

The relationship among sleep reactivity, job-related stress, and subjective cognitive dysfunction: a cross-sectional study using path analysis

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Abstract: Insomnia, job-related stress, and cognitive dysfunction affect the mental health of workers. However, the relationships among sleep reactivity, job-related stress, and subjective cognitive dysfunction in workers remains not fully understood. Therefore, this study seeks to investigate the relationships among these variables in Japanese adult workers. In total, 536 adult workers in Japan were evaluated using the Japanese version of Ford Insomnia Response to Stress Test, Brief Job Stress Questionnaire, and Cognitive Complaints in Bipolar Disorder Rating Assessment to assess sleep reactivity, job-related stress, and subjective cognitive function, respectively. Path analysis was also carried out. The results of the path analysis showed that sleep reactivity significantly influenced on subjective cognitive dysfunction directly and indirectly via job stressors and stress reaction. Our results may not be generalizable to underage workers because only adult workers were included, which is a limitation of this study. The results of the present study suggest that job-related stress mediates the effect of sleep reactivity on subjective cognitive dysfunction in Japanese adult workers. This underscores the need to evaluate the mediating effect of job-related stress in addressing the subjective cognitive dysfunction associated with insomnia in workers.

Key words: Sleep reactivity, Job stress, Subjective cognitive function, Mediator, Workers

Introduction

Occupational stress affects the mental health of workers. Mental health problems lead to a loss in work productivi-

ty¹). Recently, the relationship between cognitive function and presenteeism in workers has attracted much attention. Cognitive dysfunction is considered a cause rather than a consequence of burnout²). The relationship between work-stress-related exhaustion and attention deficit has also been reported³). The relationship between job-related stress and cognitive dysfunction is a close one in workers.

Cognitive functioning can be evaluated objectively and subjectively. Subjective cognitive assessment has the ad-

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vantage that it can be carried out easily within a short time⁴). In addition, it has various characteristics and has been found to play important roles in daily life as well as having a correlation with depressive symptoms and quality of life⁵). In addition, subjective cognitive function is more closely related to social function than objective cognitive function is⁶). Furthermore, work functioning is associated with subjective cognitive dysfunction⁷), while psychosocial working conditions affect subjective cognitive dysfunction among employees⁸). Regarding work productivity, depressive symptoms and subjective cognitive dysfunction affect presenteeism in workers⁹). Thus, subjective cognitive dysfunction is one of the important factors that influence the mental health of workers.

One of the important factors in workers' mental health is insomnia. Sleep deprivation affects work performance¹⁰), and insomnia has been linked to accidents and work-related errors¹¹). Sleep quality is believed to be affected by job-related stress in workers¹²). A meta-analysis found a correlation between insomnia and job-related stress among workers¹³). Furthermore, insomnia is associated with human relationships at the workplace, job satisfaction, and social support status¹⁴). Recently, sleep reactivity, the likelihood of sleep disturbances by stressful situations¹⁵), has attracted much attention in workers, and this is correlated with depressive and anxiety symptoms¹⁶). Simply put, sleep quality is closely associated with job-related stress.

Recent research suggests that insomnia has a correlation with subjective cognitive dysfunction¹⁷), and a meta-analysis found a relationship between insomnia and both subjective and objective cognitive dysfunction¹⁸). Furthermore, overtime work affects stress responses¹⁹). Although, perceived stress decreases subjective cognitive function²⁰), to the best of our knowledge, the effect of insomnia and job-related stress on subjective cognitive dysfunction in workers has not been previously reported.

In particular, we aimed to answer the question of whether stressors and stress reactions mediate the effect of sleep reactivity on subjective cognitive dysfunction. "Sleep reactivity" is considered as "a trait characteristic," which is consistent over time and across a variety of stress stimuli^{15, 21–23}). Regarding subjective cognitive dysfunction, Toyoshima *et al* suggested the "trait marker → state marker → subjective cognitive dysfunction" model²⁴). Therefore, we hypothesized the "trait marker of insomnia → stress → cognitive dysfunction" model, referring to the previous studies. Regarding the difference between "sleep quality" and "sleep reactivity," "sleep quality" is composed of three indicators: falling asleep, staying asleep, and restorative

sleep¹²), whereas "sleep reactivity" is vulnerability to stress-related insomnia, which is a trait characteristic of insomnia²⁵). Regarding the difference between "stressors" and "stress reactions," "stressors" indicate perceived job stressors, such as perceived job overload, poor physical environment, and interpersonal conflicts, whereas "stress reactions" indicate stress responses, defined by mental and physical symptoms^{26, 27}). Regarding our hypothesis of "sleep reactivity → stress (stressor, stress reaction) → subjective cognitive dysfunction," we referred to the previous model "affective temperaments → depressive symptoms → subjective cognitive dysfunction" by Toyoshima *et al*²⁴). Sleep reactivity is associated with stress-related worry and rumination, cognitive-emotional reactivity, and perceived stress²⁵). "Stress reactions" indicate stress responses, defined by mental and physical symptoms^{26, 27}). Thus, stress-related worry and rumination are considered "stress reactions." The relationship of sleep reactivity, perceived stress, and stress reaction has been reported. However, the association of sleep reactivity, perceived stress, and stress reaction with subjective cognitive dysfunction is not well understood. Although the relationship of sleep reactivity, stress, and neurobiological dysfunction has been reported²³), no studies have reported on the relationship of sleep reactivity, stress (perceived stress and stress reaction), and subjective cognitive dysfunction. Therefore, the present study aimed to investigate the relationships of sleep reactivity, job-related stress, and subjective cognitive dysfunction as well as the mediating role of job-related stress (perceived stress and stress reaction) using a path analysis.

Subjects and Methods

Participants

In total, 597 adult participants were conveniently recruited in Japan between April 2017 and April 2018 in accordance with the Declaration of Helsinki²⁸). The approval from the Local Ethics Committee of Tokyo Medical University was obtained before the commencement of the study (approval number: SH3502). We excluded the participants who were not employed at the time and those who did not complete the assessments in this study. The present study is part of a larger research, where several assessments were evaluated⁵). Written informed consent was obtained from all the participants before participation. This article does not reveal identifiable information of any of the participant. Recruitment was performed through the word of mouth, using poster at the Tokyo Medical University, and distributing self-administered questionnaires to 597 adult

volunteers. Ten participants were currently unemployed, and 51 participants did not complete the assessments. Therefore, the data of 536 participants were used in the analysis.

Self-Assessments

Sleep reactivity

The Ford Insomnia Response to Stress Test (FIRST) evaluates sleep reactivity, that is, the likelihood of sleep disturbances by stressful situations¹⁵⁾. It comprises nine items and makes evaluations using the Likert scale from 1 to 4 points. The maximum total score is 36, which indicates extremely high sleep reactivity. In this study, we used the Japanese version (FIRST-J), which was developed and validated on the basis of the original version²⁹⁾.

Job stress

The Brief Job Stress Questionnaire (BJSQ) has been authorized by the Japanese Ministry of Health, Labour and Welfare²⁸⁾ and is considered a standard questionnaire for evaluating occupational stress²⁷⁾. The BJSQ evaluates four areas using a Likert scale: job stressors (with a score range from 17 to 68); stress reaction (with a score range from 29 to 116); social support (with a score range from 9 to 36); and job and life satisfaction (with a score range from 2 to 8). A higher score in the job stressors, stress reaction, and social support shows worse circumstances for each area³⁰⁾, while a higher score in job and life satisfaction shows better circumstances. In the present study, we defined job stressors and stress reaction as “job-related stress.”

Subjective cognitive dysfunction

The Cognitive Complaints in Bipolar Disorder Rating Assessment (COBRA) comprises 16 items and evaluates subjective cognitive dysfunction⁴⁾. These items are associated with the performance of daily mental tasks^{4, 31)}. The COBRA evaluates each item using a four-point scale from 0 to 3. The maximum total score is 48, with a higher score showing worse subjective cognitive dysfunction. In this study, we used the Japanese version, which has been used for the general adult population^{5, 25, 31)}.

Statistical analysis

Spearman’s rank correlation analysis using Bonferroni adjustment was used to investigate the relationships among sleep reactivity, job-related stress, and subjective cognitive dysfunction. Multiple regression analyses by forced entry method were conducted using the scores of the COBRA, BJSQ sub-areas, and FIRST-J as dependent variables. Path

analysis was conducted to evaluate the effects of sleep reactivity and job-related stress on subjective cognitive dysfunction. We calculated standardized path coefficients to evaluate the degree of the effects. In this study, correlation analysis, multiple regression analysis, and path analysis were performed based on the hypothesis: “trait marker → stress → cognitive dysfunction,” namely, “sleep reactivity → stress → cognitive dysfunction.” Our previous study reported about “affective temperaments → depressive symptoms → cognitive dysfunction,” wherein depressive symptoms partially mediated the relationship between affective temperaments and cognitive dysfunction³²⁾. Thus, we assumed that job-related stress might mediate the relationship between sleep reactivity and cognitive dysfunction. Regarding the multiple regression analysis on FIRST-J, the BJSQ scores were not included as independent variables owing to our hypothesis of the path analysis. In addition, regarding the path analysis, only the parameters of sleep reactivity, job-related stress, and subjective cognitive dysfunction were included, owing to our hypothesis of investigating the mediating role of job-related stress in the relationship between sleep reactivity and subjective cognitive dysfunction. These parameters, using path analysis, were analyzed in an exploratory manner based on our hypothesis. All the statistical analyses were conducted using IBM SPSS Statistics for Windows, Version 21.0 (IBM Corp, Armonk, NY, USA), and STATA/MP 16 (StataCorp LLC, College Station, TX, USA), except for path analysis. A path analysis conducted using Mplus version 8.4. A saturated model was used in this study; therefore, a goodness-of-fit index was not mentioned. Results of all analyses yielding $p < 0.05$ were considered statistically significant.

Results

Basic findings

The clinical and sociodemographic characteristics of the research participants are shown in Table 1. All the participants were employed at the time, and 20 (3.7%) individuals had ongoing psychiatric treatment. The five participants were diagnosed as depression, the two participants were diagnosed as anxiety disorder, the six participants were diagnosed as insomnia, the one participant was diagnosed as schizophrenia, none of the participant was diagnosed as bipolar disorder, alcoholism, and drug addiction, and the six participants were diagnosed other psychiatric illness.

Relationship among sleep reactivity, job-related stress, and subjective cognitive dysfunction

Table 1. Basic findings (N=536)

Characteristics	Mean (SD) or n (%)
Age (SD)	41.2 (12.0)
Sex (Male) (%)	237 (44.2)
Married (%)	353 (65.9)
Number of cohabiters (SD)	3.0 (1.6)
Years of education (SD)	14.7 (1.8)
Psychiatric history (%)	57 (10.6)
Current psychiatric treatment (%)	20 (3.7)
Drinking (%)	347 (64.7)
Smoking (%)	102 (19.0)
FIRST-J (SD)	19.1 (6.0)
BJSQ sub-areas	
Job stressors (SD)	40.5 (6.2)
Stress reaction (SD)	53.8 (14.9)
Social support (SD)	19.0 (5.4)
Job and life satisfaction (SD)	5.8 (1.4)
COBRA total score (SD)	8.3 (6.5)

Abbreviations: BJSQ, Brief Job Stress Questionnaire; COBRA, Cognitive Complaints in Bipolar Disorder Rating Assessment; FIRST-J, Japanese version of Ford Insomnia Response to Stress Test.

Table 2. Spearman’s rank correlation analyses (N=536)

FIRST-J	9–35	-				
Job stressors	20–61	0.17***	-			
Stress reaction	29–112	0.47***	0.42***	-		
Social support	9–35	0.21***	0.33***	0.36***	-	
Job and life satisfaction	2–8	-0.27***	-0.35***	-0.47***	-0.57***	-
COBRA	0–32	0.41***	0.17**	0.47***	0.18***	-0.24***

Abbreviations: BJSQ, Brief Job Stress Questionnaire; COBRA, Cognitive Complaints in Bipolar Disorder Rating Assessment; FIRST-J, Japanese version of Ford Insomnia Response to Stress Test.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

The results of Spearman’s rank correlation analyses are shown in Table 2. There were significantly positive correlations among sleep reactivity and job stressors, stress reaction, social support, and subjective cognitive dysfunction, while there were significantly negative correlations between sleep reactivity and job and life satisfaction. There were significantly positive correlations among subjective cognitive dysfunction and job stressors, stress reaction, and social support, while there were significantly negative correlations between subjective cognitive dysfunction and job and life satisfaction.

Multiple regression analyses

The results of the multiple regression analyses are shown in Table 3. Significant predictors of subjective cognitive dysfunction were sleep reactivity and stress reaction. Significant predictors of job stressors were marital status, past history of psychiatric illness, current psychiatric treatment, and sleep reactivity. Significant predictors of stress reaction were age, marital status, current psychiatric treatment, and sleep reactivity. Significant predictors of social support were age, marital status, years of education, and sleep reactivity. Significant predictors of job and life satisfaction were marital status, years of education, and sleep reactivity. Significant predictors of sleep reactivity were sex and past history of psychiatric illness.

Path analysis

We performed path analysis to investigate the relationships among sleep reactivity, job stressors, stress reaction, and subjective cognitive dysfunction (Table 4, Fig. 1). In the model, the squared multiple correlation coefficient of subjective cognitive dysfunction was 0.226.

In the path analysis, sleep reactivity directly affected job stressors (0.180, $p < 0.001$), stress reaction (0.399, $p < 0.001$), and subjective cognitive dysfunction (0.259, $p < 0.001$). Job stressors directly affected stress reaction (0.347, $p < 0.001$), while there was no significant direct effect of job stressors on the subjective cognitive dysfunction (0.005, $p = 0.914$, *n.s.*). The stress reaction directly affected subjective cognitive dysfunction (0.295, $p < 0.001$).

Sleep reactivity indirectly affected stress reaction via job stressors (0.063, $p < 0.001$), while there was no significant indirect effect of sleep reactivity on subjective cognitive dysfunction via job stressors (0.001, $p = 0.913$, *n.s.*). Sleep reactivity indirectly affected subjective cognitive dysfunction via job stressors and stress reaction (0.018, $p < 0.01$) and only via stress reaction (0.118, $p < 0.001$). Job stressors affected subjective cognitive dysfunction via stress reaction

Table 3. Multiple regression analysis of COBRA, BJSQ, and FIRST (N=536)

	COBRA		Job stressors		Stress reaction		Social support		Job and life satisfaction		FIRST-J	
	F (14, 521)		F (10, 525)		F (10, 525)		F (10, 525)		F (10, 525)		F (9, 526)	
	= 12.00,		= 3.89,		= 18.71,		= 6.07,		= 7.21,		= 9.04,	
	<i>p</i> <0.0001		<i>p</i> <0.0001		<i>p</i> <0.0001		<i>p</i> <0.0001		<i>p</i> <0.0001		<i>p</i> <0.0001	
Independent variables	β	VIF	β	VIF	β	VIF	β	VIF	β	VIF	β	VIF
Age	0.09	1.51	-0.06	1.45	-0.13**	1.45	0.10*	1.45	0.00	1.45	0.05	1.45
Sex: 1; Male, 2; Female	0.03	1.31	-0.02	1.31	0.01	1.31	-0.04	1.31	0.00	1.31	0.26***	1.23
Married status: 1; No, 2; Yes	-0.04	1.47	-0.11*	1.42	-0.10*	1.42	-0.10*	1.42	0.19***	1.42	-0.05	1.42
Number of cohabiters	0.01	1.32	0.07	1.30	-0.01	1.30	-0.08	1.30	0.04	1.30	-0.00	1.30
Years of education	0.03	1.53	-0.09	1.49	-0.04	1.49	-0.17**	1.49	0.14**	1.49	-0.04	1.49
Psychiatric history, 1; No, 2; Yes	0.04	1.32	-0.12*	1.28	0.06	1.28	0.05	1.28	-0.01	1.28	0.15**	1.25
Current psychiatric treatment, 1; No, 2; Yes	0.07	1.30	0.13**	1.28	0.09*	1.28	-0.01	1.28	0.00	1.28	0.08	1.27
	COBRA		Job stressors		Stress reaction		Social support		Job and life satisfaction		FIRST-J	
	F (14, 521)		F (10, 525)		F (10, 525)		F (10, 525)		F (10, 525)		F (9, 526)	
	= 12.00,		= 3.89,		= 18.71,		= 6.07,		= 7.21,		= 9.04,	
	<i>p</i> <0.0001		<i>p</i> <0.0001		<i>p</i> <0.0001		<i>p</i> <0.0001		<i>p</i> <0.0001		<i>p</i> <0.0001	
Drinking, 1; No, 2; Yes	0.04	1.16	-0.02	1.15	-0.02	1.15	-0.02	1.15	0.01	1.15	-0.00	1.15
Smoking, 1; No, 2; Yes	-0.03	1.11	-0.02	1.09	-0.01	1.09	-0.08	1.09	-0.03	1.09	0.02	1.09
FIRST-J	0.25***	1.41	0.17***	1.15	0.43***	1.15	0.16***	1.15	-0.22***	1.15	-	-
BJSQ sub-areas												
Job stressors	0.00	1.35	-	-	-	-	-	-	-	-	-	-
Stress reaction	0.28***	1.75	-	-	-	-	-	-	-	-	-	-
Social support	-0.02	1.65	-	-	-	-	-	-	-	-	-	-
Job and life satisfaction	-0.04	1.75	-	-	-	-	-	-	-	-	-	-
Adjusted R²	0.22		0.05		0.25		0.09		0.10		0.12	

Abbreviations: BJSQ, Brief Job Stress Questionnaire; COBRA, Cognitive Complaints in Bipolar Disorder Rating Assessment; FIRST-J, Japanese version of Ford Insomnia Response to Stress Test; β , standardized regression coefficients; VIF, variance inflation factor.

p*<0.05, *p*<0.01, ****p*<0.001

Table 4. Standardized path coefficients between FIRST-J, job stressors, stress reaction, and COBRA (N=536)

Direct effect to			
From	Job stressors	Stress reaction	COBRA
FIRST-J	0.180***	0.399***	0.259***
Job stressors		0.347***	0.005
Stress reaction			0.295***
Indirect effect to			
	Job stressors	Stress reaction	COBRA
FIRST-J		0.063*** (via Job stressors)	0.001 (via Job stressors) 0.018** (via Job stressors and Stress reaction)
Job stressors			0.102*** (via Stress reaction)
Total indirect effect to			
	Job stressors	Stress reaction	COBRA
FIRST-J		0.063***	0.137***
Job stressors			0.102***
Total effect to			
	Job stressors	Stress reaction	COBRA
FIRST-J	0.180***	0.461***	0.396***
Job stressors		0.347***	0.107**
Stress reaction			0.295***

Abbreviations: COBRA, Cognitive Complaints in Bipolar Disorder Rating Assessment; FIRST-J, Japanese version of Ford Insomnia Response to Stress Test.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

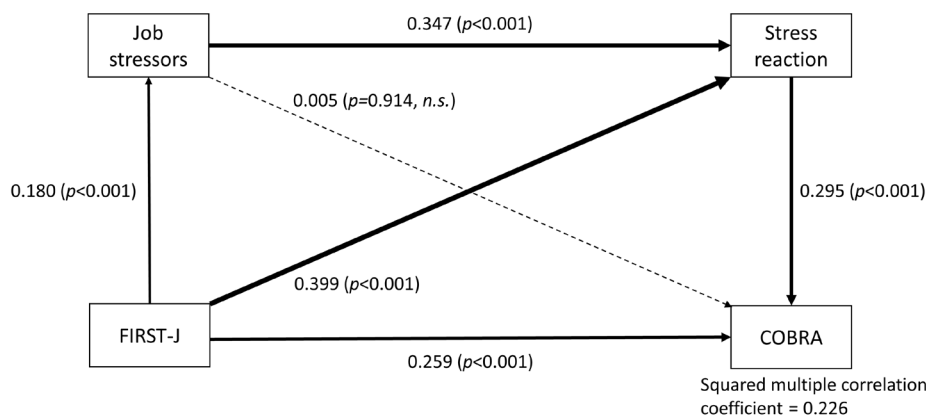


Fig. 1. Path analysis of the FIRST-J, job-related stressors, stress reaction, and the COBRA.

The solid arrows indicate statistically significant paths, and the broken arrow demonstrates non-significant paths. The numbers beside the arrows represent the direct standardized path coefficients. The width of the solid line shows the strength of the effect. The path analysis included only sleep reactivity, job-related stress, and subjective cognitive dysfunction, owing to our hypothesis investigating the mediating role of job-related stress in the relationship between sleep reactivity and subjective cognitive dysfunction. Significant predictors of subjective cognitive dysfunction were sleep reactivity and stress reaction. Significant predictors of job stressors were marital status, past history of psychiatric illness, current psychiatric treatment, and sleep reactivity. Significant predictors of stress reaction were age, marital status, current psychiatric treatment, and sleep reactivity. Significant predictors of social support were age, marital status, years of education, and sleep reactivity. Significant predictors of job and life satisfaction were marital status, years of education, and sleep reactivity. Significant predictors of sleep reactivity were sex and past history of psychiatric illness.

Abbreviations: BJSQ, Brief Job Stress Questionnaire; COBRA, Cognitive Complaints in Bipolar Disorder Rating Assessment; FIRST-J, Japanese version of Ford Insomnia Response to Stress Test, Job stressors; sub-score of job stressors of BJSQ; Stress reaction, sub-score of stress reaction of BJSQ; n.s., not significant.

(0.102, $p < 0.001$). Regarding total indirect effect, sleep reactivity indirectly affected stress reaction (0.063, $p < 0.001$) and subjective cognitive dysfunction (0.137, $p < 0.001$), and job stressors indirectly affected subjective cognitive dysfunction (0.102, $p < 0.001$).

Regarding the total effect, sleep reactivity affected job stressors (0.180, $p < 0.001$), stress reaction (0.461, $p < 0.001$), and subjective cognitive dysfunction (0.396, $p < 0.001$). Job stressors affected stress reaction (0.347, $p < 0.001$) and subjective cognitive dysfunction (0.107, $p < 0.01$). Stress reaction affected subjective cognitive dysfunction (0.295, $p < 0.001$).

To summarize this, the job stressors and stress reaction mediated the influence of sleep reactivity on subjective cognitive dysfunction.

Discussion

The present study shows that sleep reactivity and job-related stress affected subjective cognitive dysfunction, and our path model revealed a rate of 22.6% of subjective cognitive dysfunction in our sample. Furthermore, job-related stress may mediate the influence of sleep reactivity on subjective cognitive dysfunction; however, the indirect effect may be smaller than the direct effect.

Regarding the relationship between sleep reactivity and job-related stress, this study suggests that sleep reactivity may increase the latter. Sleep reactivity is believed to correlate with depressive and anxiety symptoms¹⁶. Hence, in the relationship between sleep reactivity and job-related stress, depressive and anxiety symptoms may play important roles in workers. Previous research suggests that insomnia correlates with occupational stress, including human relationships, job satisfaction, and social support status¹⁴. In this study, job-related stressors, stress reaction, and poor social support positively correlated with sleep reactivity, whereas having a better job and life satisfaction negatively correlated with sleep reactivity. Our findings suggest that sleep reactivity affects job-related stress, especially stress reaction. Hence, it may be better to consider sleep reactivity in dealing with stress reaction in workers.

Regarding the relationship between job stress and subjective cognitive dysfunction, the present study suggests that strong job stressors and high stress reaction may worsen subjective cognitive dysfunction in workers. Previous research shows that psychosocial working conditions influence subjective cognitive dysfunction⁸. Our findings suggest that stress reaction may have a stronger effect when compared with job-related stressors on subjective cognitive

dysfunction in Japanese workers. In a previous work of research, depressive symptoms were found to affect subjective cognitive dysfunction in workers⁵. Further, the impact of sleep disturbance and anxiety on cognitive performance has been reported³³. Hence, depressive and anxiety symptoms may influence the relationship between stress reaction and subjective cognitive dysfunction.

Regarding the relationship between sleep reactivity and subjective cognitive dysfunction, the results of this study suggests that sleep reactivity may worsen subjective cognitive dysfunction. The relationship between insomnia and subjective cognitive dysfunction has been previously evaluated^{17, 18}, and it is consistent with the results of the present study. Furthermore, the results of this study suggest that sleep reactivity affects subjective cognitive dysfunction via job-related stress in workers. Regarding the mediating role of job-related stress, stress reaction alone exerted a mediating effect, whereas job-related stressors alone exerted no mediating effect but exerted a mediating effect only via stress reaction. One possible reason is that there may be a causal relationship between job-related stressors and stress reaction. That is to say, job-related stressors may be one of the causes of stress reaction at work. However, this study has a cross-sectional design; thus, the causal linkages between the parameters could not be investigated. To the best of our knowledge, the mediator effect of job-related stress in relation to sleep reactivity and subjective cognitive dysfunction in workers is a novel finding. Job-related stress may play some roles in influencing the effect of insomnia on subjective cognitive dysfunction. Sleep reactivity is composed of a genetic component and an environmental component and is considered a genetic vulnerability for developing insomnia³⁴. Therefore, it may be useful to evaluate the mediating effect of job-related stress when workers with high sleep reactivity exhibit subjective cognitive dysfunction.

Considering the impact of subjective cognitive dysfunction on workers, subjective cognitive dysfunction may affect presenteeism directly and mediate the influence of depressive symptoms on presenteeism in workers⁹. A recent study suggests that parental bonding and resilience affect job-related stress in workers³⁵. Furthermore, job-related stress and sleep disturbance have been reported to affect presenteeism in office workers³⁶. Hence, sleep reactivity and job-related stress should be evaluated along with depressive symptoms when subjective cognitive dysfunction exerts a large effect on presenteeism. In future studies, it is necessary to investigate the role of depressive symptoms in the relationships among sleep reactivity, job stress, and subjective cognitive dysfunction in adult workers.

Limitations

The cross-sectional nature of this study made it impossible to investigate the causal relationships among the variables. Our path model, “sleep reactivity → stress → subjective cognitive dysfunction,” could not investigate the modulating role of sleep reactivity, which could also be a limitation of this study. A sample of 536 participants cannot be representative of the entire Japanese workforce. The recruitment was performed at Tokyo; therefore, our study sample was considered “adult workers from the community,” limiting the generalizability of our findings to all Japanese adult workers. That only workers were included precludes the generalization of our results to the general population and individuals with psychiatric disorders. In addition, our results may not be generalizable to underage workers because only adult workers were included. Because all the study participants were recruited in Japan, the results may not be generalizable to other countries. The effects of current medication in this study were also not evaluated. Further, the effects of employment type, working hours, overtime, position, and income were not controlled for. All the assessments were in the form of a subjective questionnaire in this study. The objective sleeping times and objective cognitive functions were also not evaluated in this study. This suggests the need to perform both subjective and objective assessments in studies in the future or even in a follow-up study. Although subjective cognitive dysfunction may affect sleep reactivity or job-related stress, our path analysis could not evaluate it. In addition, the 20 individuals with ongoing psychiatric treatment were evaluated together with healthy individuals in this study; therefore, this heterogeneity in the sample may be a limitation. Although sleep reactivity was evaluated, we did not evaluate the degree of insomnia, which could be another limitation of this study. Finally, the evaluation of subjective cognitive dysfunction was conducted using a scale to measure cognitive dysfunction in mental illness, which is also a limitation of this study.

Conclusions

The results of the present study suggest that sleep reactivity, stressors, and stress reaction may worsen subjective cognitive dysfunction. Although 65% of the effects from sleep reactivity to subjective cognitive dysfunction are direct effects, job-related stress (stressors and stress reaction) mediates the effect of sleep reactivity on subjective cognitive dysfunction. Hence, this suggests the need to evaluate the mediating effect of job-related stress in dealing with the subjective cognitive dysfunction associated with insomnia in workers.

List of Abbreviations

BJSQ: Brief Job Stress Questionnaire
 COBRA: Cognitive Complaints in Bipolar Disorder Rating Assessment
 FIRST-J: Japanese version of Ford Insomnia Response to Stress Test
n.s.: not significant
 β : standardized regression coefficients
 VIF: variance inflation factor

Declarations

Ethics approval and consent to participate

The present study was approved by the Local Ethics Committee of the Tokyo Medical University (Ethics Approval Number: SH3502). All participants provided written informed consent after receiving an explanation about the study.

Consent for publication

Not Applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Competing interests

Jiro Masuya has received personal compensation from Otsuka Pharmaceutical, Eli Lilly, Astellas, and Meiji Yasuda Mental Health Foundation, as well as grants from Pfizer. Ichiro Kusumi has received honoraria from Daiichi Sankyo, Dainippon Sumitomo Pharma, Eisai, Eli Lilly, Janssen Pharmaceutical, Lundbeck, Meiji Seika Pharma, Mochida Pharmaceutical, MSD, Mylan, Novartis Pharma, Ono Pharmaceutical, Otsuka Pharmaceutical, Pfizer, Shionogi, Shire, Taisho Toyama Pharmaceutical, Takeda Pharmaceutical, Tsumura, and Yoshitomyakuhin, and has received research/grant support from Asahi Kasei Pharma, Astellas, Daiichi Sankyo, Dainippon Sumitomo Pharma, Eisai, Eli Lilly, Mochida Pharmaceutical, Novartis Pharma, Otsuka Pharmaceutical, Pfizer, Shionogi, Takeda Pharmaceutical and Tanabe Mitsubishi Pharma. Takeshi Inoue is a member of the advi-

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Authors' contributions

All authors contributed toward data collection and reviewed and approved this manuscript.

KT: Writing - original draft, Data curation, Writing - review & editing. TI: Writing - original draft, Data curation, Writing - review & editing. AS: Data curation, Writing - review & editing. JM: Data curation, Writing - review & editing. YF: Data curation, Writing - review & editing. SH: Data curation, Writing - review & editing. IK: Data curation, Writing - review & editing.

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