

BMJ Open A cross-sectional study of shift work, sleep quality and cardiometabolic risk in female hospital employees

P Lajoie,¹ K J Aronson,^{1,2} A Day,^{1,3} J Tranmer^{1,3,4}

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¹Department of Public Health Sciences, Queen's University, Kingston, Canada

²Division of Cancer Care and Epidemiology, Cancer Research Institute, Queen's University, Kingston, Canada

³Clinical Research Centre, Kingston General Hospital, Kingston, Canada

⁴Faculty of Health Sciences, School of Nursing, Queen's University, Kingston, Canada

Correspondence to

Dr Joan Tranmer;
tranmerj@kgh.kari.net

ABSTRACT

Objectives: Investigating the potential pathways linking shift work and cardiovascular diseases (CVD), this study aimed to identify whether sleep disturbances mediate the relationship between shift work and the metabolic syndrome, a cluster of CVD risk factors.

Design: Cross-sectional study.

Setting: A tertiary-level, acute care teaching hospital in Southeastern Ontario, Canada.

Participants: Female hospital employees working a shift schedule of two 12 h days, two 12 h nights, followed by 5 days off (n=121) were compared with female day-only workers (n=150).

Primary and secondary outcome measures: Each of the seven components of the Pittsburgh Sleep Quality Index (PSQI) was measured. Of these, PSQI global score, sleep latency and sleep efficiency were examined as potential mediators in the relationship between shift work and the metabolic syndrome.

Results: Shift work status was associated with poor (>5) PSQI global score (OR=2.10, 95% CI 1.20 to 3.65), poor (≥2) sleep latency (OR=2.18, 95% CI 1.23 to 3.87) and poor (≥2) sleep efficiency (OR=2.11, 95% CI 1.16 to 3.84). Although shift work was associated with the metabolic syndrome (OR=2.29, 95% CI 1.12 to 4.70), the measured components of sleep quality did not mediate the relationship between shift work and the metabolic syndrome.

Conclusions: Women working in a rapid forward rotating shift pattern have poorer sleep quality according to self-reported indicators of the validated PSQI and they have a higher prevalence of the metabolic syndrome compared with women who work during the day only. However, sleep quality did not mediate the relationship between shift work and the metabolic syndrome, suggesting that there are other psychophysiological pathways linking shift work to increased risk for CVD.

INTRODUCTION

In industrialised countries, approximately 20% of the working population engages in some type of shift work schedule.¹ According to the Canadian General Social Survey (2009), 4.1 million employed Canadians are shift workers, representing roughly 27% of the workforce.² In the healthcare sector, the

Strengths and limitations of this study

- This study is strengthened by its use of a thoroughly validated sleep questionnaire which has been widely applied in the scientific literature (Pittsburgh Sleep Quality Index Questionnaire).
- Its strength also lies in the statistical analysis that was performed using a well-known mediation analysis methodology.
- The cross-sectional nature of this study limits the assessment of causality.

proportion of shift workers is estimated to be even higher at 45%.² Furthermore, for all health occupations combined, 84% of Canadian hospital employees are female.³ This study aimed to further examine the potential pathways in which shift work as a highly prevalent exposure may lead to risk for poor health among female hospital workers.

Shift work has been associated with many adverse health outcomes including gastrointestinal disturbances, the metabolic syndrome (MetS), diabetes mellitus, reproductive difficulties and breast and prostate cancer.^{1 4-7} In this study, we are focusing on the relationship between shift work and atherosclerotic-related cardiovascular disease (CVD), which is inconsistently supported in the literature.⁸⁻¹¹ A review in 2012 of shift work and vascular morbidity, vascular mortality or all-cause mortality identified that, in 34 studies including 2 011 935 participants, shift work was associated with myocardial infarction with a relative risk (RR) of 1.23 (95% CI 1.15 to 1.31) and ischaemic stroke with an RR of 1.05 (95% CI 1.01 to 1.09).⁸ Working night shifts was associated with the highest increase in risk for coronary events with an RR of 1.41 (95% CI 1.13 to 1.76).⁸

In the healthcare setting specifically, women of the Nurses' Health Study cohort were compared prospectively with women who had never been shift workers and the

multivariate age-adjusted RR for developing coronary heart disease was 1.51 (95% CI 1.12 to 2.03) among those with six or more years of rotating shift work experience (≥ 3 nights/month with days and evenings).¹² Another analysis of this cohort revealed a risk for ischaemic stroke, where every 5 years of rotating shift work was associated with 4% increased risk (HR=1.04, 95% CI 1.01 to 1.07).¹³

A major issue among shift workers is disturbed sleep and this has been shown to be independent of levels of physical activity, smoking and drinking habits.^{14 15} Common problems include insufficient sleep (duration), difficulty getting to sleep (sleep latency) and the feeling of not being refreshed after sleep.^{15 16} Two recent reviews suggest that dysfunctional sleep patterns could contribute to the increased CVD risk in shift workers as several characteristics of sleep disturbances are associated with cardiometabolic consequences.^{9 10} For instance, evidence supports the relationship of poor sleep quality and short duration of sleep with the activation of the sympathetic nervous system,¹⁷ and increased levels of vascular inflammation.^{18 19} Using the Pittsburgh Sleep Quality Index (PSQI) Questionnaire, a cross-sectional study found that women with poor sleep latency (frequent episodes of >30 min to fall asleep) and poor overall sleep quality had higher levels of inflammatory biomarkers (C reactive protein and interleukin 6).²⁰ Moreover, sleep has a regulatory effect on glucose metabolism and hormones regulating appetite, and therefore disturbances in sleep may promote weight gain among shift workers.¹¹ In the population-based Wisconsin Sleep Cohort Study, those with 5 h of sleep compared with those with 8 h or more had lower levels of the appetite suppressing hormone leptin, and higher levels of the appetite stimulating hormone ghrelin, suggesting that a lack of sleep could encourage food consumption and therefore weight gain.²¹ Meanwhile, another study aiming to examine the effects of sleep from a metabolic perspective found that glucose clearance and acute insulin response were reduced up to 40% following nights of curtailed sleep in healthy individuals (≤ 4 h).²² Similar results were observed in a case-crossover study of men and women exposed to experimentally fragmented sleep.²³ These findings suggest that it is biologically plausible that recurrent, long-term exposure to short duration and poor sleep quality among female shift workers increases the risk of MetS and CVD.

Direct evidence of the association between shift patterns and biomarkers of CVD is needed.²⁴ It is suggested that research needs to characterise shift work with regard to clearly defined patterns of shift schedules and identify contributors in the pathways between shift work and CVD.²⁴ To this end, a mediation analysis is appropriate as it can provide further evidence in making a causal interpretation.²⁵ Conceptually, a mediator is a variable that accounts for the relationship between an exposure and outcome; as such, it can represent the mechanism.²⁶ The

objective of this study was to determine the association between work patterns and the MetS among female hospital employees. The next step was to test whether sleep quality lies on the pathway between shift work and an increased risk of CVD as represented by the MetS. MetS is a cluster of risk factors for CVD that present together.²⁷ This is the outcome of interest for three reasons: first, studies have demonstrated that MetS leads to an increased risk of developing CVD; for instance, a meta-analysis identified that the risks of myocardial infarction, stroke and CVD mortality among those with MetS were 1.99 (95% CI:1.61 to 2.46), 2.27 (95% CI 1.80 to 2.85) and 2.40 (95% CI 1.87 to 3.08), respectively.²⁸ Second, the association between poor sleep quality and MetS has been demonstrated in cross-sectional studies.^{29 30} Lastly, rotating shift work has been associated with MetS in cross-sectional³¹ and prospective studies.^{32 33}

METHODS

Study design

In a tertiary-level acute care teaching hospital in Southeastern Ontario, Canada, we conducted a cross-sectional study in 2012–2013 with recruitment through posters in the hospital and email advertising. Women were eligible if they had been working for a minimum of 2 years and were not pregnant. To qualify as shift workers, they had to be working a pattern of two 12 h days, two 12 h nights with 5 days off. The comparison group consisted of women working only during the day. During an in-person interview, participants received information about the study protocol, and after they provided consent anthropometric measurements were taken. Each participant provided detailed information in a written questionnaire and they completed the PSQI. This study was approved by the Queen's University Health Sciences Research Ethics Board.

The MetS was defined according to the 2009 Joint Interim Studies consensus statement.²⁷ A participant was considered as positive for the MetS if she met three or more of the following criteria: high waist circumference (≥ 80 cm); elevated triglycerides (≥ 1.7 mmol/L); reduced high-density lipoprotein (<1.3 mmol/L); elevated blood pressure (systolic ≥ 130 and/or diastolic ≥ 85 mm Hg); elevated fasting blood glucose (≥ 100 mg/dL). Women currently taking medication to treat their levels of cholesterol or high blood pressure were also identified as positive. The mean of three consecutive readings of blood pressure was taken using the BpTRU blood pressure monitor (VSM MedTech Ltd, Coquitlam, Canada).

Mediation measures: sleep quality

The PSQI is a validated and widely used tool to identify elements of sleep over the past 30 days and reflects the cohort's perception of sleep on shift and non-shift days.³⁴ This questionnaire identifies seven "components" of sleep routinely assessed clinically: sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance,

use of sleep medication, daytime dysfunction and subjective sleep quality. The sum of scores of the aforementioned seven component scores gives a global PSQI score that ranges from 0 to 21 points; a score >5 is associated with poor sleep quality, and was therefore dichotomised as such in our analysis. The PSQI scores have been shown to have good test–retest reliability, with a correlation coefficient of 0.85 for the global score, and correlation coefficients ranging from 0.65 (medication use) to 0.84 (sleep latency) for the component scores.³⁴

Statistical analyses

The PSQI component scores range from 0 (best) to 3 (worst) and were dichotomised as good (0,1) and poor (2,3) in logistic regression models. The adjusted OR relating shift workers to day workers for the global PSQI score (>5) and each of its seven components were computed separately. For multivariable models, age was always retained. To assess other variables as potential confounders, a backward deletion approach was taken, with a change in estimate of 10% or more as the criterion to keep a variable in the model.³⁵

Global PSQI, sleep latency and sleep efficiency scores were all significantly associated with shift work and therefore tested as mediating variables using multivariate logistic regression in separate models using the classic method of Baron and Kenny²⁶ investigating the significance of individual relationships in the mediation pathway. According to the Baron and Kenny criteria, mediation occurs if: (1) the independent variable shift work affects the dependent variable MetS (*path c*); (2) the independent variable shift work significantly affects the mediators (*path a*); and, (3) the mediators affect the dependent variable MetS while controlling for shift work (*path b*).²⁶ Mediation occurs if, when *paths a* and *b* are controlled, the significant relationship between the predictor and outcome of interest is attenuated (*path c*).²⁶ These conditions are depicted in figure 1 and summarised by the following regression equations:

$$Y = \beta_{0(2)} + cX \quad (1)$$

$$M = \beta_{0(1)} + aX \quad (2)$$

$$Y = \beta_{0(3)} + c'X + bM \quad (3)$$

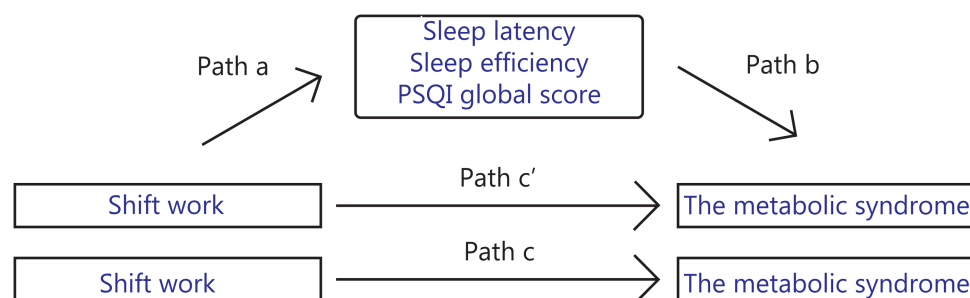


Figure 1 Conceptual framework for a mediation analysis of the relationship between shift work and the metabolic syndrome (PSQI, Pittsburgh Sleep Quality Index).

In terms of assessing for confounders, we considered that many behavioural factors potentially altering sleep quality could feasibly be a result of shift work, such as smoking and stress.³⁶ Behavioural changes are suggested as components of the multifactorial relationship existing between shift work and CVD risk,¹⁰ and many studies investigating this relationship erroneously consider these factors as confounders, when they in fact lie on the causal path.²⁴ This analysis included only those variables that are not known to be on the causal pathway between shift work and sleep disturbances or the MetS: age, income and menopausal status. All data analyses were performed using SAS V.9.3 (SAS Institute Inc., Cary, North Carolina, 2012).

RESULTS

Table 1 shows that, on average, shift workers were younger than day workers; a larger proportion were single or never married without children, had achieved a university degree and had higher household income. Groups were comparable in regard to CVD risk factors including family history of heart disease, body mass index and smoking. The majority of shift workers were in nursing positions and the rest of the group was comprised of women in other regulated health professions and administrative and support services. The majority (>75%) of the day working group included women in nursing and management positions. A greater proportion of current shift workers (39%) had worked more than 15 years of shift work, although about 25% of day workers had also worked more than 15 years of shift work in the past.

Table 2 shows that a greater proportion of shift workers were positive for all but one of the risk factors of the MetS. Almost twice as many shift workers presented with the MetS than day workers with frequencies of 22% and 13%, respectively ($p=0.05$).

Mean scores of the PSQI global score and its seven components are presented in table 3 along with the proportion of shift and day workers with a component score ≥ 2 (a 'poor' score). Poor sleep latency score was significantly more frequent in shift workers (42%) compared with day workers (27%), and mean scores differed significantly ($p<0.01$). Significant differences were also

Table 1 Characteristics of the study population

	Shift workers (n=121) n (%)	Day workers (n=150) n (%)
Age* (mean±SD)	38.4 (11.6)	45.0 (9.5)
Marital status†		
Married or common law	77 (63.6)	112 (75.2)
Widowed, separated or divorced	12 (9.9)	18 (12.1)
Single or never married	32 (26.5)	19 (12.8)
Number of children‡		
None	58 (47.9)	33 (22.0)
1–2	49 (40.5)	85 (56.7)
≥3	14 (11.6)	32 (21.3)
Education‡		
High school	0	10 (6.7)
Postsecondary (certificate/ diploma)	58 (47.9)	84 (56.0)
University degree (Undergraduate, Masters, PhD, etc)	63 (52.1)	56 (37.3)
Household income		
<\$50 000	5 (4.1)	18 (12.0)
\$50 000–\$99 999	73 (60.3)	76 (50.7)
≥\$100 000	43 (35.5)	56 (37.3)
Postmenopausal	31 (29.0)	49 (34.8)
Use of hormone replacement therapy	5 (4.1)	13 (8.7)
Diagnosed with a sleep disorder	6 (5.0)	13 (8.7)
Family history of heart attack before age 60	16 (13.2)	26 (17.3)
Meets physical activity guidelines	71 (58.7)	77 (51.3)
Overweight (kg/m ²)		
BMI ≥25 to <30	40 (33.1)	45 (30.0)
BMI ≥30	29 (24.0)	35 (23.3)
History of/current medication for		
High cholesterol	7 (5.8)	8 (5.3)
High blood pressure	10 (8.3)	19 (12.7)
Smoking status†		
Current smoker	7 (5.8)	19 (12.7)
Former smoker	23 (19.0)	40 (26.7)
Never-smoker	91 (75.2)	91 (60.7)
Frequency of alcohol consumption‡		
≤Once a month	55 (45.6)	50 (33.3)
2–4 times a month	42 (34.7)	46 (30.7)
>Once a week	24 (19.8)	54 (36.0)
Employment category‡		
Laboratory and diagnostic services	0	10 (6.7)
Nursing	112 (92.6)	81 (54.0)
Occupational therapy, physiotherapy, radiation therapy, respiratory therapy	5 (4.1)	10 (6.7)
Support services	2 (2.0)	10 (6.7)
Administrative support	2 (1.7)	34 (22.7)
Management	0	5 (3.3)
Position‡		
Permanent	121 (100)	142 (94.7)
Temporary	0	7 (4.7)
Casual	0	1 (0.7)

Table 1 Continued

	Shift workers (n=121) n (%)	Day workers (n=150) n (%)
History of rotating shift work including night shifts†		
Never (year)	0	38 (25.3)
>0 to ≤7	46 (38.0)	43 (28.7)
>7 to ≤15	28 (23.1)	32 (21.3)
>15 years	47 (38.8)	37 (24.7)
Duration of one shift/work day‡		
8 h	0	114 (76.0)
12 h	116 (95.9)	11 (7.3)
Various shifts	4 (3.3)	10 (6.7)
Some other shifts	1 (0.8)	15 (10.0)

Variables marked with a symbol indicate that the p value was <0.05.
*Wilcoxon rank sum test.

† χ^2 test.

‡Fisher's exact test.

BMI, body mass index.

apparent for sleep efficiency, a measure that reflects factors such as fragmented sleep and ability to stay asleep. The sleep efficiency score was 1.2 (± 1.1) in shift workers, corresponding to a mean sleep efficiency of $\geq 65\%$ to $< 85\%$ as compared with a mean score of 0.6 (± 0.9) in day workers, corresponding to a mean sleep efficiency of $> 75\%$ to 100%. Similarly, significant differences in the mean PSQI global score were observed with 47.9% of shift workers having a PSQI score > 5 and only 32.7% in our day working group ($p < 0.01$). These differences persisted in multivariate logistic regression, adjusting for age, household income and menopausal status.

Results of the mediation analysis are seen in [table 4](#). Shift work is strongly associated with the MetS with an OR of 2.29 (95% CI 1.12 to 4.70; path c), while controlling for age, menopausal status and income. When regressing all three indicators of sleep quality on the independent variable shift work, each relationship was statistically significant with ORs ranging from 2.10 to 2.18 (path a). In the analysis of the relationship of sleep quality with the MetS, no relationship was statistically significant (path b). Furthermore, the relationship between shift work and the MetS did not change when taking into account all three suspected mediators (path c'), and therefore no mediation is apparent.

DISCUSSION

Shift work is strongly associated with MetS, a proxy measure for CVD risk, among this group of female workers. Our result is of similar magnitude to results in one study of men working a rapidly rotating three-shift system (OR=2.38, 95% CI 1.13 to 4.98).³¹ The large population-based Swedish Västerbotten intervention programme identified that the RR relating a group of females working various shift schedules compared with day workers in association with the MetS was 1.7

Table 2 The metabolic syndrome and its risk factors

	Shift workers (n=121) n (%)	Day workers (n=150) n (%)	p Value*
Metabolic syndrome and its risk factors			
Elevated waist circumference (>80 cm)	85 (70.3)	96 (64.3)	0.28
Elevated serum triglycerides (≥ 1.7 mmol/L)	18 (14.9)	13 (8.7)	0.11
Low HDL cholesterol (<1.3 mmol/L)	44 (36.4)	35 (23.3)	0.02
Elevated blood pressure (systolic ≥ 130 and/or diastolic ≥ 85 mm Hg)	20 (16.5)	35 (23.3)	0.17
Elevated fasting blood glucose (≥ 5.55 mmol/L)	25 (20.7)	23 (15.3)	0.25
Presents with the metabolic syndrome (≥ 3 positive risk factors)	27 (22.3)	20 (13.3)	0.05

* χ^2 test.

HDL, high-density lipoprotein.

($p < 0.0001$).³⁷ The relationship has also been demonstrated in prospective studies,^{32 33} one of which included male and female nurses working night shifts or rotating shifts with ≥ 4 nights/month: after 4 years, the RR for developing the MetS was 5.0 (95% CI 2.1 to 14.6).³²

Having observed a significant relationship between shift work and MetS, we explored this in relation to indicators of sleep quality using the extensively administered and validated PSQI to facilitate the comparison with other studies.^{34 38} We observed that shift work is strongly associated with poor sleep latency (difficulty falling asleep), as have other studies among those working early morning shifts^{14 16} and other shift-working groups.^{39 40} It has been suggested that adaptation to night shifts occurs rarely, since usual daytime activity and night-time sleep are resumed on days off.⁴¹ In our study, shift work was also associated with poor sleep efficiency with its components of prolonged sleep latency, waking during the night and early awakenings.⁴² Since shift workers and day workers reported similar answers to the question about trouble sleeping because of “waking up in the middle of the night or early morning”, this suggests that sleep latency was the most important contributor to poor sleep efficiency. Our study also demonstrated that shift work was associated with poor overall sleep as measured by the PSQI global score, corresponding to results of other studies of shift workers.^{43–45} Similar to our findings, a study of female nurses in Taiwan found that working a rotational shift schedule was associated with

poor overall sleep quality (OR=2.26; 95% CI 1.57 to 3.28 for a global PSQI score >5 compared with day workers).

We systematically investigated whether three indicators of sleep quality acted as mediators in the relationship between shift work and the MetS, and we found no such evidence. From a methodological perspective, the measures of sleep used in our study could have lacked the precision needed to observe mediation if it exists. Our measurements did not allow us to identify *when* in the shift cycle a participant had difficulty falling asleep or inefficient sleep, and whether this persisted on days off. A Norwegian study of 1586 nurses provides insight into *when* sleep latency may be problematic during a shift cycle: among those working a three-shift system, difficulty initiating sleep was a problem for 28% after nights shifts, 12% after day shifts and 8% on days off.⁴² Similarly, our questionnaire may not have effectively captured short sleep length, a component that has been demonstrated as a risk factor for the development of CVD in the Nurses' Health Study and in a meta-analysis.^{46 47} One study looking at sleep among nurses over three consecutive 12 h night shifts observed that short sleep (<6 h) occurred *between* night shifts, while longer sleep periods occurred before the first night shift, with some sleeping as long as 15 h.⁴⁸ Since the PSQI questionnaire represents general sleep duration in the past month, it limits our ability to identify the variability of sleep length within a shift cycle. To address this, future studies utilising tools such as actigraphy devices will allow us to isolate the effect of poor sleep quality at various moments within one shift cycle.

Alternatively, assuming that shift work is causally associated with the MetS, the lack of mediation observed suggests that there may be other factors contributing to this relationship such as stress (sociotemporal disruption, poor work–life balance), unhealthy lifestyle factors (poor dietary habits, increased smoking and alcohol consumption and lack of physical activity) and other markers of circadian disruption (ie, phase shifting of melatonin).⁹ In addition, the exact timing of sleep relative to the body's internal circadian rhythm may be an important contributing factor to increased risk of CVD observed in shift-working populations. Some experimental studies support that circadian misalignment, which can be described as inappropriate timing of physiological and behavioural processes,⁴⁹ can be detrimental to cardiovascular health. Metabolic effects have been described in animal models⁵⁰ and in humans^{51 52}; for instance, one experimental study demonstrated that circadian misalignment of sleep and food consumption decreased leptin, increased mean arterial blood pressure and led to glucose responses that were typical of a prediabetic state in adults.⁵¹

In terms of potential limitations of this study, selection bias is unlikely because we did not advertise ‘sleep quality’ in the recruitment process. There is potential for residual confounding as medications that affect sleep, such as benzodiazepines, antidepressants and antipsychotics, were not considered in this study.⁵³ The

Table 3 Mean PSQI global and component scores; proportion of women with scores >2 (components) or >5 (global); and adjusted ORs comparing shift and day workers for seven components and PSQI global score

Variable	Shift workers (n=98)	Day workers (n=132)	p Value	Adjusted OR	95% CI
Sleep latency					
Mean score (±SD)	1.4 (0.9)	1.0 (0.9)	<0.01*		
Proportion with a score ≥2 (n, %)	51 (42.2)	40 (26.7)	0.01†	2.18‡	1.23 to 3.87
Sleep duration					
Mean score (±SD)	0.7 (0.9)	0.8 (0.8)	0.25*		
Proportion with a score ≥2 (n, %)	22 (18.2)	29 (19.3)	0.81†	1.01§	0.52 to 1.98
Habitual sleep efficiency					
Mean score (±SD)	1.2 (1.1)	0.7 (1.0)	<0.01*		
Proportion with a score ≥2 (n, %)	41 (33.9)	30 (20.0)	<0.01†	2.11‡	1.16 to 3.84
Sleep disturbances					
Mean score (±SD)	2.5 (0.6)	2.5 (0.6)	0.90*		
Proportion with a score of 0,1,2 vs 3 (n, %)	57 (47.1)	72 (48.0)	0.88†	0.91§	0.54 to 1.55
Use of sleeping medication					
Mean score (±SD)	0.5 (0.9)	0.3 (0.8)	0.06*		
Proportion with a score ≥2 (n, %)	16 (13.2)	13 (8.7)	0.23†	2.06¶	0.89 to 4.74
Daytime dysfunction					
Mean score (±SD)	1.0 (0.6)	0.8 (0.7)	0.03*		
Proportion with a score ≥2 (n, %)	23 (19.0)	22 (14.7)	0.34†	1.12**	0.56 to 2.27
Subjective sleep quality					
Mean score (±SD)	1.1 (0.6)	1.1 (0.8)	0.53*		
Proportion with a score ≥2 (n, %)	28 (23.1)	39 (26.0)	0.59†	0.90**	0.49 to 1.66
PSQI global score					
Mean global score (range of 0–21; ±SD)	5.8 (2.8)	4.7 (3.4)	<0.01*		
Proportion of poor sleepers (global score >5)	58 (47.9)	49 (32.7)	<0.01†	2.10‡	1.20 to 3.65

*Wilcoxon rank sum test.

† χ^2 test.

‡Model adjusted for age, household income and menopausal status.

§Model adjusted for age.

¶Model adjusted for age and household income.

**Model adjusted for age and menopausal status.

PSQI, Pittsburgh Sleep Quality Index.

cross-sectional nature of this study limits the assessment of temporality and therefore causality. Nonetheless, a temporal relationship is plausible, as it was longitudinally demonstrated by Åkerstedt *et al*⁵⁴ that entering shift work (2-shift or 3-shift system) was associated with an increased risk of difficulties in falling asleep, and leaving shift work was associated with an increased probability of these difficulties being reduced. Finally, it is a strength that this study focuses on women since there are known sex differences in sleep disturbances.⁵⁵

An important strength of this study is the use of a mediation analysis. To the best of our knowledge, no study has explicitly tested the mediating effect of sleep quality in the relationship between shift work and cardiometabolic risk. Our findings further contribute to the body of knowledge about a forward and rapidly rotating shift schedule among working women. This may be a more optimal shift schedule in terms of health, as some research has found that changing from a backward and slowly rotating shift to a forward and rapidly rotating shift is beneficial for sleep length and sleep quality.^{56–60}

Table 4 Mediation analysis of the relationship between shift work and the metabolic syndrome by sleep disturbances in female hospital employees

Mediator	Path c OR (95% CI)	Path a OR (95% CI)	Path b OR (95% CI)	Path c' OR (95% CI)
Poor sleep efficiency	2.29 (1.12 to 4.70)	2.11 (1.16 to 3.84)	1.61 (0.78 to 3.17)	2.12 (1.02 to 4.41)
Poor sleep latency		2.18 (1.23 to 3.87)	0.79 (0.38 to 1.66)	2.36 (1.43 to 4.89)
Poor global score		2.10 (1.20 to 3.65)	1.72 (0.86 to 3.44)	2.09 (1.01 to 4.35)

Models adjusted for age, menopausal status and household income.

c=Direct path from shift work to the metabolic syndrome.

a=Path from shift work to the mediating variable.

b=Path from the mediating variable to the metabolic syndrome, while controlling for shift work.

c'=Path from shift work to the metabolic syndrome, while controlling for the mediating variable.

improvements in levels of triglycerides, cholesterol, glucose and blood pressure.^{37–60}

If poor sleep quality is indeed a routine occurrence beyond the 30-day period examined in this study, this could have important adverse health effects on shift workers in the long term. The American Academy of Sleep Medicine has guidelines for the clinical management of shift-working patients presenting with sleep disturbances or those who have been diagnosed with shift work disorder.⁶¹ Medical surveillance of shift workers in the workplace can help detect early signs of severe sleep disturbances and, in turn, help diminish work accidents and absenteeism, which are both related to sleep disturbances in shift-working women.^{62–64}

A future direction is to perform this mediation analysis using measures of actigraphy to discriminate between those who have poor sleep quality precisely after a night shift. Finally, since the relationship between shift work and CVD is certainly multifactorial, other path analyses considering work stress, lifestyle behaviours, measures of circadian disruption and misalignment should be pursued. More investigations of the adverse sleep quality in well-defined shift systems will allow us to develop healthy shift scheduling policies.

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