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Relationship between job stress and impaired fasting glucose in male steel industry workers: a cross-sectional study

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ABSTRACT

Background: The purpose of this study is to investigate the relationship between job stress and impaired fasting glycemia (IFG) of male workers in a manufacturing industry.
Methods: Data were collected from 5,886 male workers in a manufacturing industry who participated in the medical examination from June 19 to August 14, 2020 through self-reported questionnaires. The general characteristics of the subjects, shift work, high blood pressure, dyslipidemia, and job stress were included. Job stress was measured using the Korean Occupational Stress Scale (KOSS) consisting of 8 items and 43 questions. Multivariable logistic regression analysis was used to investigate the IFG association with job stress.
Results: Among the various factors that can cause job stress, only high job demand was associated with a risk of IFG (odds ratio, 1.43; 95% confidence interval, 1.13–1.82) especially in non-shift worker. For all other factors, no statistically significant results were obtained.
Conclusions: In this study of male workers engaged in the Korean steel manufacturing industry, the 'job demand' item among job stress of non-shift worker was related to IFG.

Keywords: Job stress; Job demand; Impaired fasting glucose

BACKGROUND

Type 2 diabetes (T2DM), one of the most common chronic diseases, is a major public health problem in both developed and developing countries. Its incidence continues to increase.[1,2] Epidemiological evidence has suggested that its incidence will continue to rise without effective prevention programs.[3] Risk factors for T2DM include lifestyle factors such as obesity, low physical activity, and smoking in addition to aging. High blood pressure and low-density lipoprotein cholesterol rise are also widely known as risk factors for T2DM.[4-6]

Impaired fasting glycemia (IFG), a fasting blood glucose disorder and an intermediate condition between normal glucose metabolism homeostasis and diabetes, is thought to be a precursor to diabetes, although progression to an obvious disease is not certain.[7] However, early detection of IFG might be important in that it is used as a risk indicator for future T2DM and cardiovascular disease (CVD).[8]

Abbreviations

BMI, body mass index; CI, confidence interval; CVD, cardiovascular disease; HPA-Axis, hypothalamic pituitary adrenal axis; IFG, impaired fasting glycemia; IRB, Institutional Review Board; JCQ, Job Content Questionnaire; KOSS, Korean Occupational Stress Scale; OR, odds ratio; T2DM, type 2 diabetes.

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Competing interests

The authors declare that they have no competing interests.

Author Contributions

Conceptualization: Lee HK, Kwon SC; Data curation: Lee HK, Lee YJ, Jang EC, Kwon SC, Min YS, Lee IH, Yun JS; Formal analysis: Lee HK, Lee YJ, Jang EC, Kwon SC, Min YS, Lee IH, Yun JS; Investigation: Lee HK, Lee IH, Yun JS, Kwon SC; Writing - original draft: Lee HK; Writing - review & editing: Kwon SC.

In addition to these risk factors, job stress is also emerging as a risk factor for T2DM.[9] According to a demand-control model proposed by Karasek, job stress occurrence can be explained using two concepts: job control and job demand.[10] Job control is a concept that measures workers' authority to exercise decision authority in the work process. Job demand is a concept to evaluate mental job needs. It is closely related to the overall production level of the workplace, that is, labor quantity and labor intensity.[11] According to this model, job stress increases when workers are exposed to high job demands for a long time in a structure with a low job control.[12]

In people at risk of job-related stress, the imbalance in glucose metabolism can progress slowly over a long period of time.[13] Recent studies have shown that high levels of stress in daily life, especially latent stress conditions such as exhaustion, are associated with T2DM.[14,15] In addition, unfavorable conditions in the social environment, such as socioeconomic status and stressful working environment, are attracting attention as risk factors for T2DM.[9,16]

Although there are many physiological mechanisms by which job stress can impair glucose metabolism, it is commonly explained through autonomic nerves and hypothalamic pituitary adrenal axis (HPA-Axis).[17] Constant exposure to stress can cause hyperstimulation of sympathetic nerves and the HPA-Axis.[18] Abnormalities in the HPA-Axis due to hyperactivity of sympathetic nerves can cause CVD and cancer through various mechanisms such as increased cortisol in the blood, increased norepinephrine, and increased pulse rate.[19-21] In addition, they affect the endocrine system, increasing insulin resistance and causing abnormal glucose metabolism.[22] The sensory and endocrine systems operate around the autonomic nervous system, and stress affects these systems, resulting in complex reactions related to metabolism.[23] As job demand increases, stress hormones such as cortisol and norepinephrine increase.[24] These hormones reduce insulin secretion and promote glucose production and secretion, and these reactions can cause hyperglycemia or IFG.[23,24]

However, unlike known physiological mechanisms, research results on the association between T2DM and job stress are inconsistent. One study has found that among subjects classified by the Job Content Questionnaire (JCQ), those with high job stress are about 16% more likely to develop diabetes than those with low job stress.[25] On the contrary, a meta-analysis conducted by Cosgrove et al.[26] in 2012 showed that high psychological stress was not directly related to an increased risk of T2DM, showing inconsistent patterns. In a North American study of female nurses aged 29 to 46 years, job burden was not associated with the risk of T2DM,[27] although other studies on female workers reported a link between job stress at work and T2DM.[28]

As such, there have been many studies on the relationship between T2DM and job stress.[25,26,29] However, studies on the relationship between IFG, a pre-diabetes stage, and job stress have not been reported yet. In addition, no research has been conducted on such relationship using large-scale workplaces with more than 5,000 employees. Thus, the aim of this study was to determine the relationship between job stress and IFG in a single steel manufacturing workplace, focusing on the relationship between IFG and each item of KOSS. By examining the relationship between job stress and IFG, especially among “male” workers in Korea who have not been previously studied, we would like to provide insight to the relationship between job stress and IFG.

METHODS

Study participants

This was a cross-sectional study. Participants aged 20 to 62 years were recruited based on regular annual worker checkups agreed by workers at a steel mill in Dangjin, Chungcheongnam-do, Rebublic of Korea. Medical checkups were conducted at a university hospital in Cheonan, Chungcheongnam-do, Korea. The examination has been conducted from June 29, 2020 to August 14, 2020. During this period, a total of 6,350 people were examined. A total of 111 women were excluded due to small sample size for gender-specific analysis. In addition, 353 patients with existing diabetes and those with a fast glucose level of 126 mg/dL or higher were excluded. Finally, a total of 5,886 male patients were analyzed.

Measurement

General and occupational characteristics

A structured questionnaire was used to collect information on age, body mass index (BMI), exercise, smoking, alcohol consumption, shift work history, and chronic diseases diagnosed by medical doctors (e.g., hypertension, dyslipidemia). In other words, information on general characteristics and occupational characteristics of subjects were obtained through specific questions presented in the special examination and shift work questionnaire.[30,31] The age group was classified based on the age of 40, considering the increased risk of diabetes, metabolic disease, and metabolic syndrome factors with age and the significant difference in the distribution of IFG around the 30s and 40s in the study results. BMI was classified as "more than 25 kg/m^2" and "less than 25 kg/m^2".[32] Alcohol intake was classified as "people who do not drink," "those who drink one to two times a week," and "those who drink more than three times a week." Smoking was classified as "current smokers," "past smokers," and "non-smokers." Exercise was classified as "those who perform no exercise," "those who exercise one to two times a week," and "those who exercise more than three times a week." Shift work was classified into "those who have work shifts" and "those who do not have work shifts".[33] Tenure was classified as 'less than 5 years,' 'more than 5 years and less than 10 years,' 'more than 10 years and less than 15 years,' and 'more than 15 years.' Hypertension was defined as systolic blood pressure of 140 mmHg or higher, diastolic blood pressure of 90 mmHg or higher, or taking high blood pressure drugs according to guidelines of the Korea Hypertension Association in 2018.[34] Dyslipidemia was defined as total cholesterol of 240 mg/dL or more, a neutral fat of 200 mg/dL or more, a high-density cholesterol of 40 mg/dL or a low-density cholesterol of 160 mg/dL or more, or taking a dyslipidemia drug.[35]

Assessment of job stress

The Korean Occupaiotnal Stress Scale (KOSS) was developed in consideration of characteristics of Korean workers to evaluate job stress.[36] KOSS was evaluated for validity and reliability based on 30,146 workers at workplaces nationwide. In a study that evaluated the reliability and validity of KOSS, KOSS showed a high correlation with the mental fatigue scale, the short form of psychosocial well-being index, and the job content questionnaire.[37] KOSS consists of eight subscales and a total of 43 questionnaires, specifically consisting of physical environment, job demand, insufficient job control, interpersonal conflict, job insecurity, organizational system, lack of reward, and occupational climate. Each item uses a 4-point Likert scale. Total job stress score and lower category score of KOSS were converted to a 100-point system. Subjects were classified into a high-risk group if their KOSS scores were higher than top 25% Korean worker score (75% percentile) based on the KOSS reference value. They were classified into a low-risk group if their KOSS scores were less than top 25%.[32]

Impaired fasting glucose levels

Fasting blood samples were collected after at least 8 hours of fasting. Based on blood tests, fasting blood sugar levels ≤ 99 mg/dL were considered normal whereas fasting blood sugar levels ranging from 100 mg/dL to 125 mg/dL were considered IFG.

Statistical methods

After dividing the groups according to shift work, the prevalence of IFG by the potential confounders of the subjects was compared, and statistical significance was shown through the chi-square test. In addition, the mean value and high risk participants ratio by job stress subscale according to IFG were investigated. The mean value for each job stress subscale according to IFG was statistically verified through a Student's *t*-test.

Logistic regression analyses were performed to investigate relationship between job stress and IFG according to shift work. The analysis models were as follows.

Model 1: crude
Model 2: Adjusted for Age, BMI
Model 3: Adjusted for Age, BMI, lifestyle characteristic (Alcohol consumption, Smoking, Regular exercise) and chronic diseases (such as hypertension and dyslipidemia)

Results are presented as odds ratio (OR) with 95% confidence interval (CI). Difference was considered statistically significant if *p*-value was less than 0.05. Statistical analysis was performed with SPSS 26.0 (IBM Corp., Armonk, NY, USA).

Ethics statement

This study was approved by the Institutional Review Board (IRB) of Soonchunhyang University Hospital, Cheonan (IRB No. 2022-12-040-002). The requirement of informed consent was waived due to its retrospective nature.

RESULTS

Characteristics and lifestyle

Table 1 shows the general characteristics of the study subjects according to the shift work. In the non-shift worker group, the incidence of IFG was higher in those over 40 years of age. On the other hand, in the shift worker group, when divided based on the age of 40, the group under the age of 40 (51.7%) had a slightly higher IFG incidence rate than the group over the age of 40 (48.3%). In the high BMI, the incidence of IFG was quite high for both shift workers and non-shift workers. Both shift workers and non-shift workers with hypertension and dyslipidemia had significantly higher IFG incidence rates. Significant differences in IFG incidence were observed in both groups in drinking and smoking. In the case of regular exercise, there was no statistically significant difference in the non-shift worker group, but in the shift worker group, the incidence of IFG was high in the group without exercise.

Job stress of research subjects

Table 2 lists the KOSS score, KOSS reference value (75th percentile), and the number and proportion of participants classified as high risk. The total job stress score for KOSS was 44.71 ± 9.14 for the non-IFG group and 44.55 ± 8.69 for the IFG group. When comparing job stress scores by subclassification, the IFG group scored lower in Physical environment and

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Table 1. Characteristics of study subjects by shift work

Variables	Category	Non-shift work (n = 2,686)			Shift work (n = 3,200)		
		Non-IFG (n = 1,679)	IFG (n = 1,007)	*p*-value[a]	Non-IFG (n = 2,252)	IFG (n = 948)	*p*-value[a]
Age (years)	< 40	955 (56.9)	376 (37.3)	< 0.001	1,636 (72.6)	490 (51.7)	< 0.001
	≥ 40	724 (43.1)	631 (62.7)		616 (27.4)	458 (48.3)	
BMI	< 25	789 (47.0)	350 (34.8)	< 0.001	1,101 (48.9)	340 (35.9)	< 0.001
	≥ 25	890 (53.0)	657 (65.2)		1,161 (51.1)	608 (64.1)	
HTN	Yes	100 (6.0)	141 (14.0)	< 0.001	77 (3.4)	103 (10.9)	< 0.001
	No	1,579 (94.0)	866 (86.0)		2,175 (96.6)	845 (89.1)	
Dyslipidemia	Yes	104 (6.2)	94 (9.3)	0.003	104 (4.6)	81 (8.5)	< 0.001
	No	1,575 (93.8)	913 (90.7)		2,148 (95.4)	867 (91.5)	
Alcohol consumption (times/week)	0	445 (26.5)	216 (21.4)	< 0.001	855 (38.0)	295 (31.1)	< 0.001
	1–2	1,058 (63.0)	607 (60.3)		1,145 (50.8)	513 (54.1)	
	≥ 3	176 (10.5)	184 (18.3)		252 (11.2)	140 (14.8)	
Smoking	Never	896 (53.4)	435 (43.2)	< 0.001	1,307 (58.0)	470 (49.6)	< 0.001
	Past	452 (26.9)	331 (32.9)		499 (22.2)	266 (28.1)	
	Current	331 (19.7)	241 (23.9)		446 (19.8)	212 (22.4)	
Regular exercise (times/week)	0	679 (40.4)	430 (42.7)	0.090	761 (33.8)	389 (41.0)	< 0.001
	1–2	476 (28.4)	303 (30.1)		655 (29.1)	283 (29.9)	
	≥ 3	524 (31.2)	274 (27.2)		836 (37.1)	276 (29.1)	

BMI: body mass index; HTN: hypertension.
[a]Calculated by χ^2 test.

Table 2. Job stress levels of the participants by IFG (n = 5,886)

Subscales	IFG(−) (n = 3,931)			IFG(+) (n = 1,955)			*p*-value[b]
	Mean ± SD	Reference[a]	High risk participants	Mean ± SD	Reference[a]	High risk participants	
Physical environment	51.02 ± 20.06	66.7	1,172 (29.8)	48.14 ± 20.38	66.7	498 (25.5)	< 0.001
Job demand	40.67 ± 14.40	58.4	311 (7.9)	42.38 ± 14.28	58.4	195 (10.0)	< 0.001
Insufficient job control	48.75 ± 12.14	60.1	382 (9.7)	47.49 ± 11.99	60.1	149 (7.6)	< 0.001
Interpersonal conflict	35.44 ± 13.93	50.1	296 (7.5)	36.50 ± 12.58	50.1	162 (8.3)	0.005
Job insecurity	51.00 ± 12.76	61.2	521 (13.3)	51.05 ± 12.34	61.2	247 (12.6)	0.885
Organizational system	49.84 ± 16.18	62.0	698 (17.8)	49.81 ± 15.19	62.0	313 (16.0)	0.952
Lack of reward	44.79 ± 14.29	77.8	130 (3.3)	44.52 ± 13.66	77.8	46 (2.4)	0.490
Occupational climate	36.16 ± 15.48	50.1	410 (10.4)	36.42 ± 15.03	50.1	203 (10.4)	0.535
Total job stress score	44.71 ± 9.14	56.6	330 (8.4)	44.55 ± 8.69	56.6	143 (7.3)	0.504

Values are presented as number (%).
IFG: impaired fasting glycemia; IFG(−): IFG-negative group; IFG(+): IFG-positive group; SD: standard deviation.
[a]Korean Occupational Stress Scale reference value (75th percentile).
[b]Calculated by Student's *t*-test.

Insufficient job control than the non IFG group, while the IFG group scored higher in Job demand than the group that did not ($p < 0.001$).

Table 3 in appendix shows the KOSS score, the KOSS reference value (75th percentile), and the number and proportion of participants classified as high risk in the non-shift work group. The total job stress score for KOSS was 44.13 ± 8.79 for the non-IFG group and 43.82 ± 8.93 for the IFG group. Comparing job stress scores by subclassification, the IFG group scored lower in physical environment ($p = 0.002$) and Insufficient job control ($p = 0.018$) than the non IFG group, whereas the IFG group scored higher in job demand ($p = 0.021$).

Table 4 in appendix shows the KOSS score, the KOSS reference value (75th percentile), and the number and proportion of participants classified as high risk in the shift worker group. The total job stress score for KOSS was 45.15 ± 9.36 for the non-IFG group and 45.32 ± 8.36 for the IFG group. Comparing the job stress scores by subclassification, there was no statistically significant difference in scores compared to the non-IFG group compared to the IFG group in all items.

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Table 3. Job stress levels of the participants (non-shift work) by IFG (n = 2,686)

Subscales	IFG(−) (n = 1,679)			IFG(+) (n = 1,007)			*p*-value[b]
	Mean ± SD	Reference[a]	High risk participants	Mean ± SD	Reference[a]	High risk participants	
Physical environment	44.86 ± 19.71	66.7	326 (19.4)	42.47 ± 19.77	66.7	175 (17.4)	0.002
Job demand	44.38 ± 14.36	58.4	200 (11.9)	45.72 ± 14.92	58.4	155 (15.4)	0.021
Insufficient job control	44.38 ± 10.82	60.1	75 (4.5)	43.36 ± 10.84	60.1	35 (3.5)	0.018
Interpersonal conflict	35.15 ± 13.43	50.1	113 (6.7)	35.65 ± 12.37	50.1	72 (7.1)	0.334
Job insecurity	50.35 ± 12.54	61.2	195 (11.6)	50.17 ± 12.46	61.2	122 (12.1)	0.726
Organizational system	49.91 ± 15.32	62.0	277 (16.5)	49.82 ± 14.95	62.0	154 (15.3)	0.872
Lack of reward	45.29 ± 14.15	77.8	53 (3.2)	44.84 ± 13.95	77.8	24 (2.3)	0.425
Occupational climate	38.68 ± 15.15	50.1	223 (13.3)	38.47 ± 15.24	50.1	129 (12.8)	0.731
Total job stress score	44.13 ± 8.79	56.6	127 (7.6)	43.82 ± 8.93	56.6	62 (6.2)	0.378

Values are presented as number (%).
IFG: impaired fasting glycemia; IFG(−): IFG-negative group; IFG(+): IFG-positive group; SD: standard deviation.
[a]Korean Occupational Stress Scale reference value (75th percentile).
[b]Calculated by Student's *t*-test.

Table 4. Job stress levels of the participants (Shift work) by IFG (n = 3,200)

Subscales	IFG(−) (n = 2,252)			IFG(+) (n = 948)			*p*-value[b]
	Mean ± SD	Reference[a]	High risk participants	Mean ± SD	Reference[a]	High risk participants	
Physical environment	55.61 ± 19.06	66.7	846 (37.6)	54.17 ± 19.26	66.7	323 (34.1)	0.052
Job demand	37.90 ± 13.79	58.4	111 (4.9)	38.83 ± 12.65	58.4	40 (4.2)	0.075
Insufficient job control	52.01 ± 12.04	60.1	307 (13.6)	51.89 ± 11.59	60.1	114 (12.0)	0.801
Interpersonal conflict	35.65 ± 14.30	50.1	183 (8.1)	37.40 ± 12.75	50.1	90 (9.5)	0.001
Job insecurity	51.48 ± 12.91	61.2	326 (14.5)	51.98 ± 12.16	61.2	125 (13.2)	0.313
Organizational system	49.78 ± 16.80	62.0	421 (18.7)	49.81 ± 15.43	62.0	159 (16.8)	0.968
Lack of reward	44.41 ± 14.38	77.8	77 (3.4)	44.17 ± 13.34	77.8	22 (2.3)	0.662
Occupational climate	34.28 ± 15.46	50.1	187 (8.3)	34.25 ± 14.51	50.1	74 (7.8)	0.954
Total job stress score	45.15 ± 9.36	56.6	203 (9.0)	45.32 ± 8.36	56.6	81 (8.5)	0.626

Values are presented as number (%).
IFG: impaired fasting glycemia; IFG(−): IFG-negative group; IFG(+): IFG-positive group; SD: standard deviation.
[a]Korean Occupational Stress Scale reference value (75th percentile).
[b]Calculated by Student's *t*-test.

Relationship between job stress and impaired fasting glucose

Table 5 shows the relationship between job stress and IFG by logistic regression analysis. Interestingly, for non-shift workers, the job demand subcategory showed an increase in IFG risk (Model 1, OR: 1.43, 95% CI: 1.13–1.82, $p < 0.01$; Model 2, OR: 1.42, 95% CI: 1.12–1.82, $p < 0.01$; Model 3, OR: 1.42, 95% CI: 1.11–1.81, $p < 0.01$). In the case of shift workers, on the other hand, all subcategories could not statistically confirm the relationship between job stress and IFG.

DISCUSSION

This study examined demographic characteristics and the correlation between job stress and IFG of male workers in a domestic steel manufacturing industry. Using KOSS, eight job stressors were investigated and the effect of each stressor on IFG was determined. Among these factors, job demand refers to the degree of burden on jobs. It was evaluated in detailed categories such as time pressure, disruption, increased workload, responsibility, excessive job burden, work family balance, and work multifunction.[38]

Among various factors that could cause job stress, psychological stress, especially stress due to high job demand, was related to an increased risk of IFG in non-shift worker group (Model 1, OR: 1.43).

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Table 5. ORs and 95% CIs for impaired fasting glycemia and job stress by shift work

Job stress	Non-shift work (n = 2,686)			Shift work (n = 3,200)		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Physical environment						
Low risk	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
High risk	0.87 (0.70–1.06)	0.95 (0.76–1.17)	0.99 (0.80–1.23)	0.89 (0.75–1.05)	0.99 (0.84–1.18)	1.04 (0.87–1.23)
Job demand						
Low risk	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
High risk	1.43 (1.13–1.82)**	1.42 (1.12–1.82)**	1.42 (1.11–1.81)**	0.96 (0.65–1.42)	0.95 (0.64–1.42)	0.92 (0.61–1.37)
Insufficient job control						
Low risk	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
High risk	0.78 (0.51–1.20)	0.94 (0.61–1.46)	0.97 (0.62–1.51)	0.91 (0.72–1.17)	1.09 (0.85–1.40)	1.10 (0.85–1.42)
Interpersonal conflict						
Low risk	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
High risk	1.13 (0.82–1.57)	0.92 (0.66–1.29)	0.89 (0.64–1.26)	1.33 (1.00–1.77)	1.18 (0.88–1.59)	1.19 (0.88–1.61)
Job insecurity						
Low risk	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
High risk	1.09 (0.85–1.39)	1.03 (0.79–1.32)	0.95 (0.73–1.23)	0.96 (0.76–1.20)	0.94 (0.74–1.19)	0.90 (0.71–1.15)
Organizational system						
Low risk	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
High risk	0.93 (0.83–1.19)	0.90 (0.70–1.15)	0.91 (0.71–1.17)	0.89 (0.71–1.12)	0.84 (0.66–1.06)	0.81 (0.64–1.04)
Lack of reward						
Low risk	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
High risk	0.73 (0.43–1.25)	0.90 (0.52–1.55)	0.95 (0.55–1.65)	0.73 (0.43–1.24)	0.80 (0.47–1.37)	0.86 (0.50–1.47)
Occupational climate						
Low risk	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
High risk	0.94 (0.73–1.21)	1.05 (0.81–1.36)	1.02 (0.79–1.33)	1.04 (0.76–1.41)	1.06 (0.77–1.45)	1.10 (0.80–1.51)
Total job stress score						
Low risk	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
High risk	0.80 (0.59–1.10)	0.90 (0.65–1.25)	0.90 (0.64–1.25)	0.94 (0.72–1.24)	1.02 (0.77–1.34)	1.03 (0.78–1.36)

OR: odds ratio; CI: confidence interval; IFG: impaired fasting glycemia.
Model 1: crude; Model 2: adjusted for age, BMI; Model 3: adjusted for Model 2 + HTN, dyslipidemia, alcohol consumption, smoking, regular exercise.
**$p < 0.01$.

Based on the correlation between the 'job demand' sub-scale items in KOSS and JCQ, it can be suggested that the demand-control model proposed by Karasek may be partially explained by KOSS.[36] However, it should be noted that interpreting Karasek's model solely based on KOSS is subjective and may involve logical leaps.

The results of this study are consistent with previous research on the increased risk and association between job-related high-risk groups (e.g., overwork) and T2DM, as well as studies on female workers in general evaluated using JCQ, suggesting a potential similar relationship with the results of this study which targeted male workers.[26,28] Also this study confirmed a relationship between job demands and abnormal blood glucose levels, particularly IFG, only for non-shift worker in a group of male workers employed in a steel manufacturing plant, using KOSS as the job stress evaluation tool. This relationship has not been previously studied in this population.

Physiologically, IFG means that the liver's ability to regulate glucose metabolism has weakened due to a lack of insulin secretion or decreased sensitivity to insulin in the liver.[39] Therefore, job stress, especially 'Job demand' in terms of IFG, a pre-stage of T2DM, means that excessive job demands have been associated with glycated metabolic abnormalities, which could increase the risk of developing T2DM, as well as CVDs, as suggested by previous studies.[40] However, it should be noted that job demand is only one aspect of job-related stress and cannot solely determine an individual's stress level. In other words, this study is valuable

from the perspective of preventing and preventing the progression to disease in that IFG is a pre-stage of diabetes.

It is well known that it is necessary to correct lifestyle factors such as proper diet and proper physical activity to prevent the progression of diabetes.[41,42] However, evaluating various factors that can affect job stress while performing work, especially 'job demand,' as well as individual approaches through lifestyle factors correction, is important for IFG's prevention in public health.[43] Results of this study suggest that preventing job stress in companies through systematic approaches such as Employee Assistance Program (EAP) is necessary before IFG progresses to diabetes.[44]

What should be considered in the results of this study is that even though the "job demand" as a job stressor confirms the risk of IFG for non-shift workers, it cannot be confirmed for shift workers. Although many studies have been conducted on the link between diabetes, the link between IFG and night shift is still unclear, and risk factors including obesity, family history, high blood pressure, and cyclical rhythm disorders, which are known to directly affect diabetes, are higher risks for shift workers.[45] In addition, considering that night work itself can also affect the factors affecting diabetes, it is a complex problem to determine how much risk the job demand can increase in IFG.[45] In other words, further research is needed on the impact of job demand on Diabetes and IFG according to Karasek's Job Demand-Control model model.[46] It will also be important to develop research and surveys on shift workers by strengthening the current KOSS questionnaire.

Limitations of this study are as follows. First, it was difficult to accurately identify the causal relationship between variables in this study due to the nature of a cross-sectional study. In particular, unlike day workers, the lack of significant results in shift workers is a limitation of cross-sectional research that occurs because there is no data on shift workers despite other factors that can affect IFG. Second, since this study used only self-report data, there might be a possibility of response bias that might cause distorted results. Third, in this study, participants fasted for more than eight hours before blood collection, but it is difficult to accurately confirm this, the study was based on the results of one blood test, and no tests were conducted on variables that can provide information on blood sugar such as HbA1C. Fourth, it was difficult to generalize results of this study to other professional workers because the survey was conducted on manufacturing workers. Therefore, in future studies, it is necessary to comprehensively verify the effect of job stress exposure in consideration of work content and environment for workers engaged in various jobs. Further research should also consider different variables as the evaluation tool did not include stress causes other than personal personality items or jobs (such as family problems). Fifth, it was difficult to verify the influence of gender because subjects of this study were men with a very small number of women excluded. In the future, it is necessary to sufficiently recruit female subjects and conduct additional research. Lastly, KOSS was developed to understand the unique circumstances and working conditions of Korean workers and to identify factors contributing to job stress in that context.[37,47] However, there are numerous survey tools available for evaluating job stress that have been developed and validated internationally, including the JCQ. These tools have been widely implemented in various countries and have been shown to possess high levels of reliability and validity.[48] Although KOSS has been evaluated as an objective and valid measurement tool for assessing job stressors among Korean workers, it is essential to consider the potential benefits of employing other established job stress assessment tools. By doing so, we can ensure that the results of this

study are strengthened and enhanced. Therefore, in order to determine how to improve the results of this study using these additional tools, it is necessary to evaluate the mental health effects caused by job stress, such as DASS (Depression Anxiety Stress Scales) and SCL-90-R (Symptom Checklist-90-Revised).

Therefore, in order to dig deeper into the causal relationship between stress level and IFG as well as job stress factors, more various measurement tools and methodologies will be needed, and these limitations will be considered in interpreting the results of this study. In addition, the top 25% of the previously suggested criteria were used in this study to compare high-risk and low-risk groups, but the previous criteria were for all workers at the beginning of the past study, so there is a limit to accurately explaining the current criteria. In this study, the quartile was classified and checked with job stress data, but it was only for specific steel manufacturing workers, and it was confirmed that the frequency was concentrated on a specific score as discrete data to select the standard value of 5,886. Therefore, it was determined that an investigation into the job stress standard in the future would be necessary. By using a variety of job stress assessment tools, we can gain a more comprehensive understanding of the job stress situation among Korean workers, which will ultimately lead to more effective strategies for managing and preventing job stress in the workplace.

Nevertheless, this study was meaningful in that it was conducted as a large-scale study analyzing more than 5,000 subjects in a single workplace. In addition, since few previous studies have verified the relationship between job stress and IFG, this study is meaningful in that it can lay the foundation for preventing and managing diabetes in advance.[49]

CONCLUSIONS

In this study of male workers engaged in the steel manufacturing industry in Korea, the item of 'job demand' among job stressor was related to IFG. In the future, more extensive research needs to be conducted considering effects of job stress on IFG not only for workers in the manufacturing industry, but also for white-collar works such as those who are office workers and professionals.

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