



Mediating effects of hair cortisol on the mutual association of job burnout and insomnia: A retrospective exploratory study

Chao Wang^{a,b}, Junming Dai^{b,*}, Jue Li^{a,**}

^a Department of Disease Surveillance, Beijing Prevention and Treatment Hospital of Occupational Disease for Chemical Industry, Beijing, 100093, China

^b School of Public Health, Fudan University, Shanghai, 200032, China

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ABSTRACT

Backgrounds: The present study was designed to clarify the mutual association of job burnout and insomnia and to detect the mediating effects of hair cortisol on that association.

Methods: In all, 68 female employees were recruited for the study from one secondary and one tertiary hospital between October 2018 and November 2018 in Beijing. Participants completed a questionnaire for the collection of demographic data and standardized measures for burnout and insomnia. Hair sample collection and anthropometric measurements were performed at the same time.

Results: Median hair cortisol concentration (HCC) was 5.89 ng/g hair (interquartile range = 2.20–10.74). And ages are between 22 and 51 years old (32.50 ± 6.13), among which 22 were below 30 years, 20 were between 30 and 35 years, and 26 were over 35 years. A majority of Pearson's coefficients were significant, with the exception of that for the correlation between personal accomplishment and HCC or depersonalization. Significant mutual correlations were shown between burnout dimensions and insomnia directly. HCC acted as a mediator in the pathway from emotional exhaustion, depersonalization to insomnia; and no significant mediating effect of HCC in the pathway from insomnia to burnout was found.

Conclusions: Job burnout may directly or indirectly (through chronically elevated cortisol) increase insomnia risk, whereas insomnia probably promotes burnout. Prospective studies involving different body systems and a larger sample size should be performed to further identify the mechanisms underlying the associations between burnout and insomnia among the working population.

1. Introduction

Strong correlations between burnout and insomnia have been identified in studies conducted over the previous decades (Cheng and Cheng, 2017; Metlaine et al., 2018). Burnout has been majorly documented as an influencing factor to insomnia as it reportedly affects sleep physiology by prolonging sleep latency and disturbing rapid eye movement (REM) sleep or sleep quality (Metlaine et al., 2017; Peterson et al., 2008; Salvagioni et al., 2017). Higher levels of sleepiness, disturbed sleep quality, and more frequent awakenings have been reported in females with high burnout than in those with a lower burnout (Grossi et al., 2003). With respect to the young population, individuals with higher burnout scores reportedly experienced more arousals and sleep fragmentation, more awake time and stage-1 sleep, lower sleep efficiency, and reduced slow-wave sleep and REM sleep than those with lower burnout scores (Soderstrom et al., 2004). In contrast, insomnia

can reportedly increase burnout risk because adequate sleep is important for restoring energy after each working day, whereas insufficient sleep increases an individual's sensitivity to negative emotions and stress (Carskadon, 2011; Ly et al., 2015). In addition, insufficient sleep is associated with daytime sleepiness, which undermines an individual's coping mechanisms for emotionally-charged experiences in daily work (Abdulghani et al., 2012; Walker, 2009).

Burnout and insomnia are both considered to affect physiology and psychology; however, only a few studies have examined the bidirectional association between burnout and sleep disorders that causes mutual negative feedback (Pagnin et al., 2014). In addition, inconsistent results have been reported (Jansson-Frojmark and Lindblom, 2010; Pagnin et al., 2014). For example, reportedly, insomnia increases emotional exhaustion risk but burnout is not associated with subsequent insomnia (Jansson-Frojmark and Lindblom, 2010). In contrast, it has also been reported that burnout predicts insomnia and vice versa

* Corresponding author. 30th Dongan Road, Xuhui district, Shanghai, China.

** Corresponding author. 50th Xiangshan Road, Haidian district, Beijing, China.

E-mail addresses: wchao1987@126.com (C. Wang), jmdai@fudan.edu.cn (J. Dai), Lijue888@163.com (J. Li).

(Armon, 2009). Therefore, the present study aimed to clarify this mutual association using standardized measurements.

In addition, the physiological mechanisms underlying burnout or insomnia have been discussed previously (de Vente et al., 2015; Ly et al., 2015; Metlaine et al., 2018), with the hypothalamic–pituitary–adrenal (HPA) axis being one of the most extensively investigated subjects (Melamed et al., 2006). Although studies on burnout and HPA axis activity have reported inconsistent results, a majority of studies have shown an association between burnout and elevated HPA axis activity (Mommersteeg et al., 2008; Onen Sertoz et al., 2008). Furthermore, elevated HPA axis activity has been observed among individuals with insomnia (Ismailogullari et al., 2017; Reed et al., 2016; Wang and Liu, 2016). Therefore, it is suggested that the association between burnout and sleep disturbances may be mediated by a disturbance of the HPA axis, which is considered to be the central stress-physiological system for an organism's long-term adaptation to stress (Melamed et al., 2006). However, to the best of our knowledge, no empirical research has yet been conducted on this theoretical hypothesis.

The present study examined cortisol, the ultimate hormone of the HPA axis, as the mediator between burnout and insomnia because it is involved in the regulation of a wide range of bodily processes (Keller et al., 2017). Therefore, changes in cortisol secretion may have an impact on metabolism and body composition, leading to potential health problems (Schatzberg et al., 2014). At present, cortisol has primarily been detected in saliva, serum, or urine, which limits the prevalence of research or practice in occupational health due to the restricted sampling compliance and circadian rhythm of cortisol (acute reflection of HPA axis activity by saliva, serum, or urine) (Lindfors et al., 2017; Mrug et al., 2016; Schreier and Chen, 2017). It is difficult to manage the sampling point due to circadian rhythm of cortisol when cortisol was measured through saliva, serum or urine. These measurements could only reflect acute alterations of cortisol secretion rather than being an assessment of long-term cortisol levels. Since the exposure of occupational burnout or insomnia has been thought as a relatively constant and chronic issue, it will bring uncontrollable risks to study conclusions by time-point cortisol concentration. Moreover, the limited compliance of sampling from saliva, serum or urine always decreases the response rate in studies among human participants. In contrast, cortisol assessments based on hair are considered to be less affected by these methodological limitations. And as a stable biomaterial, hair is easier to transport and store which means less risk in the process of quality control. As Kirschbaum claimed, since the HPA axis (cortisol) performs large day-to-day variation, a measure reflecting cortisol secretion over multiple weeks or months would provide an indispensable research tool for characterizing the individual (Kirschbaum et al., 2009). Studies have shown positive correlations between hair cortisol concentrations (HCC) and cortisol concentrations from repeated samplings of other matrices. Van Holland et al. found that HCC was moderately correlated with mean salivary cortisol concentrations taken on three days ($r = 0.41$, $p = 0.03$, samples were taken at six time points on each day) (van Holland et al., 2012). Statistically significant correlation between 24-h urinary cortisol concentrations and HCC has also been reported (Sauve et al., 2007). Therefore, the cortisol concentrations of participants in the present study were measured in hair strands, considering the fact that burnout and insomnia are often considered to be relatively constant and chronic issues (Wells et al., 2014). Because an average hair growth rate of 1 cm/month is usually observed, the hair cortisol concentration (HCC) can retrospectively reflect cortisol concentrations up to 6 months, which matched the duration surveyed in the questionnaire of burnout and insomnia (Stalder et al., 2017).

The present study was subsequently designed to investigate the mediating effect of HCC in the bidirectional association between burnout and insomnia among the female employees of hospital. This particular occupation was selected as it is known to be highly stressful

in China, with poor working conditions, poor doctor-patient relationship, and a high work load. We hypothesized that burnout and insomnia influence each other directly and that HCC mediates the mutual association.

2. Methods

A cross-sectional study of employees from one secondary and one tertiary hospital was conducted between October 2018 and November 2018 in Beijing, China, using a paper-based self-administered questionnaire as well as anthropometric measurements. Female employees working in both clinical and management roles were recruited by stratified random sampling in these two hospitals. Nurses were not enrolled in the study as their shift work was considered to be a strong confounding factor for insomnia under the assumption of the present study. A study briefing session was conducted 3 months prior to the field investigation, to set a recall date and assist in reducing recall bias. An appointment was made for hair sample collection, questionnaire surveying, and anthropometric measurements. The inclusion criteria were as follows: (i) participants who had worked continuously in the same position for at least 6 months and (ii) those with no history of mental illness and no history of psychotropic drug use for 1 week prior to the investigation, basing on the clinical records and self-report of each participant. The exclusion criteria were as follows: (i) participants who had taken ≥ 1 month sick leave within the last 3 months; (ii) those for whom $\geq 10\%$ information was missing in the entire questionnaire; (iii) hair length on the posterior vertex measuring < 2 cm or the presence of hair perming or dyeing within the last 3 months. Specific conditions that excluded from study could be found at Table 1.

All participants provided written informed consent prior to participating in the study. The ethics committee of the Beijing Prevention and Treatment Hospital of Occupational Disease for the Chemical Industry approved the study protocol (code no. BO160901) and the study was conducted in accordance with the Declaration of Helsinki.

3. Measurements

3.1. Demographic characteristics

Demographic characteristics, which included age, body mass index (BMI), physical activity, smoking and alcohol habits, and job position, were obtained using a self-administered questionnaire. Based on the age distribution and characteristics of the study sample, age was classified into the following three subgroups: < 30 years, 30–35 years,

Table 1
Exclusion conditions that interfere with the function of HPA axis.

Exclusion conditions	Subgroup	Typical Case
Medical conditions	Adrenocortical Conditions	Cushing's syndrome, Addison's disease Adrenal insufficiency
	Chronic Disorders	Chronic Pain Cardiovascular Disease Depression/Anxiety Illness
	Medication Intake	Corticosteroids Beta-blocker Calcium channel blocker Diuretics Dopaminergic Agonists/ Antagonists Antidepressants/anxiolytics
Early Life Events	Injury	Post-traumatic Stress Disorder Severe Injury/Disability
	Pregnancy	Whole Gestational Period Mothers of Newborns 3 Months of age

and > 35 years. Occupational positions included physician and those in management. BMI was categorized according to the BMI standards of the World Health Organization.

3.2. Burnout

The Chinese version of the Maslach Burnout Inventory-General Survey (MBI-GS) (Schutte et al., 2000), which has shown satisfactory validity among Chinese workers (Wu et al., 2008), was used to assess burnout in the study population. The survey comprised a total of 16 items, which are regulated to measure three dimensions of burnout, with 5 items measuring emotional exhaustion (EE; a drained, depleted feeling arising from excessive psychological and emotional demands), five items measuring depersonalization (DP; a tendency to view others in an excessively detached, impersonal manner), and 6 items measuring personal accomplishment (PA; a sense of competence and accomplishment) (Wu et al., 2008). Each subscale is a continuous variable, which can be computed by the sum or the average of the respective subscale items. Each item was rated between 0 (not at all) and 6 (serious frequency). Cronbach's alpha coefficients for total burnout scale, EE, DP, and PA scales were 0.923, 0.926, 0.948, and 0.880, respectively, in the present study.

3.3. Insomnia

Athens Insomnia Scale (AIS), one of the most common and validated global instruments of insomnia (Chiu et al., 2016) showing sufficient reliability and validity among the Chinese population (Han et al., 2017), was used for insomnia evaluation. The scale comprised eight items, of which the first five items assessed sleep quality, including sleep initiation, awakening during the night, early morning awakening, total sleep duration, and overall quality of sleep, whereas the last three items assessed the consequences of insomnia on the following day. Each item of the AIS was rated between 0 (no problem at all) and 3 (seriously problematic). A higher AIS score represented a higher state of insomnia. Cronbach's alpha coefficient for AIS was 0.816 in the present study.

3.4. Hair cortisol concentration analyses

One or two hair strands with a 2–3-mm diameter, were collected from every participant. Hair strands were removed from as close to the scalp as possible, from a posterior occipital position. One scalp-adjacent 3-cm hair segment was used for HCC analysis, which was considered to reflect a 3-month hair growth period. Hair samples were first washed with 1.5 ml absolute ethanol in digital ultrasonic cleaner for 2 min, air dried, and cut into small segments (approximately 1–3-mm segments) with surgical scissors prior to weighing them according to Huang et al.

(2008). Cortisol was extracted using 1,400 μ l methanol for 16 h at room temperature in a 1.5-ml centrifuge tube. From this, 200 μ l was subsequently injected into a Waters UPLC-tandem triple quadrupole mass spectrometry system (Waters, I-class, US). The lower limits of quantification for this assay have been shown to be < 0.1 ng/L cortisol. Inter-assay and intra-assay coefficients of variance were 1.90%–3.30% and 4.2%–9.0%, respectively.

3.5. Statistical analyses

Continuous variables are presented as the mean \pm SD, and were compared using analysis of variance (ANOVA). Partial correlation analysis was performed to examine the associations between burnout dimensions, HCC, and insomnia. Subsequently, structural equation model (SEM) analysis was performed to detect the direct and indirect associations of the research variables based on the study hypotheses. HCC (the mediator between burnout and insomnia) was not included in SEM if no significant correlation was found in the correlation analyses. All three dimensions of burnout and insomnia were structured as latent variables. The bootstrap statistical method was used to examine the mediating effects of HCC, and the sampling number was set as 2,000, according to Preacher and Hayes (2008), with the bias-correction interval as the confidence interval. Epidata3.1 was used for data entry, and SPSS Statistics 22.0 and AMOS 21.0 were used for statistical analysis; $\alpha = 0.05$ (two-tailed).

4. Results

Of the 90 selected participants, only 68 participants were included and only 68 samples were analyzed. Of the 22 excluded participants, nine did not provide hair samples, 11 had hair perming or dyeing within the last 3 months, the length of hair samples from two participants was < 2 cm, and three participants left > 10% of the information on the questionnaire blank. The age range was 22–51 years (32.50 ± 6.13), with 22, 20, and 26 participants in the < 30 years, 30–35 years, and > 35 years groups, respectively. The BMI range was 15.78–34.06, and the BMI of a majority of participants was within the normal level. The median HCC was 5.89 ng/g hair (interquartile range = 2.20–10.74). Because few participants were fat or thin, they were combined into overweight or normal levels. ANOVA revealed only a slight statistical difference between groups with respect to demographic characteristics. Participants that performed regular physical activity had significantly lower insomnia scores. See Table 2 for details.

Pearson's coefficients indicated numerous significant correlations among the three dimensions burnout (EE, DP, and PA), HCC, and insomnia. Among these correlations, PA was not significantly associated with DP (-0.210 , $p = 0.098$) or HCC (-0.167 , $p = 0.174$). HCC was

Table 2
Values of HCC, burnout and insomnia among different demographic characteristics.

Characteristic	Total	HCC (ng/g)	EE	DP	PA	Insomnia	
Age	< 30 years	22	6.05 \pm 4.72	2.63 \pm 1.85	1.71 \pm 1.70	1.97 \pm 1.04	5.27 \pm 3.18
	30–35 years	20	8.00 \pm 6.65	3.72 \pm 1.72	2.42 \pm 2.35	1.48 \pm 1.71	7.30 \pm 4.85
	> 35 years	26	6.74 \pm 4.60	2.97 \pm 1.26	1.87 \pm 1.69	1.93 \pm 1.20	5.77 \pm 2.94
	p-value		0.489	0.552	0.460	0.423	0.186
BMI	Normal	58	6.53 \pm 5.02	2.77 \pm 1.85	2.15 \pm 2.01	2.57 \pm 1.17	6.31 \pm 3.75
	Overweight	10	8.96 \pm 6.57	2.24 \pm 0.71	1.00 \pm 0.52	3.23 \pm 1.36	4.60 \pm 3.23
	p-value		0.183	0.370	0.078	0.232	0.180
Physical activity	Regular	56	6.92 \pm 5.34	2.72 \pm 1.71	1.90 \pm 1.88	1.92 \pm 1.33	5.64 \pm 2.84
	irregular	12	6.74 \pm 5.26	2.60 \pm 1.95	2.33 \pm 2.09	1.27 \pm 1.25	8.00 \pm 6.23
	p-value		0.913	0.828	0.487	0.125	0.045
Position	Management	26	6.82 \pm 4.72	2.46 \pm 1.41	1.60 \pm 1.59	1.83 \pm 1.40	6.08 \pm 5.17
	Physician	42	6.93 \pm 5.55	2.84 \pm 1.91	2.21 \pm 2.06	1.80 \pm 1.30	6.04 \pm 2.48
	p-value		0.931	0.378	0.196	0.925	0.975

Note: smoking habits and alcohol habits were not included into analysis in terms of the very little sample showed to be positive, as only 2 participants had smoking habit and no participant had alcohol habit.

Table 3
Correlations between dimensions of burnout, HCC and insomnia.

Study variables	EE	DP	PA	HCC	Insomnia
1. EE	1.00	0.792**	−0.289*	0.337**	0.593**
2. DP	0.830**	1.00	−0.210	0.434**	0.598**
3. PA	−0.348**	−0.209	1.00	−0.167	−0.318**
4. HCC	0.342**	0.432**	−0.129	1.00	0.504**
5. Insomnia	0.627**	0.597**	−0.285*	0.541**	1.00

Note: correlation coefficients over '1.00' were calculated by single factor analyses of Pearson test, and correlation coefficients under '1.00' were calculated by Partial correlation tests controlling for age, BMI, physical activity habits and job position; *, $p < 0.05$; **, $p < 0.01$; EE, emotional exhaustion; DP, depersonalization; PA, personal accomplishment; HCC, hair cortisol concentration.

significantly associated with EE (0.337, $p = 0.005$), DP(0.434, $p < 0.001$), and insomnia (0.504, $p < 0.001$). Partial correlation revealed only a slight change after controlling for demographic characteristics compared with Pearson's coefficients. See Table 3 for details.

SEM analyses were initially performed to assess the risking effects of burnout dimensions on insomnia. HCC was included simultaneously if it was shown to be correlated with both burnout dimensions and insomnia. EE, DP, or PA had significant direct effects on insomnia, with respective standardized coefficients of 0.494 (0.165–0.760), 0.395 (0.144–0.691), and $-0.336(-0.531\sim-0.101)$, respectively. Furthermore, EE and DP had significant indirect effects on insomnia through HCC, with respective standardized coefficients of 0.123(0.032–0.278) and 0.131 (0.039–0.310), respectively. The present study also assessed whether burnout dimensions were associated with factors of insomnia, and whether they were mediated by HCC. Statistically, insomnia also affected EE, DP, or PA directly, with respective standardized coefficients of 0.582 (0.141–0.997), 0.440 (0.155–0.745), and $-0.336(-0.531\sim-0.101)$, respectively. However, we did not find any significant mediating effect of HCC on the path from insomnia to burnout. See Table 4, Table 5 and Fig. 1 for details.

5. Discussion

The present study assessed the mutual association between burnout and insomnia and evaluated the mediating effect of cortisol in the specific population of female employees of a hospital. The results confirmed our first hypothesis that burnout and insomnia are significantly and bidirectionally associated, and have mutual influence even after controlling for demographic characteristics. It is well known that burnout has definite effects on insomnia, which can be explained by chronic hyperarousal of the HPA axis and is associated with stress accumulation at work, which is responsible for disturbed emotion (Chow et al., 2018). In addition, burnout is often understood as the chronic depletion of an individuals' physical, emotional, and cognitive energy resources (Maslach and Leiter, 2016). In the present study, all three burnout dimensions were confirmed as strong and direct risk factors for insomnia. These findings are consistent with those of previous studies. Individuals experiencing high levels of chronic burnout reportedly suffered from difficulty in falling asleep, early awakening, a lack of daytime energy, and difficulty in maintaining sleep (Melamed

Table 4
Insomnia as independent variable of burnout dimensions mediated by HCC.

Burnout	Insomnia		Indirect effects (95% CI)	<i>p</i> -value
	Direct effects (95% CI)	<i>p</i> -value		
EE	0.494(0.165–0.760)	0.008	0.123(0.032–0.278)	0.006
DP	0.395(0.144–0.691)	0.002	0.131(0.039–0.310)	0.004
PA	$-0.336(-0.531\sim-0.101)$	0.017	–	–

et al., 2006). Similar conclusions presented in other studies indicate that individuals experiencing burnout may be unable to withdraw from work, tend to think excessively about sleep, and worry about the consequences on the following day's work if their energy was not recovered through sufficient and high-quality sleep (Grossi et al., 2003; Vela-Bueno et al., 2008).

The results of the present study also support the conclusion that insomnia increases the risk of burnout among the female employees of a hospital. As proposed by Vandekerckhove, adequate sleep restores vitality for each working day, whereas employees with insufficient sleep were more sensitive to negative emotions and stressful events at work (Vandekerckhove and Cluydts, 2010). In addition, daytime sleepiness resulting from insomnia can undermine attention, reactivity, and efficiency at work. Sleep dysfunction has been previously reported to be associated with DP toward learning among medical students, indicating that sleep disturbance decreases personal motivation at work, which ultimately promotes diffidence to academic learning and interferes with cognitive functions and self-assessment (Pagnin et al., 2014). In our study population, insomnia might have induced a more frustrated mood due to the frequency of emergency circumstances, heavy workload, or responsibilities at work, all of which require high levels of mental and physical energy that are mainly derived from quality sleep. Therefore, the results of the present study provide evidence for understanding how insomnia risks the mental health of those working in stressful environments, such as a hospital.

The results of the present study showed that both burnout and insomnia were associated with elevated HCC among female employees of hospital. Existing reports have shown that both burnout and insomnia are HPA-active issues. In study involving healthcare professionals, daily cortisol levels in female employees with high burnout were reportedly significantly higher than those without burnout (Fernandez-Sanchez et al., 2018). Penz evaluated the association of HCC and burnout, and concluded that the presence of hypercortisolism was significant among those with burnout (Penz et al., 2016). In addition, in a 10-year follow-up study, participants reporting short sleep durations reportedly had higher cortisol levels later in the day and flattened salivary cortisol patterns throughout the day (Abell et al., 2016).

Notably, analyses have been performed to investigate the mediating role of cortisol in the association of burnout and insomnia, and partial mediating effects of HCC have been detected. The present study found that HCC significantly mediated the pathway from EE, DP to insomnia; however, such effects were not significant the other way round. Therefore, burnout directly disturbs sleep in perception; and physiological changes on activation of the HPA axis (cortisol) derived from burnout may also risk an individuals' sleep, with studies having clarified that cortisol can excite the sympathetic nervous system and inhibit melatonin secretion (Jensen et al., 2016; Ngampramuan et al., 2018; Valent et al., 2016). These findings are consistent with those reported in a previous study that elevated cortisol promoted a longer average length of wake episodes and frequent awakenings during sleep (Palesh et al., 2008). In the future, multiple body systems, including the sympathetic nervous system and sympathetic adrenal medullary system, should be involved in investigations in this area. On the contrary, HCC showed no significant mediating effect on the pathway from insomnia to burnout. Therefore, insomnia mainly influences burnout by damaging attentiveness and efficiency at work and increasing worries regarding unrecovered energy, whereas the elevated cortisol resulting from insomnia does not promote burnout physically. This is partly in accordance with the conclusion of a previously reported study, which found that job strain represents a burnout risk factor only if associated with insomnia (Metlaine et al., 2017). Combining the results of the present study with existing evidences, we conclude that insomnia probably promotes burnout by negatively affecting ability and efficiency of working. This conclusion partly supports our second hypothesis.

The mean HCC (5.89, 2.20–10.74 ng/g) was measured and

Table 5
Burnout dimensions as independent variables of insomnia mediated by HCC.

Insomnia	EE (95% CI)	DP (95% CI)	PA (95% CI)
Direct effects	0.582(0.141–0.997)	0.440(0.155–0.745)	–0.336(–0.531–0.101)
p-value	0.009	0.002	0.017
Indirect effects	0.034(–0.123–0.253)	0.086(–0.022–0.275)	–
p-value	0.444	0.117	–

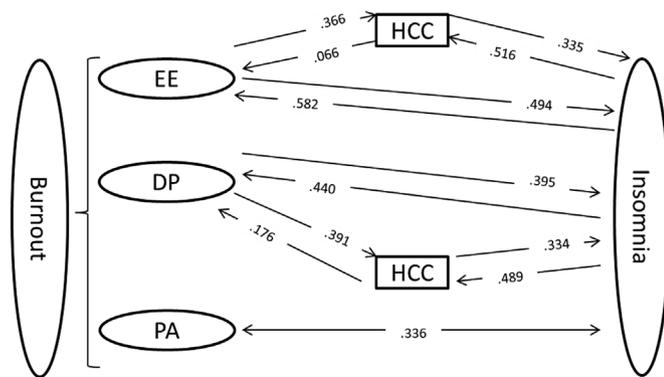


Fig. 1. Standardized coefficients of SEMs between dimensions of burnout, HCC and insomnia.

calculated by the method of UPLC-tandem triple quadrupole mass spectrometry system. It was slightly higher than that of two other studies in which HCC was 5.73 or 3.27 tested by similar method (Janssens et al., 2017; Steinisch et al., 2014). Besides the random effects of HCC testing, exposure of air pollution might be a plausible explanation to these differences since the present study was conducted in Beijing, a city known to have suffered from frequent problems of inhalable particulates pollution. Epidemiological evidence have shown that exposure to PM_{2.5} may activate the HPA axis in human through potential mechanisms as inducing inflammatory responses, up-regulating the expression of glucocorticoid-sensitive genes (Niu et al., 2018; Thomson et al., 2013; Ying et al., 2014). Thus, future studies, especially the multi-center design, should be aware of the confounding effects of air pollution on HCC.

The present study has several limitations. First, the relatively small sample size restricted the statistical efficiency of analyses and extrapolation of conclusions. Also, the cross-sectional design cannot draw any causal conclusion which is recommended to be clarified in future prospective studies. Second, information on other demographic variables, including smoking habits (two valid samples) or drinking habits (no valid samples), which are reportedly associated with cortisol were collected but not included in statistical analyses due to the limited sample size. Therefore, it was not possible to report on their potential influence on the study variables. In addition, the exclusion of potential participants has been based on clinical records and self-administered questionnaires, which might lead to increased risk to data reliability. Third, base HCC values were not used for each participant, as burnout and insomnia are always considered to be chronic processes. Alternatively, demographic variables, such as age, BMI, physical activity, and job position, were controlled in the statistical analyses. Furthermore, occupational burnout or insomnia was evaluated using a retrospective questionnaire and the recall bias may have influenced the interpretation of our exploratory findings.

6. Conclusion

To the best of our knowledge, this is the first study examining the role of HPA axis activity (represented by HCC) in the mutual association between job burnout and insomnia. The results supported the

hypotheses of the bidirectional association of burnout and insomnia and revealed the mediating effects of chronic cortisol secretion on the pathway from EE and DP to insomnia. It was concluded that job burnout can directly or indirectly (through chronically elevated cortisol) increase insomnia risk. In addition, insomnia probably promotes burnout by negatively affecting ability and efficiency of working, whereas the elevated cortisol resulting from insomnia does not promote burnout physically. These results provide further understanding on the effects of job burnout on insomnia and how insomnia promotes burnout. Prospective studies involving different body systems and larger sample sizes should be conducted to further elucidate the mechanisms underlying the mutual association between burnout and insomnia in the working population.

Disclosure

The authors report no conflicts of interest in this work. Acknowledgments

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Conflicts of interest

The authors report no conflicts of interest in this work.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jpsychires.2019.07.001>.

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