Ann Occup Environ Med. 2021 May 4;33:e15
https://doi.org/10.35371/aoem.2021.33.e15
eISSN 2052-4374

Annals of Occupational and Environmental Medicine AOEM

Research Article

Relationship between fatigue severity scale and occupational injury in Korean workers

Hyeonwoo Ju [1,2], Hwan-Cheol Kim [1,2*], Sung Wook Jang [1,2], Youna Won [1], Shin-Goo Park [1,2], and Jong-Han Leem [1,2]

[1]Department of Occupational and Environmental Medicine, Inha University Hospital, Incheon, Korea
[2]Department of Social and Preventive Medicine, School of Medicine, Inha University, Incheon, Korea

Received: Nov 27, 2020
Accepted: Apr 9, 2021

***Correspondence:**
Hwan-Cheol Kim
Department of Occupational and Environmental Medicine, Inha University Hospital, 27 Inhang-ro, Jung-gu, Incheon 22332, Korea.
E-mail: carpediem@inha.ac.kr

ORCID iDs
Hyeonwoo Ju
https://orcid.org/0000-0001-5296-2808
Hwan-Cheol Kim
https://orcid.org/0000-0002-3635-1297
Sung Wook Jang
https://orcid.org/0000-0003-4747-1400
Youna Won
https://orcid.org/0000-0002-5924-2712
Shin-Goo Park
https://orcid.org/0000-0002-1544-4486
Jong-Han Leem
https://orcid.org/0000-0003-3292-6492

Abbreviations
CI: confidence interval; FSS: fatigue severity scale; OR: odds ratio.

ABSTRACT

Background: The aim of this study is to investigate the relationship between fatigue and occupational injury.
Methods: This study was conducted at a university hospital in 2014 and 2015. In 2014, the fatigue severity scale (FSS) was used to evaluate workers' fatigue levels. Later, when the same workers were examined in 2015, a questionnaire survey was conducted to determine whether they had experienced absences or treatment for work-related accidents. The χ^2 test was used to analyse the relationship between demographic characteristics, fatigue levels, and occupational injuries. After controlling for confounders, a logistic regression analysis was performed to calculate the odds ratios (ORs).
Results: In 2014, 19,218 workers were screened during health examination and their fatigue level were evaluated using FSS questionnaires. in 2015, workers' occupational injury was evaluated. In result, men in the moderate- and high-fatigue groups, after adjusting for age, smoking and drinking habits, chronic diseases, and occupational factors such as size of company industrial classification and type of work (shift or non-shift), adjusted ORs for hospital treatment due to occupational injury were 1.76 (95% confidence interval [CI]: 1.39–2.24) and 2.61 (95% CI:1.68–4.06), respectively. Among men in the medium- and high-fatigue groups, the adjusted ORs for absence due to occupational injury were 2.06 (95% CI: 1.52–2.80) and 3.65 (95% CI: 2.20–6.05), respectively. No significant association was observed between fatigue and occupational injury in women.
Conclusions: Male workers with high fatigue levels have a higher risk of experiencing work injuries. This study suggests that active intervention be considered to prevent injuries in workers with high scores on workplace fatigue evaluation scales.

Keywords: Fatigue; Fatigue severity scale; Occupational injury; Disease; Korean worker

BACKGROUND

According to International Labour Organization, an occupational injury is defined as any personal injury, disease or death resulting from an occupational accident which is an unexpected and unplanned occurrence, including acts of violence, arising out of or in connection with work which results in one or more workers incurring a personal injury, disease or death.

Funding
This study was supported by an Inha University Hospital Research Grant.

Competing interests
The authors declare that they have no competing interests.

Author Contributions
Conceptualization: Ju H, Kim HC ; Data curation: Ju H, Kim HC ; Formal analysis: Ju H, Kim HC ; Funding acquisition: Kim HC ; Investigation:: Kim HC ; Methodology: Ju H, Kim HC, Park SG, Leem JH ; Project administration: Kim HC, Park SG ; Resources: Ju H, Kim HC, Leem JH ; Software: Ju H, Kim HC; Supervision: Kim HC; Validation: Ju H, Kim HC, Jang SW, Won Y ; Visualization: Ju H, Kim HC, Jang SW, Won Y ; Writing - original draft: Ju H ; Writing - review & editing: Ju H, Kim HC, Leem JH, Park SG.

According to an analysis about industrial accidents on 2018 [1], among the 2.6 million workplaces covered by the Industrial Accident Compensation Insurance Act, 19 million workers had 102,305 injuries requiring more than 4 days of care, 2,142 of them died (0.2% of all injuries), and 89,588 workers (2.3%) were injured in need of medical care more than 6 months, and 10,302 (1%) were affected by occupational disease. Occupational injury goes beyond personal levels, but also social losses. The amount of direct losses (injury compensation payments) due to occupational accidents reached $4.3 billion in 2018, and the estimated economic loss, including indirect losses, is estimated at $25.2 billion [1]. In study of Belgian workers, during the last 12 months about 11.7% of workers were absent from work because of work-related accident [2]. In study of 1,479 injured Danish workers, 36% of these reported absence from work by themselves or others [3].

Occupational injuries are caused by a variety of causes. Previous studies have shown that occupational injuries are associated with cardiovascular disease, musculoskeletal problems [4], and it have been pointed out that incomplete work environments or non-ergonomic environments are related with occupational injuries. Recently, it is known that social and psychological factors such as low job autonomy, high job demand, low social support, interpersonal conflict, job dissatisfaction, and job stress are also related [5]. In a study of workers in Finland, the probability of occupational injuries was 1.42 times higher when they were under stress while performing the task [6], and if they hated the work, they suffer from occupational injuries with a higher probability [7]. It is known that fatigue during work is also related occupational injury [5].

Fatigue is a normal, everyday experience that complains after lack of rest or sleep, and exhaustion due to physical activity, and can also occur due to lack of motivation for work. Fatigue, broadly defined as "a feeling of weariness, tiredness, or lack of energy," is a frequently cited complaint in workplace. The prevalence of fatigue in the general public has been variously reported from 7% to 45% due to differences in definition of fatigue, measurement tools, and diversity of subjects [8-10]. In a study of 3,300 workers in United States, 18.7% of workers complained of persistent fatigue for more than 1 month, and 11.5% complained of chronic fatigue for more than 6 months [11].

Fatigue significantly impair a person's functioning and have a negative effect on his or her health-related quality of life, without which a person might drop into unrecoverable exhaustive state and, in the most severe case, can even die, referred to in Japanese as Karoshi. The major medical causes of Karoshi deaths are heart attack and stroke due to stress [12,13].

Previous studies on the relationship between fatigue and occupational injury have been reported. According to a study by Blackburn et al. [14], workers with fatigue were 3.1 times more likely to suffer eye damage. In a study of American police officers, the odds ratio (OR) of occupational accidents increased by 1.08 and 1.67 times in the medium and high fatigue groups compared to the low fatigue group [15]. However, these studies mainly targeted small and medium-sized businesses, or the number of samples was small. Therefore, this study intends to analyze largely and prospectively the relationship between workers' fatigue and occupational injury.

METHODS

Population

This study was conducted at a university hospital in Incheon between January 1, 2014 and December 31, 2015. In 2014, during the health examination of 19,218 workers, fatigue level was evaluated using fatigue severity scale (FSS). And in 2015, occupational injury was evaluated. A 12,275 workers completed questionnaire about hospital treatment due to work related accident, while 12,254 workers completed questionnaire about absence due to work related accident. Follow rates of workers were 63.7%, 63.8% respectively. In result, total 12,275, 12,254 workers were included in this study.

Questionnaire survey

The questionnaire used in this study was self-written, and for whom couldn't complete the questionnaire, a nurse or physician helped them to complete it. The FSS used in this study is a measurement tool developed to evaluate fatigue that is difficult to make objective evaluation [16]. The FSS consists of 9 questions, and the last week's fatigue level is evaluated on a scale of 1 to 7 points. Higher score was regarded as more fatigue workers felt. In this study, the group with a fatigue evaluation scale score of less than 27 was regarded as a group with low fatigue, a group with a score of 27 or more and 44 or less as a medium fatigue group, and a group with a score of 45 or higher as high fatigue group.

In addition, occupational injury was defined as hospital treatment due to work-related accidents or worker's absence due to work-related accidents. To evaluate these, workers were asked to answer "yes or no" questions below.

1) "Have you ever been hospitalized due to work-related accidents in last year?"—evaluating hospital treatment due to work-related accidents.
2) "Did you have been absent from work for more than one day in the last year because of work-related accidents?"—evaluating worker's absenteeism due to work-related accidents.

In addition, age, gender, diabetes mellitus or hypertension, smoking history (current smoker, ex-smoker, or never smoker), drinking habit (units/day), and occupational characteristics such as industry classification, type of work (shift or non-shift) and size of workplace (less than 300 or not) were identified through the subjects' health examination data. Questionnaire items were listed on the workers' health checkup questionnaire. Participants received a consent to the use of personal information.

Statistical analysis

We analyzed the data of men and women separately because gender can influence occupational injury rates and fatigue level. Experiences of occupational injury according to the participant's general and occupational characteristics and FSS were analyzed using the χ^2 test. In order to calculate the OR of FSS for occupational injury, a logistic regression analysis was performed. Adjusted ORs were calculated after adjusting for potential confounders. Age, hypertension or diabetes mellitus, smoking habit, alcohol consumption, industry classification, type of work (shift or non-shift) and size of employment were adjusted. These confounding variables were selected based on results of χ^2 testing by gender. SPSS (version 25; IBM Corp., Armonk, NY, USA) was used for statistical analysis.

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RESULTS

Demographic characteristics of the study subjects

A 19,218 workers were completed FSS questionnaires in 2014. And in 2015, 12,275 (63.9%) workers responded question about hospital treatment due to occupational injury, and 12,254 (63.8%) workers responded question about absence due to occupational injury respectively.

As a result, 488 workers answered that they had experienced occupational injury. Among them, 354 patients (2.8%) received hospital treatment due to work-related accidents and 211 (1.7%) experienced absence from work due to work-related accidents.

Demographic characteristics of cases of hospital treatment due to occupational injury

For men, there was no significant difference between the group consist of cases of hospital treatment due to occupational injury ("injury group") and the control group in terms of age, hypertension or diabetes mellitus, and industry classification. Differences were observed according to the history of alcohol intake, smoking habit, size of employment, type of work (shift) and FSS scores. In the case of women, significant differences were found between the injury group and the control group for age groups, and there were no significant differences in other variables including the FSS score (**Tables 1** and **2**).

Demographic characteristics of cases of absence from work-related accidents

For men, no significant difference was found between the injury group and the control group in terms of age, diabetes mellitus or hypertension, and history of alcohol intake and industry classification but differences were found according to the smoking habit, size of employment, type of work (shift) and FSS scores. In the case of women, significant

Table 1. General characteristics of male and female that experienced hospital treatment due to occupational injury

Variables	Male			Female		
	Total	Value	*p*-value[a]	Total	Value	*p*-value[a]
Total	9,305	305 (3.3)		2,970	49 (1.6)	
Age (years)			0.70			0.03
< 30	997	40 (4.0)		944	20 (2.1)	
39–39	2,778	92 (3.3)		949	7 (0.7)	
40–49	2,946	94 (3.2)		596	12 (2.0)	
50–59	2,403	73 (3.0)		449	8 (1.8)	
> 59	181	6 (3.3)		32	2 (6.3)	
Hypertension or diabetes mellitus			0.80			0.15
No	7,889	257 (3.3)		2,805	44 (1.6)	
Yes	1,416	48 (3.4)		165	5 (3.0)	
Smoking habit			0.01			0.94
Never	2,317	56 (2.4)		2,818	47 (1.7)	
Former	2,690	83 (3.1)		70	1 (1.4)	
Current	4,298	166 (3.9)		82	1 (1.2)	
Alcohol consumption (unit/week)			0.02			0.69
0	2,217	71 (3.2)		1,648	30 (1.8)	
1–14	4,649	133 (2.9)		1,155	17 (1.5)	
> 15	2,439	101 (4.1)		167	2 (1.2)	
Fatigue severity scale			< 0.01			0.88
< 27	5,379	138 (2.6)		1,152	18 (1.6)	
27–44	3,243	142 (4.4)		1,467	25 (1.7)	
> 44	378	25 (6.6)		302	6 (2.0)	

Values are presented as number (%).
[a]Obtained by a χ^2 test or Fisher's exact test.

Table 2. Occupational characteristics of male and female that experienced hospital treatment due to occupational injury

Variables	Male			Female		
	Total	Value	*p*-value[a]	Total	Value	*p*-value[a]
Total	9,305	305		2,970	49	
Industry			0.14			0.92
Manufacturing	4,947	168 (3.4)		1,365	28 (2.1)	
Sewerage, waste management, materials recovery and remediation activities	11	0 (0.0)		2	0 (0.0)	
Construction	11	1 (9.1)		1	0 (0.0)	
Wholesale and retail trade	215	7 (3.3)		33	0 (0.0)	
Transportation	2,523	81 (3.2)		86	0 (0.0)	
Accommodation and food service activities	53	2 (3.8)		27	0 (0.0)	
Information and communications	194	1 (0.5)		39	0 (0.0)	
Financial and insurance activities	3	0 (0.0)		0	0 (0.0)	
Real estate activities and renting and leasing	47	0 (0.0)		6	0 (0.0)	
Professional, scientific and technical activities	4	0 (0.0)		0	0 (0.0)	
Business facilities management and business support services	342	18 (5.3)		302	6 (2.0)	
Public administration and defence; compulsory social security	345	9 (2.6)		30	1 (3.3)	
Education	193	4 (2.1)		110	2 (1.8)	
Human health and social work activities	258	4 (1.6)		944	12 (1.3)	
Membership organizations, repair and other personal services	126	8 (6.3)		4	0 (0.0)	
Other	33	2 (6.1)		21	0 (0.0)	
Size of employment			< 0.01			0.62
< 300	4,488	183 (4.1)		820	12 (1.5)	
300 or more	4,817	122 (2.5)		2,150	37 (1.7)	
Shift work			< 0.01			0.18
No	8,449	296 (3.5)		2,454	44 (1.8)	
Yes	856	9 (1.1)		516	5 (1.0)	

Values are presented as number (%).
[a]Obtained by a χ^2 test or Fisher's exact test.

differences were found between the injury group and the control group for age groups, hypertension or diabetes mellitus, and there was no significant difference in other variables (**Tables 3** and **4**).

ORs for hospital treatment due to occupational injury

In the group with moderate and high scores in the male FSS, the OR was 1.71 (95% confidence interval [CI]: 1.36–2.17) and 2.58 (95% CI: 1.66–4.00). When adjusted for age, smoking habit, drinking habit, hypertension or diabetes mellitus, and occupational factors the OR was 1.76 (95% CI: 1.39–2.24) and 2.61 (95% CI 1.68–4.06) (**Table 5**).

In the group with moderate and high scores in the women's FSS score, no statistically meaningful results found even when adjusting confounding factors.

ORs for absence due to occupational injury according to FSS

In the group with medium and high scores in the male fatigue evaluation scale, the OR was 2.02 (95% CI: 1.49–2.74) and 3.69 (95% CI: 2.23–6.09). When adjusted for age, smoking habit, drinking habit, hypertension or diabetes mellitus, and occupational factors, the OR was 2.06 (95% CI: 1.52–2.80) and 3.65 (95% CI: 2.20–6.05) (**Table 6**).

In the group with moderate and high scores in the women's fatigue score scale, no statistically meaningful results found even when adjusting confounding factors.

Table 3. General characteristics of male and female experienced absence due to occupational injury

Variables	Male			Female		
	Total	Value	*p*-value[a]	Total	Value	*p*-value[a]
Total	9,290	191 (2.1)		2,964	20 (0.7)	
Age (years)			0.72			0.04
< 30	997	22 (2.2)		943	5 (0.5)	
39–39	2,774	57 (2.1)		948	2 (0.2)	
40–49	2,940	53 (1.8)		595	6 (1.0)	
50–59	2,400	56 (2.3)		447	6 (1.3)	
> 59	179	3 (1.7)		31	1 (3.2)	
Hypertension or diabetes mellitus			0.31			< 0.01
No	7,878	167 (2.1)		2,800	15 (0.5)	
Yes	1,412	24 (1.7)		164	5 (3.0)	
Smoking habit			< 0.01			0.56
Never	2,315	32 (1.4)		2,813	19 (0.7)	
Former	2,684	46 (1.7)		70	1 (1.4)	
Current	4,191	113 (2.6)		81	0 (0.0)	
Alcohol consumption (unit/week)			0.46			0.17
0	2,215	46 (2.1)		1,644	15 (0.9)	
1–14	4,640	88 (1.9)		1,153	5 (0.4)	
> 15	2,435	57 (2.3)		167	0 (0.0)	
Fatigue severity scale			< 0.01			0.87
< 27	5,511	77 (1.4)		1,168	9 (0.8)	
27–44	3,376	94 (2.8)		1,489	9 (0.6)	
> 44	403	20 (5.0)		307	2 (0.7)	

Values are presented as number (%).
[a]Obtained by a χ^2 test or Fisher's exact test.

Table 4. Occupational characteristics of male and female experienced absence due to occupational injury

Variables	Male			Female		
	Total	Value	*p*-value[a]	Total	Value	*p*-value[a]
Total	9,290	191 (2.0)		2,964	20 (0.7)	
Industry			0.11			0.99
Manufacturing	4,943	106 (2.1)		1,360	12 (0.9)	
Sewerage, waste management, materials recovery and remediation activities	11	0 (0.0)		2	0 (0.0)	
Construction	11	0 (0.0)		1	0 (0.0)	
Wholesale and retail trade	214	2 (0.9)		33	0 (0.0)	
Transportation	2,516	56 (2.2)		85	0 (0.0)	
Accommodation and food service activities	53	1 (1.9)		27	0 (0.0)	
Information and communications	194	0 (0.0)		39	0 (0.0)	
Financial and insurance activities	3	0 (0.0)		0	0 (0.0)	
Real estate activities and renting and leasing	47	0 (0.0)		6	0 (0.0)	
Professional, scientific and technical activities	4	0 (0.0)		0	0 (0.0)	
Business facilities management and business support services	342	10 (2.9)		302	3 (1.0)	
Public administration and defence; compulsory social security	345	2 (0.6)		30	0 (0.0)	
Education	192	3 (1.6)		110	1 (0.9)	
Human health and social work activities	257	3 (1.2)		944	4 (0.4)	
Membership organizations, repair and other personal services	125	7 (5.6)		4	0 (0.0)	
Other	33	1 (3.0)		21	0 (0.0)	
Size of employment			< 0.01			0.80
< 300	4,479	114 (2.5)		816	6 (0.7)	
300 or more	4,811	77 (1.6)		2,148	14 (0.7)	
Shift work			< 0.01			0.14
No	8,435	187 (2.2)		2,448	19 (0.8)	
Yes	855	4 (0.5)		516	1 (0.2)	

Values are presented as number (%).
[a]Obtained by a χ^2 test or Fisher's exact test.

Table 5. ORs for hospital treatment due to occupational injury according to FSS

Variables	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[a]
Male		
Low (< 27)	1	1
Intermittent (27–44)	1.71 (1.36–2.17)	1.76 (1.39–2.24)
High (> 44)	2.58 (1.66–4.00)	2.61 (1.68–4.06)
Female		
Low (< 27)	1	1
Intermittent (27–44)	1.09 (0.59–2.01)	1.22 (0.65–2.29)
High (> 44)	1.27 (0.50–3.23)	1.45 (0.56–3.76)

FSS: fatigue severity scale; OR: odds ratio; CI: confidence interval.
[a]Adjusted ORs and 95% CIs were presented, based on multiple logistic regression model adjusted for age, smoking, drinking, hypertension or diabetes mellitus, industrial classification, type of work (shift), and size of workplace.

Table 6. ORs for absence due to occupational injury according to FSS

Variables	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[a]
Male		
Low (< 27)	1	1
Intermittent (27–44)	2.02 (1.49–2.74)	2.06 (1.52–2.80)
High (> 44)	3.69 (2.23–6.09)	3.65 (2.20–6.05)
Female		
Low (< 27)	1	1
Intermittent (27–44)	0.78 (0.31–1.98)	1.38 (0.50–3.84)
High (> 44)	0.84 (0.18–3.93)	1.67 (0.33–8.55)

FSS: fatigue severity scale; OR: odds ratio; CI: confidence interval.
[a]Adjusted ORs and 95% CIs were presented, based on multiple logistic regression model adjusted for age, smoking, drinking, hypertension or diabetes mellitus, industrial classification, type of work (shift), and size of workplace.

DISCUSSION

This study is intended to prospectively confirm the association between fatigue and occupational injury of workers working in various workplaces. In this study, the fatigue level felt by workers was evaluated by using the FSS during the workers' health examination in 2014, And occupational injuries were checked during the workers' health examination in 2015. Thus, we evaluated association between fatigue and occupational injuries among workers prospectively. In this study, as the FSS score increased in men, the frequency of hospital treatment and absence due to accidents related with work increased.

The results are similar to previous studies evaluating association between fatigue and occupational injury (hospital treatment or absenteeism due to accidents). Chang et al. [5] classified fatigue levels into quartiles and analyzed the relationship between fatigue and medical use, work accidents, and absences. As a result, compared to the lowest quartile group, the ratio of outpatient use in the 2nd, 3rd, 4th quartile group was as high as 1.19 (95% CI: 1.05–1.35), 1.45 (95% CI: 1.28–1.65), and 1.95 (95% CI: 1.70–2.24), respectively [3]. The risk of accident of the highest fatigue group was 1.69 times higher than the low fatigue group (95% CI: 1.03–2.78) [17]. Among police officers, increase in fatigue score was associated with a 33% increase in prevalence of injury [15]. In a study of Canadian, fatigue has a statistically significant negative association with participation for individuals with spinal cord injury [18]. Significant associations between fatigue and occupational injuries have been demonstrated, but little is known about the mechanism. In previous studies, it was explained as a decrease in concentration due to fatigue during work, a decrease in judgment, and a decrease in reaction speed [17,19].

https://doi.org/10.35371/aoem.2021.33.e15

According to a previous study, risk factors for occupational injury include personal factors such as age [20], hypertension or diabetes mellitus [21,22], smoking [23], and alcohol [24,25], and workplace factors such as workplace size [26,27], shift work [2,19], and type of industry [28,29]. In this study, when these factors were identified, men were found to have higher risk of occupational injuries in group of current smoking, drinking more than 15 units per week, working in workplaces with less than 300 workers, and non-shift work. In the case of shift work, results are contrary to these of previous studies [19,28]. It might be because of selection bias. In this study, one university hospital workers (mostly nurses) and one airline workers were the only workers with shift work. Due to this, it seems that the contrary result was shown in this study. After adjusting these factors, it was found that the OR of FSS scores for occupational injuries – hospital treatment or absence due to work related accidents were significantly high in men.

However, in women, no significant association was observed between fatigue and occupational injuries in this study. This was not significant even when the general and occupational factors were adjusted. Several hypotheses can be suggested for the results.

First, it can be considered that women's fatigue awareness level is higher than that of men. The FSS used in this study measure subjective symptoms. Therefore, the number may vary depending on the workers. In this study, female workers are 1.2 to 1.7 times more likely to experience fatigue than men. In a study about 10,000 Korean workers, women's fatigue complaint rate was higher than that of men (51.2% vs. 39.9%) [30], and a similar results were revealed several studies [31,32]. For this reason, the fatigue evaluation scale is relatively high in women, and the association between fatigue and occupational injury may have been attenuated.

Second, differences in occupational factors between men and women may affected the result. Among the subjects of this study, there is a difference in the industrial classification in which women and men are mainly engaged. Men are mainly engaged in manufacturing and transportation, and women tend to work in human health and social work activities. So, relatively less cases of occupational injuries would be reported among female workers. The size of the workplace also differs between men and women. For women, 27.6% of workers were at workplaces with less than 300 employees, but 48.2% for men. Considering that workers working in small workplaces have a higher risk of occupational injury [26,27], women may have relatively fewer occupational injuries. In conclusion, it can be assumed that women experience fewer occupational injuries than men, and that symptoms are also mild. Therefore, the association between FSS and occupational injuries may not have been clearly seen.

There are some limitations in this paper. First, even in the same occupational injury, the period of absence and the type of damage are different. This may need to be revealed through further research. Second, relatively low follow-up rate (63.7%, 63.8% respectively). between 2014 and 2015, there may be workers who quit their job or had been in a sick leave due to a work-related accident. Therefore, considering this effect, it is possible that the relationship between work injury and fatigue is underestimated. Third, time difference is existing between the time when fatigue is evaluated and the time occupational injury occurred. So that, a fatigue level at the time when occupational injury occurred may not be directly evaluated.

There are limitations in evaluating differences in the types of work between blue-collar workers and white-collar workers, and whether and how shifts are made.

CONCLUSIONS

Male workers with high FSS score are at a higher risk of experiencing occupational injury. Since this study prospectively assessed fatigue and identified the subsequent occupational injuries, it is possible to consider active intervention to prevent work related accidents of workers with high FSS scores. Proactively identifying and managing workers who are likely to suffer occupational injuries not only helps workers' health, but also helps the efficient operation of the workplace. To this end, it would be helpful to classify the high-risk group with a high probability of injuries by using the FSS score and take action such as switching work or reducing work time. In addition, long-term follow-up studies on the relationship between fatigue and occupational injuries are considerable.

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