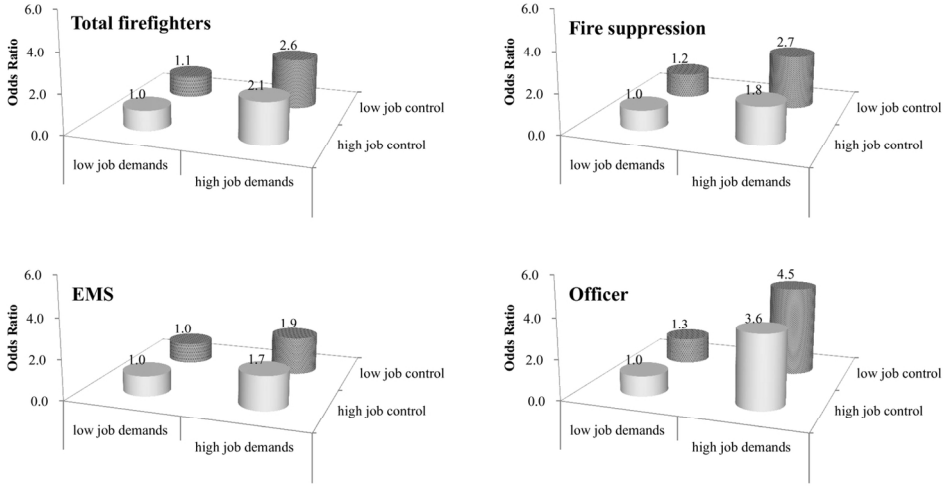


Figure 1. Adjusted ORs of occupational injury obtained from negative binomial regression model by categories of job demands and insufficient job control
138x76mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No.
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5, 6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7, 8, 10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	10, 11
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8, 10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10, 11
		(*b*) Describe any methods used to examine subgroups and interactions	11
		(*c*) Explain how missing data were addressed	10, 11

		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	7
		(*e*) Describe any sensitivity analyses	10
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	7
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7, 8, 10
		(b) Indicate number of participants with missing data for each variable of interest	12
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	16
		(*b*) Report category boundaries when continuous variables were categorized	8, 10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	18
Discussion			
Key results	18	Summarise key results with reference to study objectives	19
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	21
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	19, 20, 21
Generalisability	21	Discuss the generalisability (external validity) of the study results	19, 20
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	22

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Association between job stress and occupational injuries among Korean firefighters: the nationwide cross-sectional study

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Association between job stress and occupational injuries among Korean firefighters: the nationwide cross-sectional study

Authors

Yeong-Kwang Kim[1, 2], Yeon-Soon Ahn[3], Kyoo-Sang Kim[4], Jin-Ha Yoon[1, 2]*

Affiliations

[1]The Institute for Occupational Health, Yonsei University College of Medicine, Seoul, Korea

[2]Department of Preventive Medicine, Yonsei University College of Medicine, Seoul, Korea

[3]Department of Occupational and Environmental Medicine, Dongguk University Ilsan Hospital, Goyang, Korea

[4]Department of Occupational and Environmental Medicine, Seoul Medical Center

*Correspondence to this work

Jin-Ha Yoon, MD.

The Institute for Occupational Health, Department of Preventive Medicine,

Yonsei University College of Medicine

50 Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea.

Tel: +82.2-361-5375, Fax: +82.2-392-8622

Email: flyinyou@gmail.com

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Association between job stress and occupational injuries among Korean firefighters: the nationwide cross-sectional study

ABSTRACT

Objective: Firefighters belong to an occupation with a high risk of injury and are exposed to physical and psychological stress. Until now, only a few systematic approaches to the association between job stress and occupational injuries among firefighters exist.

Methods: A survey was conducted among 25,615 firefighters; 83.6% responded to our questionnaire. Individuals with less than 12 months of current job experience were excluded, and 20,411 firefighters were analyzed. To investigate the association between job stress and occupational injuries, we used the following statistical methods: the chi-square test, Cochran-Armitage trend test, multivariate logistic regression model, zero-inflated negative binomial regression model.

Results: Among fire suppression personnel, emergency medical service workers, and officers, High job demands were associated with occurrence of occupational injury. High job demands also increased the number of injuries among fire suppression personnel and officers, but not among emergency medical service workers. Low job control was not related to occurrence of occupational injury among all duties of subjects. However, low job control increased the number of injuries among fire suppression personnel.

Conclusion: Among most firefighters, high job demands were closely related to the occurrence and the number of occupational injuries. However, effect of job control on occupational injuries was unclear.

Strengths and limitation of this study

This is a nationwide study involving the entire firefighters of Korea.

There have been only a few systematic approaches to the association between job stress and occupational injuries among firefighters.

Major limitation is that our study is cross-sectional study based on self-reported survey.

Potential confounders such as working pattern were not included in this study.

Introduction

Firefighters are responsible for the safety of citizens, and perform functions that include fire suppression and emergency medical services (EMS). As such, firefighters are exposed to physical or chemical hazards that are leading causes of high rates of occupational injuries [1-3]. According to a report of the National Fire Protection Association (NFPA), 18,500 cases of exposure to hazards were reported, and 63,350 firefighter injuries occurred in the line of duty in 2014 at the United States [4]. According to another report, firefighters responsible for fire suppression had a 1.4–7.4 fold higher risk of non-fatal injury than did other industries [5].

Many studies on factors affecting occupational injury have been conducted to reduce the injury rates among firefighters. A study by Fabio et al. showed that occupational injuries among firefighters were influenced by work environments such as the number of alarms, grades of fire, number of structural stories at the scene, work intensity, civilian injury, time of incident, and number of pumpers [6]. Other researchers reported that long working hours [7] and shift work [8 9] could increase the risk of occupational injury. Yet another study examined the impact of individual characteristics such as obesity [10-12], moderate or heavy alcohol drinking [13 14], daytime sleepiness [15 16], sleep habits and insomnia [17 18], and obstructive sleep apnea [19] on workers' risk for occupational injuries.

Separately, other researchers also examined whether psychological factors such as negative affectivity [20], depression symptoms [21], and mental illness [22] were risk factors for occupational injuries. As working conditions or psychological factors can influence occupational injury, recent studies have shown that occupational injury is associated with excessive workload, high cognitive demands, and low job satisfaction [23], as well as low decision latitude, conflicts with the supervisor or colleagues, and high emotional demands [24].

Although many studies to date have investigated of a variety of occupations, there have been a few systematic approaches to the association between job stress and occupational injuries among firefighters. In this study, which is based on a survey of all Korean firefighters, we aimed to address this very issue in Korea.

Methods

Study subjects and methods

This cross-sectional study was conducted via a survey targeting firefighters in South Korea between July and November 2007. To explain the questionnaire and increase the response rate of the survey, survey was conducted by cooperating with the health managers in each fire station. A questionnaire was mailed to 30,630 total firefighters; 25,615 (83.6%) responded, although respondents with less than 12 months of current job experience were excluded (n = 5,204). These self-reporting structured questionnaires were used to investigate characteristics of subjects, frequency of occupational injury, and job stress. Basic characteristics included age group, marital status, smoking status, alcohol consumption, frequency of exercise, education, current job categories, current job experience, and occupational exposures. This study was approved by the Institutional Review Board (IRB) of Dongguk University Ilsan Hospital (2014-82). All authors got written informed consents for their participation.

Occupational characteristics and injury

In the current survey, subjects were asked to reply the question; "How many times have you experienced injury in workplace which required medical care during past 12 months?" Therefore, occupational injuries in this study were restricted only to events related to the firefighter's duties. Furthermore, minor injuries; i.e., those that did not require medical care, were excluded. Because a few occupational injuries were occurred in short period, the period that incidence of occupational injuries was enough to analyze was established as standard for definition of occupational injury in this study. Therefore, occupational injuries within last 12 months were measured. Firefighters included all workers who worked for a fire department and its related-services: fire suppression (extinguishing a fire),

paramedics (providing emergency medical care), rescue workers (rescuing people who are trapped or in medical emergencies), special investigators (investigating a cause of fire), informatics training officers (training other firefighters), and others[25]. These jobs were categorized into fire suppression, EMS (includes paramedics and rescue), and officers (including administrators, special investigators, and communicational and informational system operators).

Job stress

Job stress was identified through the short form of the Korean Occupational Stress Scale (KOSS-SF), which was structured questionnaire to estimate the job stress of Korean employees[26]. KOSS-SF was based on the most commonly used job stress questionnaires such as JCQ, NIOSH and OSI. This scale is comprised of 7 subscales and 24 items: job demand (4 items), job control (4 items), interpersonal conflict (3 items), job insecurity (2 items), organizational system (4 items), lack of reward (3 items), and occupational climate (4 items). Each item allowed 4 possible responses: 'strongly disagree', 'disagree', 'agree', or 'strongly agree'. Each response is given a score from 1 to 4 when higher scores mean higher job stress, and 4 to 1 when low scores mean higher job stress. The scores for each subscale was summed, and converted into 100 points. Cronbach's alpha coefficient for each subscale was calculated to evaluate the internal reliability of KOSS-SF, which ranged between 0.51 and 0.82. In this study, Subscales of job demand and job control were investigated, and Cronbach's alpha coefficient for job demand was 0.60, and 0.64 for job control. KOSS-SF also showed an acceptable validity by analyzing internal consistency and factor analysis[26]. KOSS-SF recommended using the dichotomized scores at the median of total study population. Therefore, the scores of each job stress were dichotomized at the median of the total firefighters[26] (Table 1).

Table 1. Reference values and contents of KOSS-SF

Job stress scale	Range of score	Mean±SD (male)	Mean±SD (female)	Cronbach's alpha	Contents	Questions
Job demands	0 - 100[a]	56.3	56.3	0.6	Time pressure	Due to many things to do, I always feel time pressure
					Increasing workload	My job has become increasingly overloading
					Excessive work	My work requires a long lasting concentration
					Multiple functioning	I have to do various jobs simultaneously
Job control	0 - 100 [b]	48.4	50.4	0.64	Noncreative work	My work requires creativity.
					Skill underutilization	My work requires a high level of skill or knowledge
					Little or no decision-making	I can make my own decision in my job and give influence over the work
					Low control	I can control my work pace and time schedule

[a] Higher score means high job demands

[b] Higher score means low job control

SD, Standard deviation

Occupational exposure

Firefighters have been exposed to various hazards, which are directly linked to occupational injury. Thus, clarifying the effects of numerous exposures on occupational injury of firefighters, Subjects was asked to replying whether or not they have undergone the 12 hazardous conditions and materials once or more in workplace; overload (lifting a heavy object repetitively), inadequate posture (working in an uncomfortable posture for a long time), lack of lighting (working in a darkness), excessive heat or cold (working in an excessively hot or cold condition), noise (exposed to loud noise at work), vibration (exposed to vibration at work), dust (exposed to dust at work; metallic dust, welding fume, grain dust, asbestos), organic solvent (exposed to organic solvent at work; thinner, gasoline, light oil, kerosene oil, normal hexane, benzene, trichloroethylene, and unknown organic solvents), other chemical agents (exposed to chemical agents at work; chloroform, carbon tetrachloride, dimethylformamide, carbon disulfide, pesticide, urethane, epoxy resin, and other unknown chemical agents), metals (exposed to metals at work; lead, chrome, nickel, mercury, cadmium, aluminum, and other unknown metals), biological agents (exposed to biological agents at work; droplet, blood), and radiation (exposed to radiation at work; non-destructive test).

Other confounding variables

Smoking habit was categorized as current smoker, ex-smoker, and never smoker. Alcohol consumption was categorized into drinker vs. non-drinker. Regular physical activity was defined as either <3 times or ≥3 times of exercise per week. Education levels were categorized into <12 years of schooling vs. ≥12 years (high school or above). Marital status was categorized into married and living with a spouse vs. other (never married, divorced, etc.).

Statistical Methods

All study subjects were divided into 2 groups: those that have experienced occupational injury during the previous 12 months and those that had not. Injuries according to occupational and demographic characteristics were compared by using the chi-square test and Cochran-Armitage trend test. Differences in the numbers of injuries during the previous 12 months according to job stress were analyzed using the chi-square test. Job demands and job control were used for analyzing job stress. This analysis was conducted by stratifying the jobs of firefighters as fire suppression, EMS, and officers as mentioned above.

Association between job stress and occurrence of occupational injury was identified through multivariate logistic regression model with adjustment for potential confounders that affect occupational injury on univariate analysis: sex, age group, marital status, smoking status, current job, and occupational exposures. The number of occupational injuries is counted variables that were commonly analyzed by Poisson regression model, negative binomial regression model. In this study, it was found that the distribution of the number of injuries was overdispersed and zero-inflated. Thus, to handle the distribution, we selected a zero-inflated negative binomial regression model[2728]. The model was used to analyze the association between job stress and the number of occupational injuries. The incidence rate ratio (IRR) and 95% CI were calculated by adjusting all confounding variables.

In terms of occurrence of occupational injury, the interaction of job demands and job control was analyzed by dividing workers into 4 groups: those who have high job demands and low job control, those who have high job demands and high job control, those who have low job demands and low job control, and those who have low job demands and high job control. The interaction was calculated by

multivariate logistic regression model with adjustment for confounding variables. In this study, P values below 0.05 were considered statistically significant. Statistical analysis was performed using the SAS 9.2 software (SAS Institute Inc., Cary, NC, USA.)

Result

General characteristics

Over 12 months, 2,358 (11.55%) subjects experienced occupational injury. Subjects were composed of 19,426 men and 985 women. There were significant differences between occurrence of injuries (injured vs. not injured) for sex, age, marriage status, smoking status, alcohol consumption, current job, and occupational exposures (Table 2).

Table 2. General characteristics of subjects stratified by occurrence of occupational injury

Characteristics		Not injured	Injured[a]	p-value[b]
Number of subjects		18053	2358	
Sex	Male	17170 (95.11)	2256 (95.67)	0.228
	Female	883 (4.89)	102 (4.33)	
Age group	less than 30	1375 (7.61)	218 (9.24)	<0.001[c]
(years)	30 to 39	7561 (41.87)	1157 (49.05)	
	40 to 49	7059 (39.09)	807 (34.21)	
	50 and over	2062 (11.42)	177 (7.50)	
Marriage status	with spouse	15429 (85.45)	1954 (82.83)	<0.001
	others	2628 (14.55)	405 (17.17)	
Smoking status	Current smokers	6321 (36.93)	808 (36.10)	<0.001
	Former smokers	1278 (7.47)	226 (15.03)	
	Never smokers	9517 (55.60)	1204 (53.80)	
Alcohol consumption	Drinker	15972 (88.45)	2082 (88.26)	0.780
	Non-drinker	2085 (11.55)	277 (11.74)	
Frequency of exercise	<3	10548 (58.42)	1355 (57.44)	0.366
(times/week)	≥3	7509 (41.58)	1004 (42.56)	
Education (years)	≤12	7122 (39.44)	910 (38.58)	0.547
	>12	10935 (60.56)	1449 (61.42)	
Current job	Fire suppression	9204 (50.97)	1143 (48.45)	<0.001
	EMS	4629 (25.64)	943 (39.97)	
	Officer	4224 (23.39)	273 (11.57)	
Current job experience (years)	1 to 4	8036 (44.50)	999 (42.35)	<0.926[c]
	5 to 9	3397 (18.81)	487 (20.64)	
	10 to 14	3547 (19.64)	524 (22.21)	
	15 and over	3077 (17.04)	349 (14.79)	
Overload	Exposed	10712 (62.47)	1927 (84.78)	<0.001
	Not exposed	6435 (33.14)	346 (15.22)	
Inadequate posture	Exposed	9074 (53.14)	1691 (74.99)	<0.001
	Not exposed	8001 (46.86)	564 (25.01)	
Lack of lighting	Exposed	8369 (48.88)	1581 (70.08)	<0.001
	Not exposed	8754 (51.12)	675 (29.92)	
Excessive heat or cold	Exposed	8035 (46.80)	1547 (68.33)	<0.001
	Not exposed	9133 (53.20)	717 (31.67)	
Noise	Exposed	8945 (52.02)	1652 (72.94)	<0.001
	Not exposed	8251 (47.98)	613 (27.06)	
Vibration	Exposed	6091 (35.50)	1234 (54.60)	<0.001

	Not exposed	11069 (64.50)	1026 (45.40)	
Dust	Exposed	9169 (53.12)	1669 (73.59)	<0.001
	Not exposed	8092 (46.88)	599 (26.41)	
Organic solvent	Exposed	6711 (38.88)	1340 (58.90)	<0.001
	Not exposed	10548 (61.12)	935 (41.10)	
Other chemical agents	Exposed	6751 (39.11)	1362 (60.00)	<0.001
	Not exposed	10512 (60.89)	908 (40.00)	
Metals	Exposed	4840 (28.03)	1058 (46.51)	<0.001
	Not exposed	12426 (71.97)	1217 (53.49)	
Biological agents	Exposed	5681 (32.84)	1276 (56.04)	<0.001
	Not exposed	11616 (67.16)	1001 (43.96)	
Radiation	Exposed	1823 (10.51)	419 (18.39)	<0.001
	Not exposed	15522 (89.49)	1860 (81.61)	

[a]Cases that undergo medical treatment due to the occupational injury for last 12 months

[b]p values that calculated by chi-square test

[c]p values for trend that calculated by cochran-Armitage trend test

Relationship of job stress and the number of injuries

In terms of job stress, those individuals with a high job demands experienced more occupational injuries among all firefighters ($P < 0.001$). Stratified by job categories, more occupational injuries occurred in the high job demands group than in all other job categories. In the low job control group, only firefighters working as fire suppression personnel experienced more occupational injuries, whereas EMS workers and officers did not (Table 3).

Table 3. Distribution of the number of injuries according to job stress

Occupational stress scale			Number of injuries[a] 0	1	2	3	4 or more	p-value[b]
Total firefighters								
	Job demand	Low	7949 (91.80)	383 (4.42)	118 (1.36)	84 (0.97)	125 (1.44)	<0.001
		High	10104 (85.98)	737 (6.27)	362 (3.08)	175 (1.49)	374 (3.18)	
	Job control	High	7685 (89.01)	475 (5.50)	182 (2.11)	97 (1.12)	195 (2.26)	0.063
		Low	10368 (88.04)	645 (5.48)	298 (2.53)	162 (1.38)	302 (2.58)	
Fire suppression								
	Job demand	Low	4029 (91.94)	200 (4.56)	59 (1.35)	35 (0.80)	59 (1.35)	<0.001
		High	5173 (86.75)	381 (6.39)	153 (2.57)	93 (1.56)	163 (2.73)	
	Job control	High	4604 (89.66)	297 (5.78)	92 (1.79)	52 (1.01)	90 (1.75)	0.003
		Low	4598 (88.25)	284 (5.45)	120 (2.30)	76 (1.46)	132 (2.53)	
Emergency medical services								
	Job demand	Low	1808 (86.80)	138 (6.63)	49 (2.35)	36 (1.73)	52 (2.50)	<0.001
		High	2820 (80.87)	268 (7.69)	172 (4.93)	69 (1.98)	158 (4.53)	
	Job control	High	1709 (83.77)	135 (6.62)	72 (3.63)	38 (1.86)	84 (4.12)	0.3859
		Low	2919(82.69)	271 (7.68)	147 (4.16)	67 (1.90)	126 (3.57)	
Officer								
	Job demand	Low	2112 (96.26)	45 (2.05)	10 (0.46)	13 (0.59)	14 (0.64)	<0.001
		High	2111 (91.70)	88 (3.82)	37 (1.61)	13 (0.56)	53 (2.30)	
	Job control	High	1372 (94.04)	43 (2.95)	16 (1.10)	7 (0.48)	21 (1.44)	0.9775
		Low	2851 (93.88)	90 (2.96)	31 (1.02)	19 (0.63)	46 (1.51)	

[a]Cases that undergo medical treatment due to the occupational injury for last 12 months

[b]p values that calculated by chi-square test

Analysis of occupational injury according to job stress by multivariate logistic regression model and zero-inflated negative binomial regression model

Odds ratio (OR) was calculated by multivariate logistic regression model to identify the association between job stress and occurrence of occupational injury. Among all firefighters, high job demands (odds ratio [OR] 1.28, 95% confidence interval [CI] 1.16–1.42) were associated with occurrence of occupational injury, but low job control did not show a statistically significant difference (OR 1.06, 95% CI 0.96–1.17). For fire suppression personnel, OR was 1.30 in high job demands group (95% CI 1.12–1.50), and 1.07 in low job control group (95% CI 0.93–1.22). For EMS workers, OR was 1.25 in high job demands group (95% CI 1.05–1.48), and 0.99 in low job control group (95% CI 0.84–1.16). For officers, OR was 1.58 in high job demands group (95% CI 1.16–2.14), and 1.00 in low job control group (95% CI 0.75–1.34).

The incidence rate ratio (IRR) of the number of occupational injuries were calculated by zero-inflated negative binomial regression model comparing subjects with high job stress to low job stress. In all firefighters, high job demands (incidence rate ratio [IRR] 1.43, 95% confidence interval [CI] 1.22-1.67) increased the number of occupational injuries that they have experienced during 12 months. High job demands also had relation to increased number of occupational injuries among fire suppression personnel (IRR 1.45, 95% CI 1.16–1.81) and officers (IRR 2.49, 95% CI 1.67-3.72), except emergency service worker. Low job control only increased the number of injuries among fire suppression personnel (IRR 1.48, 95% CI 1.19-1.83) (Table 4).

Table 4. The relationship between job stress and occupational injury

Job stress scale[a]			OR[b]	(95% CI)	IRR[c]	(95% CI)
Total firefighters						
	Job demand	Low	1.00		1.00	
		High	1.28	(1.16 - 1.42)	1.43	(1.22 - 1.67)
	Job control	High	1.00		1.00	
		Low	1.06	(0.96 - 1.17)	1.17	(1.01 - 1.36)
Fire suppression						
	Job demand	Low	1.00		1.00	
		High	1.30	(1.12 - 1.50)	1.45	(1.16 - 1.81)
	Job control	High	1.00		1.00	
		Low	1.07	(0.93 - 1.22)	1.48	(1.19 - 1.83)
Emergency medical services						
	Job demand	Low	1.00		1.00	
		High	1.25	(1.05 - 1.48)	1.04	(0.78 - 1.40)
	Job control	High	1.00		1.00	
		Low	0.99	(0.84 - 1.16)	0.85	(0.70 - 1.04)
Officer						
	Job demand	Low	1.00		1.00	
		High	1.58	(1.16 - 2.14)	2.49	(1.67 - 3.72)
	Job control	High	1.00		1.00	
		Low	1.00	(0.75 - 1.34)	1.33	(0.89 - 1.99)

[a]All high risk group of job stress scale was compared to low risk group.

[b]Odds ratio and 95% CI calculated from logistic regression model adjusted for sex, age group, marriage status, smoking status, current job, occupational exposures

[c]Incidence rate ratio and 95% CI calculated from zero-inflated negative binomial regression model adjusted for sex, age group, marriage status, smoking status, current job, occupational exposures

OR, odds ratio; IRR, incidence rate ratio; CI, confidence interval

Interaction of job demands and job control

Association between occurrence of occupational injury and two job stress scales was analyzed to identify an interaction between job demands and job control. In 4 groups divided by job demands and job control, odds ratio was estimated by multivariate logistic regression model with adjustment for confounding variables. When subjects had high job demands and low job control, firefighters except officers had the highest risk of experiencing occupational injury. However, there was no statistically significant interaction between job demands and job control. Differences in risk of the high job stress vs. low job stress were higher with respect to job demands (Figure 1).

Discussion

This study showed that excessive job stress is related to the occurrence and the number of occupational injuries in Korean firefighters. Many recent studies investigated occupational injury due to physical and chemical exposure, as well as psychological factors including job stress. However, the association of job stress and occupational injuries among firefighters has rarely been examined. Our study is meaningful because it is a nationwide survey involving the entire firefighter force of Korea, and reveals the association between job stress and the number of occupational injuries in Korean firefighters after adjusting for confounding variables.

Some studies report different impacts of job demands and low job control on occupational injury according to gender and occupation. In a study of Korean small-to-medium sized manufacturing enterprises, male workers with highly demanding jobs had a higher risk of occupational injury (OR 1.71, 95% CI 1.13–2.59). However, low job control did not increase the risk of occupational injury in male workers (OR 1.08, CI 0.72–1.63). In female workers, high job demands was associated with a high-risk of occupational injury (OR 2.11, 95% CI 1.18–3.78), as was low job control (OR 1.80, CI 1.02–3.17) [29]. A study from Japan showed that high quantitative workloads (OR 1.55, 95% CI 1.24–1.98), high variance in workload (OR 1.70, 95% CI 1.32–2.17), high cognitive demands (OR 1.31, 95% CI 1.03–1.67), and low job security (OR 1.35, 95% CI 1.05–1.72) were associated with occupational injury in males working in small-to-medium sized manufacturing enterprises. Among female workers, high quantitative workload (OR 1.62, 95% CI 1.07–2.44), high cognitive demands (OR 1.53, 95% CI 1.02–2.31), low job control (OR 2.04, 95% CI 1.30–3.18), and high rates of intragroup conflicts in the workplace (OR 1.66, 95% CI 1.08–2.55) were related to a high-risk of occupational workplace injury [23]. High job demands were related to increased risk of occupational injury in various occupation and both genders. However, the effect of excessive stress as it relates to job control increased the risk of

occupational injury among female workers of other occupations, but the impact of job control on male workers is not clear. In our study, because there were a small number of female firefighters, we did not stratify the data by gender, and we just adjusted it. Male firefighters of this study with high job demands had increased risk of occupational injuries, but there was no statistical significance within female firefighters with high job demands. Both male and female firefighter with low job control did not have an increased risk of occupational injuries. Along with gender, occupation and location of work are representative job-related factor affecting the risk of occupational injuries[30]. Therefore, association between job stress and risk of occupational injuries can be affected by worker's job. Among firefighters, EMS personnel and officers can communicate with each other when they are faced with a challenging situation. In contrast, fire suppression personnel can face situations where co-worker communication is severed because the job of tackling a fire may sometimes become unpredictable, and firefighters are often isolated in such situations; this environment can be hazardous and lead to occupational injuries.

Elements that make up the Job stress is a very diverse, and many researchers have defined a variety of job stressor. Karasek presented Job-Demand-Control model, and put the job demands and job control as precedence factor of job stress[31]. On the basis of this model, Impacts of job demands and control on physical and psychological health have been identified by many studies[32 33]. Furthermore, it is revealed that the relevance of the elements was associated with safety in the workplace such as safety performance and accident[34 35]. Therefore, in this study, we set the job demands and control to important elements of the job stress, and focused on figuring out the association between job stress and occupational injury.

Our study had some limitations as follows. First, because the study was conducted using a self-reported survey, recall or reporting bias may have occurred. However, because severe cases of injuries are more easily remembered, the fact that our study design surveyed only injuries that required medical

care may minimize recall bias. Self-reported survey methods also carry the limitation that the characteristics of non-respondents, and their effect on our results, could not be determined. Moreover, since workers who are hospitalized, retired, or deceased cannot response to the survey, a bias towards healthy workers may have occurred. Hence, our current study might underestimate severe injuries cases. If this study included non-respondents, it is possible that our final results would be different. Second, confounding variables such as working patterns, hours of duty, sleep patterns, and type of injury were not included, although these may have an influence on the relationship between job stress and occupational injuries. Third, because the study design was cross-sectional, we could not establish a causal relationship, and were only able to identify the association between job stress and occupational injuries. The results of our study can be interpreted that the number of occupational injuries has impact on job stress. Thus, careful interpretation of the result will be needed. However, the advantage of this study is that it was nationwide and included the entire firefighter force in Korea.

In summary, our study showed that high job demands were related to increased occurrence and number of occupational injuries in the majority of firefighters. However, low job control was only associated with the number of occupational injuries among fire suppression personnel. This study suggested what elements of job stress should be considered to prevent occupational injuries among firefighters. Thus, the results can be used to manage job stress for minimizing occupational injuries among firefighters.

Contributors

Y-KK designed the study, analyzed and interpreted the data, and drafted and revised the manuscript. Y-SA interpreted the data and revised the manuscript. K-SK suggested the study design and revised the

manuscript. J-HY suggested the study design, interpreted the data, and reviewed the manuscript.

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Competing interest

None declared.

Ethic approval

The Institutional Review Board (IRB) of Dongguk University Ilsan Hospital

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Data sharing statement

No additional data are available.

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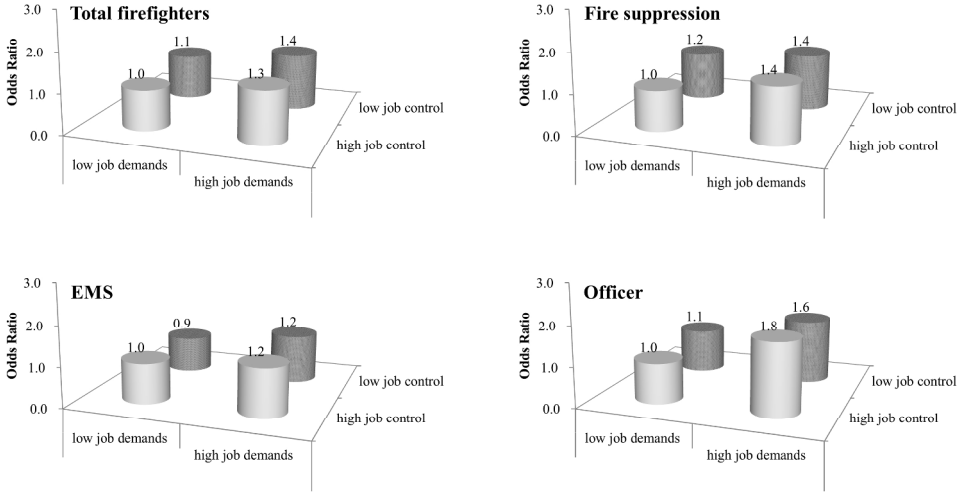

Figure 1. Adjusted ORs of occurrence of occupational injury obtained from multivariate logistic regression model by categories of job demands and job control

254x138mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No.
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5, 6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7, 8, 9, 10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	11
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7, 8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11
		(*b*) Describe any methods used to examine subgroups and interactions	11, 12
		(*c*) Explain how missing data were addressed	7, 11

		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	7
		(*e*) Describe any sensitivity analyses	8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	7
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7, 8, 9, 10
		(b) Indicate number of participants with missing data for each variable of interest	13, 14
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	16, 17
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	18, 19
		(*b*) Report category boundaries when continuous variables were categorized	8, 9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	20
Discussion			
Key results	18	Summarise key results with reference to study objectives	21
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	22, 23
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	21, 22, 23
Generalisability	21	Discuss the generalisability (external validity) of the study results	21
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	24

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Association between job stress and occupational injuries among Korean firefighters: a nationwide cross-sectional study

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Title page:

Association between job stress and occupational injuries among Korean firefighters: a nationwide cross-sectional study

Authors

Yeong-Kwang Kim[1, 2, 3], Yeon-Soon Ahn[3], KyooSang Kim[4], Jin-Ha Yoon[1, 2, 3], Jaehoon Roh[1, 2, 3*]

Affiliations

[1]The Institute for Occupational Health, Yonsei University College of Medicine, Seoul, Korea

[2]Department of Preventive Medicine and Public Health, Yonsei University College of Medicine, Seoul, Korea

[2]Graduate school of Public Health, Yonsei University, Seoul, Korea

[3]Department of Occupational and Environmental Medicine, Dongguk University Ilsan Hospital, Goyang, Korea

[4]Department of Occupational and Environmental Medicine, Seoul Medical Center

*Correspondence to this work

Jaehoon Roh, MD, PhD

The Institute for Occupational Health, Department of Preventive Medicine,

Yonsei University College of Medicine

50 Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea.

Tel: +82.2-222-1906, Fax: +82.2-392-8622

Email: ys.jhroh@gmail.com

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ABSTRACT

Objective: To date, only a few systematic studies of the association between job stress and occupational injuries among firefighters exist. We aimed to assess the nature of this association using a nationwide database in Korea.

Design: We conducted a cross-sectional nationwide survey using self-reported questionnaires. We used the chi-square test, Cochran-Armitage trend test, multivariate logistic regression model, and zero-inflated negative binomial regression model to investigate the association between job stress and occupational injuries.

Setting: South Korea

Participants: A survey was conducted among 30,630 firefighters; 25,616 (83.6%) responded to our questionnaire. Our study included firefighters 20–59 years old. Individuals with less than 12 months of current job experience and those with missing data were excluded; ultimately, 14,991 firefighters were analyzed.

Results: Among the investigated firefighters, high job demand, high interpersonal conflict, a poor organizational system, and a negative workplace environment were associated with the occurrence of occupational injury; high job demand was also associated with the frequency of injuries. Among emergency medical services personnel, high job demands, high interpersonal conflict, a poor organizational system, lack of reward, and a negative workplace environment were associated with the occurrence of occupational injury; low job control, high interpersonal conflict, lack of reward, and a negative workplace climate were also associated with a greater number of injuries. Among officers, high

job demands and a negative workplace environment were associated with the occurrence of occupational injuries; however, there was no significant correlation between job stress and the number of injuries.

Conclusion: High job stress among firefighters was not only associated with the occurrence of occupational injury, but also with an increased frequency of injuries.

Key words: firefighters, job stress, nationwide survey, occupational injuries.

Strengths and limitation of this study

This is a nationwide study including all the firefighters of Korea.

There have been only a few systematic studies of the association between job stress and occupational injuries among firefighters.

A major limitation is that our study is cross-sectional and based on self-reported surveys.

Potential confounders, such as working patterns, were not taken into account in this study.

INTRODUCTION

Firefighters are responsible for the safety of citizens, and perform functions that include fire suppression and emergency medical services (EMS). As such, they are exposed to physical or chemical hazards that lead to high rates of occupational injuries.[1-3] According to a report by the National Fire Protection Association, 18,500 cases of exposure to hazards were reported, and 63,350 injuries occurred in the line of duty, in the United States in 2014.[4] According to another report, firefighters responsible for fire suppression had a 1.4–7.4-fold higher risk of non-fatal injuries than did workers in other industries.[5]

Factors that affect occupational injury among firefighters have been investigated. A study by Fabio et al. showed that such injuries were influenced by work environments such as the number of alarms, grades of fire, number of structural stories at the scene, work intensity, civilian injury, time of incident, and number of pumpers.[6] Other studies reported that obesity was associated with increased injuries among firefighters.[7-8]

Various factors affecting occupational injury have been reported for other occupations, including long working hours [9] and shift work.[10 11] Individual characteristics such as obesity [8 12 13] and moderate or heavy alcohol consumption[14 15] also play a role. Separately, other researchers also examined whether psychological factors such as negative affectivity,[16] depression symptoms,[17] and mental illness[18] were risk factors for occupational injuries. In terms of job stress, Recent studies have shown that occupational injury is associated with excessive workload, high cognitive demands, and low job satisfaction, high intragroup conflict, job insecurity,[19] low decision latitude, conflicts with the supervisor or colleagues,[20] lack of organizational support,[21] poor physical environment, unfair reward and treatment,[22] verbal abuse and low predictability,[23] and organizational injustice.[24]

Despite a plethora of studies, there have been only a few systematic investigations to identify factors influencing occupational injuries among firefighters. In this study, which is based on a survey of all Korean firefighters, we aimed to investigate the existence of a correlation between job stress and occupational injury among firefighters.

METHODS

Study subjects and methods

This cross-sectional study was conducted via a survey targeting firefighters in South Korea between July and November 2007. To explain the questionnaire and increase the response rate, the survey was conducted in coordination with the health managers at each fire station. A questionnaire was mailed to 30,630 firefighters; 25,615 (83.6%) responded. The self-reporting structured questionnaires were used to investigate the characteristics of subjects, frequency of occupational injury during the previous 12 months, and job stress at the current place of employment. Hence, 5,165 respondents who had less than 12 months' experience in the current task job were excluded. We also excluded 5,310 firefighters with missing basic data (sex, age, marital status, smoking status, alcohol consumption, frequency of exercise, education, current job category, current job experience, occupational exposures, or job stress). Ultimately, data of 14,991 firefighters who were 20–59 years old were analyzed. This study was approved by the Institutional Review Board of Dongguk University Ilsan Hospital (2014-82). All subjects provided written informed consent for their participation.

Occupational characteristics and injury

In the survey, subjects were asked to reply to the question; "How many times have you experienced injury in the workplace that required medical care during the past 12 months?" Hence, occupational injuries in this study were restricted only to events related to the firefighters' duties. Furthermore, minor injuries; i.e., those that did not require medical care, were excluded. Occupational injuries within the previous 12 months were recorded because only a few such injuries occurred within shorted durations. Firefighters included all workers employed at a fire department and its related services, including: fire

suppression (extinguishing a fire), paramedics (providing emergency medical care), rescue workers (rescuing people who are trapped or in medical emergencies), special investigators (investigating a cause of fire), informatics training officers (training other firefighters), and others.[25] These jobs were categorized into fire suppression, EMS (includes paramedics and rescue), and officers (including administrators, special investigators, and communicational and informational system operators).

Job stress

Job stress was identified according to the short form of the Korean Occupational Stress Scale (KOSS-SF), which was a structured questionnaire to estimate the job stress of Korean employees.[26] KOSS-SF was based on the most commonly used job stress questionnaires such as the JCQ(Job Content Questionnaire), NIOSH(National Institute of Occupational Safety and Health) job stress questionnaire, and OSI(Occupational Stress Index). This scale is comprised of 7 subscales and 24 items: job demand (4 items), job control (4 items), interpersonal conflict (3 items), job insecurity (2 items), organizational system (4 items), lack of reward (3 items), and workplace environment (4 items). Each item allowed 4 possible responses: ‘strongly disagree’, ‘disagree’, ‘agree’, or ‘strongly agree’. Subscale scores were the sum of each item, which was then converted into 100 points. Cronbach’s alpha coefficient for each subscale was calculated to evaluate the internal reliability of the KOSS-SF, which ranged between 0.51 and 0.82. In this study, Cronbach’s alpha coefficient for subscales of job stress ranged from 0.55 to 0.77. The KOSS-SF also showed acceptable validity by analyzing internal consistency and factor analysis;[26] it also recommended using scores dichotomized around the median for the total study population. Therefore, the scores of each job stress were dichotomized at the median of the total firefighters (Table 1).[26]

Table 1. Reference values and contents of KOSS-SF

Job stress subscales	Range of score[a]	Mean ± SD[b] (male)	Mean ± SD[b] (female)	Cronbach's alpha[b]	Contents	Questions
Job demands	0–100	59.7 ± 16.0	61.1 ± 17.2	0.69	Time pressure	Because of my workload, I always feel time pressure[c]
					Increasing workload	My job has become increasingly overbearing[c]
					Excessive work	My work requires long lasting concentration[d]
Job control	0–100	51.7 ± 14.7	49.4 ± 13.0	0.55	Multiple functions	I have to do various jobs simultaneously[c]
					Noncreative work	My work requires creativity[d]
					Skill underutilization	My work requires a high level of skill or knowledge[d]
					Little or no decision-making	I can make my own decisions in my job and have influence over the work[d]
					Low control	I can control my pace of work and time schedule[d]
Interpersonal conflict	0–100	40.6 ± 14.3	39.3 ± 13.9	0.66	Inadequate supervisor support	My supervisor is helpful in getting the job done[d]
					Inadequate coworker support	My coworker is helpful in getting the job done[d]
					Lack of emotional support	I have someone who understands my difficulties at work[d]
Job insecurity	0–100	51.6 ± 17.9	56.4 ± 17.2	0.57	Uncertainty	My future is uncertain because the current situation of my company is unstable[c]
					Negative changes to my job	Undesirable changes (i.e. downsizing) will come to my job.
Organizational system	0–100	55.5 ± 16.5	54.3 ± 15.4	0.77	Unfair organizational policy	The organizational policy of my company is fair and reasonable[d]
					Unsatisfactory organizational support	My company provides me with sufficient organizational support[d]
					Inter-departmental conflict	Departments cooperate each other without conflicts[d]
					Limitation of communication	I have opportunities and channels to talk about my ideas[d]
Reward	0–00	50.3 ± 16.5	51.0 ± 15.2	0.73	Unsatisfactory salary	My salary is not commensurate with my effort and work performance[d]
					Future ambiguity	I believe that I will be given more rewards from my company if I work hard[d]
					Interruption of opportunity	I am provided with the opportunity to develop my capacity[d]
Workplace environment	0–100	47.0 ± 15.8	49.2 ± 16.5	0.68	Collective culture	Dining out after work makes me uncomfortable[c]
					Inconsistency of job order	I am asked to do my work with irrational principles or inconsistency[c]
					Authoritarian climate	My company climate is authoritative and hierarchical[c]
					Gender discrimination	I am at a disadvantage because I am a woman[c]

[a] The subscale scores were the sum of each item, which was converted into 100 points; a higher score means higher job stress
[b] Mean, standard deviation, and Cronbach's alpha were the values used in this study
[c] Each question allowed 4 possible responses: 'strongly disagree', 'disagree', 'agree', or 'strongly agree', which is given a score from 1 to 4
[d] Each question allowed 4 possible responses: 'strongly disagree', 'disagree', 'agree', or 'strongly agree', which is given a score from 4 to 1
KOSS-SF, Short form of Korean Occupational Stress Scale; SD, Standard deviation

Occupational injuries

Firefighters have been exposed to various hazards that are directly linked to occupational injury. To clarify the effects of numerous such exposures, subjects were asked whether or not they have experienced the following 12 hazardous conditions and/or exposure to materials in the workplace at least once: overload (lifting a heavy object repetitively), inadequate posture (working in an uncomfortable posture for a long time), lack of lighting (working in darkness), excessive heat or cold (working in an excessively hot or cold environment), noise (exposed to loud noise at work), vibration (exposed to vibration at work), dust (exposed to metallic dust, welding fume, grain dust, asbestos, or other agents at work), organic solvents (exposed to organic solvents such as thinner, gasoline, light oil, kerosene oil, normal hexane, benzene, trichloroethylene, and unknown organic solvents at work), other chemical agents (exposed to chemical agents such as chloroform, carbon tetrachloride, dimethylformamide, carbon disulfide, pesticide, urethane, epoxy resin, and other unknown chemical agents at work), metals (exposed to metals such as lead, chrome, nickel, mercury, cadmium, aluminum, and other unknown metals at work), biological agents (exposed to biological agents such as blood and other droplets or fluids at work), and radiation (exposed to non-destructive radiation at work).

Other confounding variables

Smokers were categorized as current smokers, ex-smokers, and never smokers. The Alcohol Use Disorders Identification Test (AUDIT)[27] was used to identify hazardous drinkers among firefighters. Subjects were categorized into hazardous drinkers (AUDIT score ≥8) vs. non-hazardous drinkers (AUDIT score <8).[28] Regular physical activity was divided into exercising either <3 times or ≥3 times per week. Education levels were categorized into <12 years of schooling vs. ≥12 years (high school or

above). Marital status was categorized as married and living with a spouse vs. other (never married, divorced, etc.).

Statistical Methods

All study subjects were divided into 2 groups: those who had experienced occupational injury during the previous 12 months and those who had not. Injuries according to occupational and demographic characteristics were compared by using the chi-square test and Cochran-Armitage trend test. Distribution of the numbers of injuries during the previous 12 months according to current job was also analyzed. Job demands and job control were examined for analyzing job stress; this analysis was conducted by stratifying the duties of firefighters into fire suppression, EMS, and officers as mentioned above.

Association between job stress and occurrence of occupational injury was identified through a multivariate logistic regression model with adjustment for potential confounders that affect occupational injury on univariate analysis, including sex, age group, marital status, smoking status, hazardous drinking, and occupational exposures. Some workers had one or more occupational injuries during the prior 12 months; hence, we tested whether job stress is related to the number of occupational injuries as well. The number of occupational injuries is counted variables that were commonly analyzed by Poisson regression model, negative binomial regression model. In this study, the distribution of the number of injuries was overdispersed and zero-inflated. Thus, we selected a zero-inflated negative binomial regression model to handle the distribution.[29 30] The model was used to analyze the association between job stress and the number of occupational injuries; using this method, the incidence rate ratios (IRRs) and 95% confidence intervals were calculated by adjusting all confounding variables. In this

study, P values below 0.05 were considered statistically significant. Statistical analysis was performed using the SAS 9.2 software (SAS Institute Inc., Cary, NC, USA.)

RESULTS

General characteristics

Over 12 months, 1,757 subjects comprising 14,349 men and 642 women experienced occupational injury (11.72%). There were significant differences between injured vs. not injured personnel with respect to sex, age, marriage status, smoking status, hazardous drinking, current job, and occupational exposures (Table 2).

Table 2. General characteristics of subjects stratified by occupational injury

Characteristics		Not injured n (%)	Injured[a] n (%)	P-value[b]
Number of subjects		13234 (88.28)	1757 (11.72)	
Sex	Male	12657 (88.21)	1692 (11.79)	0.200
	Female	577 (89.88)	65 (10.12)	
Age group	20–29	1042 (86.12)	168 (13.88)	<0.001[c]
(years)	30–39	5846 (86.66)	900 (13.34)	
	40–49	4998 (89.57)	582 (10.43)	
	50–59	1348 (92.65)	107 (7.35)	
Marriage status	With spouse	11215 (88.63)	1439 (11.37)	0.002
	Other	2019 (86.39)	318 (13.61)	
Smoking status	Current smokers	5220 (88.61)	671 (11.39)	0.003
	Never smokers	1022 (85.24)	177 (14.76)	
	Former smokers	6992 (88.50)	909 (11.50)	
Hazardous drinking	AUDIT <8	5291 (89.06)	650 (10.94)	0.016
	AUDIT ≥8	7943 (87.77)	1107 (12.23)	
Frequency of exercise	<3	5689 (88.28)	755 (11.72)	0.989
(times/week)	≥3	7545 (88.28)	1002 (11.72)	
Education (years)	≤12	5019 (88.66)	642 (11.34)	0.260
	>12	8215 (88.05)	1115 (11.95)	
Current job	Fire suppression	6621 (88.74)	840 (11.26)	<0.001
	EMS	3432 (82.60)	723 (17.40)	
	Officer	3181 (94.25)	194 (5.75)	
Current job experience (years)	1–4	6196 (88.73)	787 (11.27)	<0.916[c]
	5–9	2496 (87.00)	373 (13.00)	
	10–14	2532 (87.40)	365 (12.60)	
	≥15	2010 (89.65)	232 (10.35)	
Overload	Exposed	8284 (84.66)	1501 (15.34)	<0.001
	Not exposed	4950 (95.08)	256 (4.92)	
Inadequate posture	Exposed	7086 (84.19)	1331 (15.81)	<0.001
	Not exposed	6148 (93.52)	426 (6.48)	
Lack of lighting	Exposed	6495 (83.95)	1242 (16.05)	<0.001
	Not exposed	6739 (92.90)	515 (7.10)	
Excessive heat or cold	Exposed	6260 (83.88)	1203 (16.12)	<0.001
	Not exposed	6974 (92.64)	554 (7.36)	
Noise	Exposed	6921 (84.22)	1297 (15.78)	<0.001
	Not exposed	6313 (93.21)	460 (6.79)	

Vibration	Exposed	4725 (82.79)	982 (17.21)	<0.001
	Not exposed	8509 (91.65)	775 (8.35)	
Dust	Exposed	7137 (84.49)	1310 (15.51)	<0.001
	Not exposed	6097 (93.17)	447 (6.83)	
Organic solvent	Exposed	5209 (83.22)	1050 (16.78)	<0.001
	Not exposed	8025 (91.90)	707 (8.10)	
Other chemical agents	Exposed	5237 (83.03)	1070 (16.97)	<0.001
	Not exposed	7997 (92.09)	687 (7.91)	
Metals	Exposed	3759 (82.02)	824 (17.98)	<0.001
	Not exposed	9475 (91.04)	933 (8.96)	
Biological agents	Exposed	4381 (81.49)	995 (18.51)	<0.001
	Not exposed	8853 (92.07)	762 (7.93)	
Radiation	Exposed	1350 (80.94)	318 (19.06)	<0.001
	Not exposed	11884 (89.20)	1439 (10.80)	

[a]Subjects that underwent medical treatment due to the occupational injury for last 12 months

[b]P values calculated using the chi-square test

[c]P values for trend calculated using the Cochran-Armitage trend test

AUDIT, Alcohol Use Disorders Identification Test

Distribution of the number of injuries by current job

The number of firefighters who experienced injuries in the prior 12 months included 840 fire suppression personnel, 723 EMS workers, and 194 officers (Table 3). As some firefighters were injured more than once, there were 5580 injury incidents; 2691 among fire suppression personnel, 2226 in EMS workers, and 663 among officers. Including firefighters who never experienced injuries, the mean number of injuries was highest among EMS workers and lowest among officers; however, after excluding non-injured firefighters, that order was reversed (Table 4).

Table 3. Distribution of the number of injuries by current job

Current job	Subjects (n)	Number of injuries[a]					
		Total injuries	Mean ± SD[9]	Median [9]	Mean ± SD (except zero)	Median (except zero)	Maximum
Total firefighters	14991	5580	0.37±2.23	0	3.18±5.80	2	90
Fire suppression	7461	2691	0.36±2.53	0	3.20±6.93	1	90
Emergency medical services	4155	2226	0.54±2.09	0	3.08±4.17	2	40
Officers	3375	663	0.20±1.57	0	3.42±5.66	1	50

[a]Subjects who underwent medical treatment owing to occupational injury in the prior 12 months.

SD, Standard deviation

Analysis of occupational injury according to job stress

Odds ratios were calculated using a multivariate logistic regression model to identify the association between job stress and the occurrence of occupational injury. Among fire suppression personnel, high job demands, high interpersonal conflicts, a poor organizational system, and a negative workplace environment were related to the occurrence of injury. Among EMS personnel, high job demands, high interpersonal conflicts, a poor organizational system, low rewards, and a negative workplace environment were related to injury incidents. Among officers, high job demands and a negative workplace environment were associated with injury (Table 4).

The IRRs of the number of occupational injuries were calculated by a zero-inflated negative binomial regression model comparing subjects with high job stress to low job stress. Among fire suppression personnel, high job demands were associated with an increased number of injuries. Among EMS personnel, low job control, high interpersonal conflicts, low rewards, and a negative workplace environment were related to an increased number of injuries. There were no correlations between the factors investigated and injury among officers (Table 4).

Table 4. Occurrence of occupational injury (logistic regression model) and number of injuries (zero-inflated negative binomial regression model) according to job stress scales

Job stress scale[a]	OR[b]	(95% CI)	IRR[c]	(95% CI)
Total firefighters				
Job demands (high)	1.42	(1.25–1.60)	1.08	(0.95–1.22)
Job control (low)	0.93	(0.84–1.04)	0.97	(0.90–1.10)
Interpersonal conflicts (high)	1.26	(1.13–1.39)	1.06	(0.96–1.17)
Job insecurity (high)	0.83	(0.74–0.93)	0.91	(0.81–1.01)
Organizational system (poor)	1.39	(1.24–1.54)	1.02	(0.92–1.13)
Rewards (low)	1.05	(0.90–1.22)	1.09	(0.98–1.20)
Workplace environment (negative)	1.35	(1.22–1.50)	1.06	(0.96–1.18)
Fire suppression				
Job demands (high)	1.49	(1.25–1.77)	1.22	(1.01–1.47)
Job control (low)	0.92	(0.79–1.06)	0.89	(0.76–1.03)
Interpersonal conflicts (high)	1.18	(1.02–1.37)	0.97	(0.83–1.12)
Job insecurity (high)	0.73	(0.61–0.87)	0.93	(0.78–1.12)
Organizational system (poor)	1.33	(1.14–1.55)	1.00	(0.85–1.17)
Rewards (low)	1.13	(0.97–1.31)	1.10	(0.94–1.27)
Workplace environment (negative)	1.41	(1.21–1.64)	0.99	(0.85–1.16)
Emergency medical services				
Job demands (high)	1.26	(1.03–1.54)	1.05	(0.88–1.25)
Job control (low)	1.02	(0.85–1.21)	1.20	(1.04–1.38)
Interpersonal conflicts (high)	1.40	(1.19–1.66)	1.18	(1.03–1.36)
Job insecurity (high)	0.88	(0.74–1.04)	0.90	(0.78–1.04)
Organizational system (poor)	1.55	(1.30–1.85)	1.12	(0.96–1.29)
Rewards (low)	1.43	(1.21–1.69)	1.17	(1.02–1.35)
Workplace environment (negative)	1.30	(1.10–1.54)	1.16	(1.01–1.34)
Officers				
Job demands (high)	1.96	(1.35–2.85)	0.70	(0.48–1.04)
Job control (low)	1.06	(0.77–1.47)	0.91	(0.67–1.24)
Interpersonal conflicts (high)	1.22	(0.90–1.65)	0.85	(0.60–1.19)
Job insecurity (high)	0.78	(0.56–1.09)	0.93	(0.67–1.30)
Organizational system (poor)	1.28	(0.94–1.75)	0.81	(0.61–1.09)
Rewards (low)	1.12	(0.82–1.52)	0.78	(0.58–1.06)
Workplace environment (negative)	1.54	(1.13–2.10)	0.86	(0.64–1.16)

[a]All job stress scales were compared to their counterparts.

[b]OR and 95% CI were calculated using a logistic regression model adjusted for sex, age group, marriage status, smoking status, hazardous drinking, and occupational exposures.

[c]IRR and 95% CI were calculated using a zero-inflated negative binomial regression model adjusted for sex, age group, marriage status, smoking status, hazardous drinking, and occupational exposures.

CI, confidence interval; IRR, incidence rate ratio; OR, odds ratio.

DISCUSSION

This study showed that excessive job stress is related to the occurrence and the frequency of occupational injuries in Korean firefighters. Many recent studies have investigated occupational injury due to physical and chemical exposure, as well as psychological factors including job stress. However, the association between job stress and occupational injuries among firefighters has rarely been examined. Our study is meaningful because it is a nationwide survey involving the entire firefighter force of Korea; moreover, it reveals an association between job stress and the frequency of occupational injuries in Korean firefighters after adjusting for confounding variables.

In this study, high job demands were associated with the occurrence of occupational injury regardless of the nature of the current job. In a study of small-to-medium sized Korean manufacturing enterprises, workers with highly demanding jobs had a greater risk of occupational injury.[31] A study from Japan also showed that high quantitative workloads, high variance in workload, and high cognitive demands were associated with occupational injury in men working in small-to-medium sized manufacturing enterprises. Among female workers, high quantitative workloads and high cognitive demands correlated with a greater risk of occupational workplace injury.[19] The results of our study suggest that firefighters, who have high-risk jobs, also experience a greater risk of occupational injury corresponding to higher job demands.

Low job control (i.e., the ability to make decisions) was found not to be significantly associated with occupational injury among firefighters. Murata et al. showed no statistically significant effects of job control on occupational injury among blue-collar workers.[32] Nakata et al. showed that female workers in small-to-medium sized manufacturing enterprises had a higher risk of occupational injury when they had less job control.[19] Although low job control was associated with the number of occupational injuries among EMS personnel in our study, it was not associated with the occurrence of

occupational injury in either sex.

High interpersonal conflicts were associated with the occurrence of occupational injury in fire suppression and EMS personnel. A study of Finish hospital personnel showed that problems in interpersonal relationships and conflicts during collaborations at work were related to occupational injury.[33] Another study of Japanese small-to-medium sized manufacturing enterprises workers showed that female employees with high intragroup conflicts at the workplace had a higher risk of occupational injury.[19] In both our previous and current studies, high interpersonal conflicts appear to be an important factor contributing to occupational injury, although the nature of the job was different.

In this study, high job insecurity was associated with a lower occurrence of occupational injury among fire suppression personnel. There were 47 deaths of firefighters actively on the job between 1998 and 2007, which constituted 22% of all causes of death among firefighters. Additionally, the average age of death of retired firefighters was 58.8% in same period.[34] However, our reported rate of occupational injury could be underestimated if certain firefighters were unable to respond to our questionnaires because of disabilities or other medical reasons. Because we had no information on non-respondents, we could not assess the presence of the bias. However, considering the dangers of fire suppression, it is possible that the occurrences of injuries were underestimated in our study. Probst et al. reported that workers in insecure jobs underwent more occupational injuries than those in secure jobs.[35] Nakata et al. showed that high job insecurity was associated with an increased risk of occupational injury among male workers in small-to-medium sized manufacturing enterprises.[19] To clarify the association between job insecurity and the occurrence of occupational injury among firefighters, further studies that consider biases inherent in their designs are necessary.

A poor organizational system was associated with the occurrence of occupational injury in fire

suppression and EMS personnel. Recently, a 1-year follow-up prospective study in Spain was conducted to investigate any associations between job stress related to organizational support and occupational injuries.[21] Lack of organizational support was evaluated by questionnaires and then estimated by index, severity, and frequency; all were positively correlated with the risk of occupational injury. In the same context, our current results show that lack of organizational support in firefighters was also related to occupational injury.

A study in Hong Kong revealed that injuries among construction workers were influenced by emotional stress, which included unfair rewarding policies.[22] In our study, the lack of a reward was also associated with the occurrence of occupational injury among fire suppression and EMS personnel. Rewards were an important factor for predicting workers' safety and health with respect to the effort-reward model. In a cross-sectional survey of 11,636 Dutch workers, subjects with high efforts and low rewards had a significantly higher risk of emotional exhaustion, psychosomatic complaints, physical symptoms, and job dissatisfaction (odds ratio 3.23–15.43).[36] Although jobs vary by nature, the lack of rewards ought to be considered a factor affecting occupational injury.

A national representative survey in France reported that various adverse workplace practices such as verbal abuse, physical violence, low predictability, and bullying, as well as psychological demands and low decision latitude, were related to occupational injuries.[23] Furthermore, an important study revealed that organizational injustices such as supervisors' abuse of power can affect both workers' rights as well as their health and safety.[24] That study also revealed qualitative data regarding the association between the level of power abuse and risk of occupational injuries. Such aspects can equally apply to the firefighting profession in terms of workplace climate.

The association between job stress scales and the number of occupational injuries using the zero-

inflated negative binomial model significantly differed by current job duties. For fire suppression, only high job demands were associated with an increased number of occupational injuries. Among EMS personnel, low job control, high interpersonal conflict, lack of reward, and a negative workplace environment were related to the number of occupational injuries. However, there were no statistically significant results for officers. Because the association between job stress and the number of occupational injuries have rarely been researched, there are few published data to compare our results to. Nevertheless, considering the different results according to job duties, our statistical method may be useful to estimate the differences in associations between job stress and occupational injuries in various jobs.

Our study had some limitations. First, because the study was conducted using a self-reported survey, recall or reporting bias may have occurred. However, because severe cases of injuries are more easily remembered, the fact that our study design surveyed only injuries that required medical care may have minimized recall bias. Self-reported surveys also carry a bias resulting from the lack of incorporation of non-respondents' data. Moreover, since workers who are hospitalized, retired, or deceased cannot respond to the survey, a bias towards healthier workers may have occurred. If we were able to incorporate the data of non-respondents somehow, it is possible that our final results would be different. Second, confounding variables such as working patterns, hours of duty, sleep patterns, and types of injury were not included, although these may have an influence on the relationship between job stress and occupational injuries. Third, because the study design was cross-sectional, we could not establish a causal relationship, and were only able to identify the association between job stress and occupational injuries. For example, the results of our study could be interpreted as the number of occupational injuries themselves having an impact on job stress. Thus, careful interpretation of our data is required. However, the advantage of this study is that it was based on a nationwide survey that included the entire firefighter

force in Korea.

In summary, our study revealed increased occurrence and frequency rates of occupational injuries due to job stress among firefighters. Although there were differences in injury rates according to current job duties, we found that high job demands, high interpersonal conflicts, a poor organizational system, lack of rewards, and a negative workplace environment were factors associated with the occurrence of occupational injuries. As for the frequency of occupational injuries, fire suppression personnel with high job demands experienced a greater number of occupational injuries. In EMS workers, low job control, high interpersonal conflicts, lack of rewards, and a negative workplace environment were associated with an increased number of occupational injuries. This study exposes the job stress factors that should be ameliorated to prevent occupational injuries among firefighters. Our results can be used to better address job stress and hence to minimize occupational injuries among firefighters.

Contributors

Y-KK designed the study, analyzed and interpreted the data, and drafted and revised the manuscript. Y-SA interpreted the data and revised the manuscript. K-SK suggested the study design and revised the manuscript. J-HY suggested the study design, interpreted the data, and reviewed the manuscript. J-HN analyzed and interpreted the data, revised the manuscript.

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2014-44].

Competing interests

None declared.

Ethic approval

The Institutional Review Board (IRB) of Dongguk University Ilsan Hospital approved this study.

Provenance and peer review

Not commissioned; externally peer reviewed.

Data sharing statement

No additional data are available.

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No.
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3, 4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5, 6
Objectives	3	State specific objectives, including any prespecified hypotheses	5, 6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	-
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7, 8, 10, 11
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7, 8, 10, 11
Bias	9	Describe any efforts to address potential sources of bias	11
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7, 8, 10, 11
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11
		(*b*) Describe any methods used to examine subgroups and interactions	11
		(*c*) Explain how missing data were addressed	7

		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	7
		(*e*) Describe any sensitivity analyses	-
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	7
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	13, 14, 15
		(b) Indicate number of participants with missing data for each variable of interest	13, 14, 15
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	-
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	-
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	-
		Cross-sectional study—Report numbers of outcome events or summary measures	13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	18, 19
		(*b*) Report category boundaries when continuous variables were categorized	-
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	-
Discussion			
Key results	18	Summarise key results with reference to study objectives	24
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	23, 24
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	21, 22, 23, 24
Generalisability	21	Discuss the generalisability (external validity) of the study results	21, 22, 23, 24
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	24, 25

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Association between job stress and occupational injuries among Korean firefighters: a nationwide cross-sectional study

Authors

Yeong-Kwang Kim[1, 2, 3], Yeon-Soon Ahn[3], KyooSang Kim[4], Jin-Ha Yoon[1, 2, 3], Jaehoon Roh[1, 2, 3*]

Affiliations

[1]The Institute for Occupational Health, Yonsei University College of Medicine, Seoul, Korea

[2]Department of Preventive Medicine and Public Health, Yonsei University College of Medicine, Seoul, Korea

[2]Graduate school of Public Health, Yonsei University, Seoul, Korea

[3]Department of Occupational and Environmental Medicine, Dongguk University Ilsan Hospital, Goyang, Korea

[4]Department of Occupational and Environmental Medicine, Seoul Medical Center

*Correspondence to this work

Jaehoon Roh, MD, PhD

The Institute for Occupational Health, Department of Preventive Medicine,

Yonsei University College of Medicine

50 Yonsei-ro, Seodaemun-gu, Seoul 03722, Korea.

Tel: +82.2-222-1906, Fax: +82.2-392-8622

Email: ys.jhroh@gmail.com

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ABSTRACT

Objective: We aimed to assess the nature of association between job stress and occupational injuries among firefighters in Korea.

Design: Cross-sectional study.

Setting: We conducted a nationwide survey using self-reported questionnaires in South Korea.

Participants: A survey was conducted among 30,630 firefighters; 25,616 (83.6%) responded. Our study included firefighters 20–59 years old. Individuals with less than 12 months of current job experience and those with missing data were excluded; ultimately, 14,991 firefighters were analyzed.

Results: Among fire suppression personnel, high job demands (OR=1.49, 95% CI 1.25-1.77), high interpersonal conflicts (OR=1.18, 95% CI 1.02-1.37), a poor organizational system (OR=1.33, 95% CI 1.14-1.55), and a negative workplace environment (OR=1.41, 95% CI 1.21-1.64) were associated with the occurrence of occupational injury; high job demands (OR=1.22, 95% CI 1.01-1.47) were also associated with the frequency of injuries. Among emergency medical services personnel, high job demands (OR=1.26, 95% CI 1.03-1.54), high interpersonal conflicts (OR=1.40, 95% CI 1.19-1.66), a poor organizational system (OR=1.55, 95% CI 1.30-1.85), lack of reward (OR=1.43, 95% CI 1.21-1.69), and a negative workplace environment (OR=1.30, 95% CI 1.10-1.54) were associated with the occurrence of occupational injury; low job control (OR=1.20, 95% CI 1.04-1.38), high interpersonal conflicts (OR=1.18, 95% CI 1.03-1.36), lack of reward (OR=1.17, 95% CI 1.02-1.35), and a negative workplace climate (OR=1.16, 95% CI 1.01-1.34) were also associated with a greater number of injuries. Among officers, high job demands (OR=1.96, 95% CI 1.35-2.85) and a negative workplace environment

(OR=1.54, 95% CI 1.13-2.10) were associated with the occurrence of occupational injuries; however, there was no significant correlation between job stress and the number of injuries.

Conclusion: High job stress among firefighters was not only associated with the occurrence of occupational injury, but also with an increased frequency of injuries. Therefore, job stress should be addressed to prevent occupational injuries among firefighters.

Key words: firefighters, job stress, nationwide survey, occupational injuries.

Strengths and limitation of this study

This is a nationwide study including a large number of the firefighters of Korea.

There have been only a few systematic studies of the association between job stress and occupational injury among firefighters. This study showed that high job stress is not only related to the occurrence of occupational injury, but also to the frequency of occupational injuries in Korean firefighters.

Because of cross-sectional design, this study could not establish a causal relationship, and were only able to identify the association between job stress and occupational injuries.

There was possibility that the result was biased by using self-reported questionnaires and missing some potential confounders.

INTRODUCTION

Firefighters are responsible for the safety of citizens, and perform functions that include fire suppression and emergency medical services (EMS). As such, they are exposed to physical or chemical hazards that lead to high rates of occupational injuries.[1-3] According to a report by the National Fire Protection Association, 18,500 cases of exposure to hazards were reported, and 63,350 injuries occurred in the line of duty, in the United States in 2014.[4] According to another report, firefighters responsible for fire suppression had a 1.4–7.4-fold higher risk of non-fatal injuries than did workers in other industries.[5]

Factors that affect occupational injury among firefighters have been investigated. A study by Fabio et al. showed that such injuries were influenced by work environments such as the number of alarms, grades of fire, number of structural stories at the scene, work intensity, civilian injury, time of incident, and number of pumpers.[6] Other studies reported that obesity was associated with increased injuries among firefighters.[7-8]

Various factors affecting occupational injury have been reported for other occupations, including long working hours [9] and shift work.[10 11] Individual characteristics such as obesity [8 12 13] and moderate or heavy alcohol consumption[14 15] also play a role. Separately, other researchers also examined whether psychological factors such as negative affectivity,[16] depression symptoms,[17] and mental illness[18] were risk factors for occupational injuries. In terms of job stress, Recent studies have shown that occupational injury is associated with excessive workload, high cognitive demands, and low job satisfaction, high intragroup conflict, job insecurity,[19] low decision latitude, conflicts with the supervisor or colleagues,[20] lack of organizational support,[21] poor physical environment, unfair reward and treatment,[22] verbal abuse and low predictability,[23] and organizational injustice.[24]

Despite a plethora of studies, there have been only a few systematic investigations to identify factors influencing occupational injuries among firefighters. In this study, which is based on a survey of all Korean firefighters, we aimed to investigate the existence of a correlation between job stress and occupational injury among firefighters.

METHODS

Study subjects and methods

This cross-sectional study was conducted via a survey targeting firefighters in South Korea between July and November 2007. To explain the questionnaire and increase the response rate, the survey was conducted in coordination with the health managers at each fire station. A questionnaire was mailed to 30,630 firefighters; 25,615 (83.6%) responded. The self-reporting structured questionnaires were used to investigate the characteristics of subjects, frequency of occupational injury during the previous 12 months, and job stress at the current place of employment. Hence, 5,165 respondents who had less than 12 months' experience in the current task job were excluded. We also excluded 5,310 firefighters with missing basic data (sex, age, marital status, smoking status, alcohol consumption, frequency of exercise, education, current job category, current job experience, occupational exposures, or job stress). Ultimately, data of 14,991 firefighters who were 20–59 years old were analyzed. This study was approved by the Institutional Review Board of Dongguk University Ilsan Hospital (2014-82). All subjects provided written informed consent for their participation.

Occupational characteristics and injury

In the survey, subjects were asked to reply to the question; "How many times have you experienced injury in the workplace that required medical care during the past 12 months?" Hence, occupational injuries in this study were restricted only to events related to the firefighters' duties. Furthermore, minor injuries; i.e., those that did not require medical care, were excluded. Occupational injuries within the previous 12 months were recorded because only a few such injuries occurred within shorted durations. Firefighters included all workers employed at a fire department and its related services, including: fire

suppression (extinguishing a fire), paramedics (providing emergency medical care), rescue workers (rescuing people who are trapped or in medical emergencies), special investigators (investigating a cause of fire), informatics training officers (training other firefighters), and others.[25] These jobs were categorized into fire suppression, EMS (includes paramedics and rescue), and officers (including administrators, special investigators, and communicational and informational system operators).

Job stress

Job stress was identified according to the short form of the Korean Occupational Stress Scale (KOSS-SF), which was a structured questionnaire to estimate the job stress of Korean employees.[26] KOSS-SF was based on the most commonly used job stress questionnaires such as the JCQ(Job Content Questionnaire), NIOSH(National Institute of Occupational Safety and Health) job stress questionnaire, and OSI(Occupational Stress Index). This scale is comprised of 7 subscales and 24 items: job demands (4 items), job control (4 items), interpersonal conflict (3 items), job insecurity (2 items), organizational system (4 items), lack of reward (3 items), and workplace environment (4 items). Each item allowed 4 possible responses: ‘strongly disagree’, ‘disagree’, ‘agree’, or ‘strongly agree’. Subscale scores were the sum of each item, which was then converted into 100 points. Cronbach’s alpha coefficient for each subscale was calculated to evaluate the internal reliability of the KOSS-SF, which ranged between 0.51 and 0.82. In this study, Cronbach’s alpha coefficient for subscales of job stress ranged from 0.55 to 0.77. The KOSS-SF also showed acceptable validity by analyzing internal consistency and factor analysis;[26] it also recommended using scores dichotomized around the median for the total study population. Therefore, the scores of each job stress were dichotomized at the median of the total firefighters (Table 1).[26]

Table 1. Reference values and contents of KOSS-SF

Job stress subscales	Range of score[a]	Mean ± SD[b] (male)	Mean ± SD[b] (female)	Cronbach's alpha[b]	Contents	Questions
Job demands	0–100	59.7 ± 16.0	61.1 ± 17.2	0.69	Time pressure	Because of my workload, I always feel time pressure[c]
					Increasing workload	My job has become increasingly overbearing[c]
					Excessive work	My work requires long lasting concentration[d]
Job control	0–100	51.7 ± 14.7	49.4 ± 13.0	0.55	Multiple functions	I have to do various jobs simultaneously[c]
					Noncreative work	My work requires creativity[d]
					Skill underutilization	My work requires a high level of skill or knowledge[d]
					Little or no decision-making	I can make my own decisions in my job and have influence over the work[d]
					Low control	I can control my pace of work and time schedule[d]
Interpersonal conflict	0–100	40.6 ± 14.3	39.3 ± 13.9	0.66	Inadequate supervisor support	My supervisor is helpful in getting the job done[d]
					Inadequate coworker support	My coworker is helpful in getting the job done[d]
					Lack of emotional support	I have someone who understands my difficulties at work[d]
Job insecurity	0–100	51.6 ± 17.9	56.4 ± 17.2	0.57	Uncertainty	My future is uncertain because the current situation of my company is unstable[c]
					Negative changes to my job	Undesirable changes (i.e. downsizing) will come to my job.
Organizational system	0–100	55.5 ± 16.5	54.3 ± 15.4	0.77	Unfair organizational policy	The organizational policy of my company is fair and reasonable[d]
					Unsatisfactory organizational support	My company provides me with sufficient organizational support[d]
					Inter-departmental conflict	Departments cooperate each other without conflicts[d]
					Limitation of communication	I have opportunities and channels to talk about my ideas[d]
Reward	0–00	50.3 ± 16.5	51.0 ± 15.2	0.73	Unsatisfactory salary	My salary is not commensurate with my effort and work performance[d]
					Future ambiguity	I believe that I will be given more rewards from my company if I work hard[d]
					Interruption of opportunity	I am provided with the opportunity to develop my capacity[d]
Workplace environment	0–100	47.0 ± 15.8	49.2 ± 16.5	0.68	Collective culture	Dining out after work makes me uncomfortable[c]
					Inconsistency of job order	I am asked to do my work with irrational principles or inconsistency[c]
					Authoritarian climate	My company climate is authoritative and hierarchical[c]
					Gender discrimination	I am at a disadvantage because I am a woman[c]

[a] The subscale scores were the sum of each item, which was converted into 100 points; a higher score means higher job stress
[b] Mean, standard deviation, and Cronbach's alpha were the values used in this study
[c] Each question allowed 4 possible responses: 'strongly disagree', 'disagree', 'agree', or 'strongly agree', which is given a score from 1 to 4
[d] Each question allowed 4 possible responses: 'strongly disagree', 'disagree', 'agree', or 'strongly agree', which is given a score from 4 to 1
KOSS-SF, Short form of Korean Occupational Stress Scale; SD, Standard deviation

Occupational exposure

Firefighters have been exposed to various hazards that are directly linked to occupational injury. To clarify the effects of numerous such exposures, subjects were asked whether or not they have experienced the following 12 hazardous conditions and/or exposure to materials in the workplace at least once: overload (lifting a heavy object repetitively), inadequate posture (working in an uncomfortable posture for a long time), lack of lighting (working in darkness), excessive heat or cold (working in an excessively hot or cold environment), noise (exposed to loud noise at work), vibration (exposed to vibration at work), dust (exposed to metallic dust, welding fume, grain dust, asbestos, or other agents at work), organic solvents (exposed to organic solvents such as thinner, gasoline, light oil, kerosene oil, normal hexane, benzene, trichloroethylene, and unknown organic solvents at work), other chemical agents (exposed to chemical agents such as chloroform, carbon tetrachloride, dimethylformamide, carbon disulfide, pesticide, urethane, epoxy resin, and other unknown chemical agents at work), metals (exposed to metals such as lead, chrome, nickel, mercury, cadmium, aluminum, and other unknown metals at work), biological agents (exposed to biological agents such as blood and other droplets or fluids at work), and radiation (exposed to non-destructive radiation at work).

Other confounding variables

Smokers were categorized as current smokers, ex-smokers, and never smokers. The Alcohol Use Disorders Identification Test (AUDIT)[27] was used to identify hazardous drinkers among firefighters. Subjects were categorized into hazardous drinkers (AUDIT score ≥8) vs. non-hazardous drinkers (AUDIT score <8).[28] Regular physical activity was divided into exercising either <3 times or ≥3 times per week. Education levels were categorized into <12 years of schooling vs. ≥12 years (high school or

above). Marital status was categorized as married and living with a spouse vs. other (never married, divorced, etc.).

Statistical Methods

All study subjects were divided into 2 groups: those who had experienced occupational injury during the previous 12 months and those who had not. Injuries according to occupational and demographic characteristics were compared by using the chi-square test and Cochran-Armitage trend test. Distribution of the numbers of injuries during the previous 12 months according to current job was also analyzed. Job demands and job control were examined for analyzing job stress; this analysis was conducted by stratifying the duties of firefighters into fire suppression, EMS, and officers as mentioned above.

Association between job stress and occurrence of occupational injury was identified through a multivariate logistic regression model with adjustment for potential confounders that affect occupational injury on univariate analysis, including sex, age group, marital status, smoking status, hazardous drinking, and occupational exposures. Some workers had one or more occupational injuries during the prior 12 months; hence, we tested whether job stress is related to the number of occupational injuries as well. The number of occupational injuries is counted variables that were commonly analyzed by Poisson regression model, negative binomial regression model. In this study, the distribution of the number of injuries was overdispersed and zero-inflated. Thus, we selected a zero-inflated negative binomial regression model to handle the distribution.[29 30] The model was used to analyze the association between job stress and the number of occupational injuries; using this method, the incidence rate ratios (IRRs) and 95% confidence intervals were calculated by adjusting all confounding variables. In this

study, P values below 0.05 were considered statistically significant. Statistical analysis was performed using the SAS 9.2 software (SAS Institute Inc., Cary, NC, USA.)

RESULTS

General characteristics

Over 12 months, 1,757 subjects comprising 14,349 men and 642 women experienced occupational injury (11.72%). There were significant differences between injured vs. not injured personnel with respect to sex, age, marriage status, smoking status, hazardous drinking, current job, and occupational exposures (Table 2).

Table 2. General characteristics of subjects stratified by occupational injury

Characteristics		Not injured n (%)	Injured[a] n (%)	P-value[b]
Number of subjects		13234 (88.28)	1757 (11.72)	
Sex	Male	12657 (88.21)	1692 (11.79)	0.200
	Female	577 (89.88)	65 (10.12)	
Age group	20–29	1042 (86.12)	168 (13.88)	<0.001[c]
(years)	30–39	5846 (86.66)	900 (13.34)	
	40–49	4998 (89.57)	582 (10.43)	
	50–59	1348 (92.65)	107 (7.35)	
Marriage status	With spouse	11215 (88.63)	1439 (11.37)	0.002
	Other	2019 (86.39)	318 (13.61)	
Smoking status	Current smokers	5220 (88.61)	671 (11.39)	0.003
	Never smokers	1022 (85.24)	177 (14.76)	
	Former smokers	6992 (88.50)	909 (11.50)	
Hazardous drinking	AUDIT <8	5291 (89.06)	650 (10.94)	0.016
	AUDIT ≥8	7943 (87.77)	1107 (12.23)	
Frequency of exercise	<3	5689 (88.28)	755 (11.72)	0.989
(times/week)	≥3	7545 (88.28)	1002 (11.72)	
Education (years)	≤12	5019 (88.66)	642 (11.34)	0.260
	>12	8215 (88.05)	1115 (11.95)	
Current job	Fire suppression	6621 (88.74)	840 (11.26)	<0.001
	EMS	3432 (82.60)	723 (17.40)	
	Officer	3181 (94.25)	194 (5.75)	
Current job experience (years)	1–4	6196 (88.73)	787 (11.27)	<0.916[c]
	5–9	2496 (87.00)	373 (13.00)	
	10–14	2532 (87.40)	365 (12.60)	
	≥15	2010 (89.65)	232 (10.35)	
Overload	Exposed	8284 (84.66)	1501 (15.34)	<0.001
	Not exposed	4950 (95.08)	256 (4.92)	
Inadequate posture	Exposed	7086 (84.19)	1331 (15.81)	<0.001
	Not exposed	6148 (93.52)	426 (6.48)	
Lack of lighting	Exposed	6495 (83.95)	1242 (16.05)	<0.001
	Not exposed	6739 (92.90)	515 (7.10)	
Excessive heat or cold	Exposed	6260 (83.88)	1203 (16.12)	<0.001
	Not exposed	6974 (92.64)	554 (7.36)	
Noise	Exposed	6921 (84.22)	1297 (15.78)	<0.001
	Not exposed	6313 (93.21)	460 (6.79)	

Vibration	Exposed	4725 (82.79)	982 (17.21)	<0.001
	Not exposed	8509 (91.65)	775 (8.35)	
Dust	Exposed	7137 (84.49)	1310 (15.51)	<0.001
	Not exposed	6097 (93.17)	447 (6.83)	
Organic solvent	Exposed	5209 (83.22)	1050 (16.78)	<0.001
	Not exposed	8025 (91.90)	707 (8.10)	
Other chemical agents	Exposed	5237 (83.03)	1070 (16.97)	<0.001
	Not exposed	7997 (92.09)	687 (7.91)	
Metals	Exposed	3759 (82.02)	824 (17.98)	<0.001
	Not exposed	9475 (91.04)	933 (8.96)	
Biological agents	Exposed	4381 (81.49)	995 (18.51)	<0.001
	Not exposed	8853 (92.07)	762 (7.93)	
Radiation	Exposed	1350 (80.94)	318 (19.06)	<0.001
	Not exposed	11884 (89.20)	1439 (10.80)	

[a]Subjects that underwent medical treatment due to the occupational injury for last 12 months

[b]P values calculated using the chi-square test

[c]P values for trend calculated using the Cochran-Armitage trend test

AUDIT, Alcohol Use Disorders Identification Test

Distribution of the number of injuries by current job

The number of firefighters who experienced injuries in the prior 12 months included 840 fire suppression personnel, 723 EMS workers, and 194 officers (Table 3). As some firefighters were injured more than once, there were 5580 injury incidents; 2691 among fire suppression personnel, 2226 in EMS workers, and 663 among officers. Including firefighters who never experienced injuries, the mean number of injuries was highest among EMS workers and lowest among officers; however, after excluding non-injured firefighters, that order was reversed (Table 4).

Table 3. Distribution of the number of injuries by current job

Current job	Subjects (n)	Number of injuries[a]					
		Total injuries	Mean ± SD[9]	Median [9]	Mean ± SD (except zero)	Median (except zero)	Maximum
Total firefighters	14991	5580	0.37±2.23	0	3.18±5.80	2	90
Fire suppression	7461	2691	0.36±2.53	0	3.20±6.93	1	90
Emergency medical services	4155	2226	0.54±2.09	0	3.08±4.17	2	40
Officers	3375	663	0.20±1.57	0	3.42±5.66	1	50

[a]Subjects who underwent medical treatment owing to occupational injury in the prior 12 months.

SD, Standard deviation

Analysis of occupational injury according to job stress

Odds ratios were calculated using a multivariate logistic regression model to identify the association between job stress and the occurrence of occupational injury. Among fire suppression personnel, high job demands, high interpersonal conflicts, a poor organizational system, and a negative workplace environment were related to the occurrence of injury. Among EMS personnel, high job demands, high interpersonal conflicts, a poor organizational system, low rewards, and a negative workplace environment were related to injury incidents. Among officers, high job demands and a negative workplace environment were associated with injury (Table 4).

The IRRs of the number of occupational injuries were calculated by a zero-inflated negative binomial regression model comparing subjects with high job stress to low job stress. Among fire suppression personnel, high job demands were associated with an increased number of injuries. Among EMS personnel, low job control, high interpersonal conflicts, low rewards, and a negative workplace environment were related to an increased number of injuries. There were no correlations between the factors investigated and injury among officers (Table 4).

Table 4. Occurrence of occupational injury (logistic regression model) and number of injuries (zero-inflated negative binomial regression model) according to job stress scales

Job stress scale[a]	OR[b]	(95% CI)	IRR[c]	(95% CI)
Total firefighters				
Job demands (high)	1.42	(1.25–1.60)	1.08	(0.95–1.22)
Job control (low)	0.93	(0.84–1.04)	0.97	(0.90–1.10)
Interpersonal conflicts (high)	1.26	(1.13–1.39)	1.06	(0.96–1.17)
Job insecurity (high)	0.83	(0.74–0.93)	0.91	(0.81–1.01)
Organizational system (poor)	1.39	(1.24–1.54)	1.02	(0.92–1.13)
Rewards (low)	1.05	(0.90–1.22)	1.09	(0.98–1.20)
Workplace environment (negative)	1.35	(1.22–1.50)	1.06	(0.96–1.18)
Fire suppression				
Job demands (high)	1.49	(1.25–1.77)	1.22	(1.01–1.47)
Job control (low)	0.92	(0.79–1.06)	0.89	(0.76–1.03)
Interpersonal conflicts (high)	1.18	(1.02–1.37)	0.97	(0.83–1.12)
Job insecurity (high)	0.73	(0.61–0.87)	0.93	(0.78–1.12)
Organizational system (poor)	1.33	(1.14–1.55)	1.00	(0.85–1.17)
Rewards (low)	1.13	(0.97–1.31)	1.10	(0.94–1.27)
Workplace environment (negative)	1.41	(1.21–1.64)	0.99	(0.85–1.16)
Emergency medical services				
Job demands (high)	1.26	(1.03–1.54)	1.05	(0.88–1.25)
Job control (low)	1.02	(0.85–1.21)	1.20	(1.04–1.38)
Interpersonal conflicts (high)	1.40	(1.19–1.66)	1.18	(1.03–1.36)
Job insecurity (high)	0.88	(0.74–1.04)	0.90	(0.78–1.04)
Organizational system (poor)	1.55	(1.30–1.85)	1.12	(0.96–1.29)
Rewards (low)	1.43	(1.21–1.69)	1.17	(1.02–1.35)
Workplace environment (negative)	1.30	(1.10–1.54)	1.16	(1.01–1.34)
Officers				
Job demands (high)	1.96	(1.35–2.85)	0.70	(0.48–1.04)
Job control (low)	1.06	(0.77–1.47)	0.91	(0.67–1.24)
Interpersonal conflicts (high)	1.22	(0.90–1.65)	0.85	(0.60–1.19)
Job insecurity (high)	0.78	(0.56–1.09)	0.93	(0.67–1.30)
Organizational system (poor)	1.28	(0.94–1.75)	0.81	(0.61–1.09)
Rewards (low)	1.12	(0.82–1.52)	0.78	(0.58–1.06)
Workplace environment (negative)	1.54	(1.13–2.10)	0.86	(0.64–1.16)

[a]All job stress scales were compared to their counterparts.

[b]OR and 95% CI were calculated using a logistic regression model adjusted for sex, age group, marriage status, smoking status, hazardous drinking, and occupational exposures.

[c]IRR and 95% CI were calculated using a zero-inflated negative binomial regression model adjusted for sex, age group, marriage status, smoking status, hazardous drinking, and occupational exposures.

CI, confidence interval; IRR, incidence rate ratio; OR, odds ratio.

DISCUSSION

This study showed that excessive job stress is related to the occurrence and the frequency of occupational injuries in Korean firefighters. Many recent studies have investigated occupational injury due to physical and chemical exposure, as well as psychological factors including job stress. However, the association between job stress and occupational injuries among firefighters has rarely been examined. Our study is meaningful because it is a nationwide survey involving the entire firefighter force of Korea; moreover, it reveals an association between job stress and the frequency of occupational injuries in Korean firefighters after adjusting for confounding variables.

In this study, high job demands were associated with the occurrence of occupational injury regardless of the nature of the current job. In a study of small-to-medium sized Korean manufacturing enterprises, workers with highly demanding jobs had a greater risk of occupational injury.[31] A study from Japan also showed that high quantitative workloads, high variance in workload, and high cognitive demands were associated with occupational injury in men working in small-to-medium sized manufacturing enterprises. Among female workers, high quantitative workloads and high cognitive demands correlated with a greater risk of occupational workplace injury.[19] The results of our study suggest that firefighters, who have high-risk jobs, also experience a greater risk of occupational injury corresponding to higher job demands.

Low job control (i.e., the ability to make decisions) was found not to be significantly associated with occupational injury among firefighters. Murata et al. showed no statistically significant effects of job control on occupational injury among blue-collar workers.[32] Nakata et al. showed that female workers in small-to-medium sized manufacturing enterprises had a higher risk of occupational injury when they had less job control.[19] Although low job control was associated with the number of occupational injuries among EMS personnel in our study, it was not associated with the occurrence of

occupational injury in either sex.

High interpersonal conflicts were associated with the occurrence of occupational injury in fire suppression and EMS personnel. A study of Finish hospital personnel showed that problems in interpersonal relationships and conflicts during collaborations at work were related to occupational injury.[33] Another study of Japanese small-to-medium sized manufacturing enterprises workers showed that female employees with high intragroup conflicts at the workplace had a higher risk of occupational injury.[19] In both our previous and current studies, high interpersonal conflicts appear to be an important factor contributing to occupational injury, although the nature of the job was different.

In this study, high job insecurity was associated with a lower occurrence of occupational injury among fire suppression personnel. There were 47 deaths of firefighters actively on the job between 1998 and 2007, which constituted 22% of all causes of death among firefighters. Additionally, the average age of death of retired firefighters was 58.8 in same period.[34] Therefore, our reported rate of occupational injury could be underestimated if certain firefighters were unable to respond to our questionnaires because of disabilities or other medical reasons. Because we had no information on non-respondents, we could not assess the presence of the bias. However, considering the dangers of fire suppression, it is possible that the occurrences of injuries were underestimated in our study. Probst et al. reported that workers in insecure jobs underwent more occupational injuries than those in secure jobs.[35] Nakata et al. showed that high job insecurity was associated with an increased risk of occupational injury among male workers in small-to-medium sized manufacturing enterprises.[19] To clarify the association between job insecurity and the occurrence of occupational injury among firefighters, further studies that consider biases inherent in their designs are necessary.

A poor organizational system was associated with the occurrence of occupational injury in fire

suppression and EMS personnel. Recently, a 1-year follow-up prospective study in Spain was conducted to investigate any associations between job stress related to organizational support and occupational injuries.[21] Lack of organizational support was evaluated by questionnaires and then estimated by index, severity, and frequency; all were positively correlated with the risk of occupational injury. In the same context, our current results show that lack of organizational support in firefighters was also related to occupational injury.

A study in Hong Kong revealed that injuries among construction workers were influenced by emotional stress, which included unfair rewarding policies.[22] In our study, the lack of a reward was also associated with the occurrence of occupational injury among fire suppression and EMS personnel. Rewards were an important factor for predicting workers' safety and health with respect to the effort-reward model. In a cross-sectional survey of 11,636 Dutch workers, subjects with high efforts and low rewards had a significantly higher risk of emotional exhaustion, psychosomatic complaints, physical symptoms, and job dissatisfaction (odds ratio 3.23–15.43).[36] Although jobs vary by nature, the lack of rewards ought to be considered a factor affecting occupational injury.

A national representative survey in France reported that various adverse workplace practices such as verbal abuse, physical violence, low predictability, and bullying, as well as psychological demands and low decision latitude, were related to occupational injuries.[23] Furthermore, an important study revealed that organizational injustices such as supervisors' abuse of power can affect both workers' rights as well as their health and safety.[24] That study also revealed qualitative data regarding the association between the level of power abuse and risk of occupational injuries. Such aspects can equally apply to the firefighting profession in terms of workplace climate.

The association between job stress scales and the number of occupational injuries using the zero-

inflated negative binomial model significantly differed by current job duties. For fire suppression, only high job demands were associated with an increased number of occupational injuries. Among EMS personnel, low job control, high interpersonal conflict, lack of reward, and a negative workplace environment were related to the number of occupational injuries. However, there were no statistically significant results for officers. Because the association between job stress and the number of occupational injuries have rarely been researched, there are few published data to compare our results to. Nevertheless, considering the different results according to job duties, our statistical method may be useful to estimate the differences in associations between job stress and occupational injuries in various jobs.

Our study had some limitations. First, because the study was conducted using a self-reported survey, recall or reporting bias may have occurred. However, because severe cases of injuries are more easily remembered, the fact that our study design surveyed only injuries that required medical care may have minimized recall bias. Self-reported surveys also carry a bias resulting from the lack of incorporation of non-respondents' data. Moreover, since workers who are hospitalized, retired, or deceased cannot respond to the survey, a bias towards healthier workers may have occurred. If we were able to incorporate the data of non-respondents somehow, it is possible that our final results would be different. Second, confounding variables such as working patterns, hours of duty, sleep patterns, and types of injury were not included, although these may have an influence on the relationship between job stress and occupational injuries. Third, because the study design was cross-sectional, we could not establish a causal relationship, and were only able to identify the association between job stress and occupational injuries. For example, the results of our study could be interpreted as the number of occupational injuries themselves having an impact on job stress. Thus, careful interpretation of our data is required. However, the advantage of this study is that it was based on a nationwide survey that included the entire firefighter

force in Korea.

In summary, our study revealed increased occurrence and frequency rates of occupational injuries due to job stress among firefighters. Although there were differences in injury rates according to current job duties, we found that high job demands, high interpersonal conflicts, a poor organizational system, lack of rewards, and a negative workplace environment were factors associated with the occurrence of occupational injuries. As for the frequency of occupational injuries, fire suppression personnel with high job demands experienced a greater number of occupational injuries. In EMS workers, low job control, high interpersonal conflicts, lack of rewards, and a negative workplace environment were associated with an increased number of occupational injuries. This study exposes the job stress factors that should be ameliorated to prevent occupational injuries among firefighters. Our results can be used to better address job stress and hence to minimize occupational injuries among firefighters.

Contributors

Y-KK designed the study, analyzed and interpreted the data, and drafted and revised the manuscript. Y-SA interpreted the data and revised the manuscript. K-SK suggested the study design and revised the manuscript. J-HY suggested the study design, interpreted the data, and reviewed the manuscript. J-HN analyzed and interpreted the data, revised the manuscript.

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2014-44].

Competing interests

None declared.

Ethic approval

The Institutional Review Board (IRB) of Dongguk University Ilsan Hospital approved this study.

Provenance and peer review

Not commissioned; externally peer reviewed.

Data sharing statement

No additional data are available.

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No.
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3, 4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5, 6
Objectives	3	State specific objectives, including any prespecified hypotheses	5, 6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	-
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7, 8, 10, 11
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7, 8, 10, 11
Bias	9	Describe any efforts to address potential sources of bias	11
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7, 8, 10, 11
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11
		(*b*) Describe any methods used to examine subgroups and interactions	11
		(*c*) Explain how missing data were addressed	7

		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	7
		(*e*) Describe any sensitivity analyses	-
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	7
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	13, 14, 15
		(b) Indicate number of participants with missing data for each variable of interest	13, 14, 15
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	-
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	-
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	-
		Cross-sectional study—Report numbers of outcome events or summary measures	13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	18, 19
		(*b*) Report category boundaries when continuous variables were categorized	-
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	-
Discussion			
Key results	18	Summarise key results with reference to study objectives	24
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	23, 24
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	21, 22, 23, 24
Generalisability	21	Discuss the generalisability (external validity) of the study results	21, 22, 23, 24
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	24, 25

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.