Impact of shift work on sleep problems, hormonal changes, and features of metabolic syndrome in a sample of Egyptian industrial workers: a cross-sectional study

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Background
The effect of shift work on health is mainly thought to be related to its interference with circadian rhythms with consequence effects on sleep, hormonal balance, and features of metabolic syndrome.
The aim of this work was to investigate the impact of shift work on sleep problems, hormonal balance, and features of metabolic syndrome (BMI, cardiovascular problems, type II diabetes mellitus) among a sample of Egyptian industrial workers.

Patients and methods
Participants were 99 male workers (36 morning shift workers, 19 afternoon shift workers, and 44 night shift workers), with an age ranging from 25 to 60 years with fixed shift for at least 2 years. Participants were assessed using *Diagnostic and Statistical Manual of Mental Disorders*, 4th ed., text revision Diagnostic Criteria for Circadian Rhythm Sleep Disorder (shift work type), and by using sleep characteristics, and sleep/sleepiness problems items from Karolinska Sleep Questionnaire. Features of metabolic syndrome were obtained (BMI used to assess obesity, history of cardiovascular problems, and type II diabetes mellitus). Blood samples were collected at workplace, and morning samples were examined to detect levels of 6-sulfatoxymelatonin, leptin, testosterone, prolactin, and thyroid-stimulating hormone.

Results
Sleep problems were higher in night shift workers and they had higher BMI and higher prevalence of type II diabetes and cardiovascular problems than those workers in the morning and afternoon shifts, and the differences were statistically significant. The concentrations of 6-sulfatoxymelatonin, leptin, and testosterone were lower in those night shift workers than afternoon and morning shift workers. Prolactin and thyroid-stimulating hormone levels were higher in the night shift workers than in the other two groups, with a statistically significant differences ($P<0.05$). Night shift workers had disturbed hormone levels than morning and afternoon workers, and hormonal levels were independently influenced by night shift, but not by BMI, or sleep disorders, thus suggesting that the difference in hormonal levels may be will mediated by circadian disruption.

Conclusion
Night shift workers are at risk for sleep problems, hormonal imbalance, and features of metabolic syndrome (high BMI, cardiovascular problems, type II diabetes mellitus).

Keywords:
features of metabolic syndrome, hormonal changes, shift work, sleep problems

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Introduction

Night shift work is defined as a work that is performed between 10 p.m. and 6 a.m. the next day [1]. Shift work is prevalent in many societies. In 2000, 19.3% of employees were shift workers in the European Union (15 member states) and 23.0% were shift workers in the UK [2].

Shift work can induce sleep disturbances, as well as other difficulties, including accidents because of sleepiness during night-time working hours and, in more extreme cases, a shift work syndrome characterized by gastro-intestinal and cardiovascular disorders [3].

Studies have consistently shown that shift and night work may cause several problems for the employee. These problems can occur in terms of physical and mental health, safety, social life, and work performance/effectiveness [4].

There has been a scarcity of studies on the impact of shift work on mental health. Many studies have revealed that night shift work can cause many adverse effects on health such as fatigue, sleep problems, obesity, and cardiovascular disorders [5].

The sleep-related problems of shift work usually occur as transient phenomena related to the timing of work [6]. Complaints are usually related to the inability to sustain long-quality sleep after a night shift. These conditions can be accompanied by intense feelings of fatigue and drowsiness or lack of sleep, as well as reduced capacity for mental functioning owing to lack of vigor and willingness to adequately respond to the tasks. Reduced levels of alertness or willingness to respond to everyday tasks are resulting in reduced capacity for performance of everyday activities not just during the night shifts, which in turn reflect on various aspects of personal safety. Increased level of irritability is also notable, which probably stems from the conflict caused by the need for sleep and the need for social activities [7].

Studies have found an association between shift work and general mental health [8,9], psychological well-being, irritability/irritation/strain [10], and severe emotional problems [11]. Studies have also shown that shift workers experience depression to different degrees, general malaise including depression and anxiety elements [12], higher levels of burnout [13], more fatigue [7,14,15], and mental tiredness [16].

A negative impact of shift work on mental health may be varying with the duration of exposure, type of shift work, and gender; shift work has been associated with increased incidences of obesity and other features of the metabolic syndrome, such as hypertension, hyperlipidemia, and insulin resistance, ultimately leading to an increased incidence of cardiovascular disease [17].

Internal body clock is keyed to natural daylight and darkness, and as shift work disrupts the circadian rhythm this leads to links between biological clocks and metabolic hormone regulation. Previous researches have revealed that night shift workers had disturbed levels of prolactin, melatonin, testosterone, leptin, and thyroid hormone [18,19]. Animal studies suggest a relation, but relatively few studies have been conducted on people engaged in shift work [20].

The objective of this study was to determine the impact of shift work on hormonal balance, sleep problems, and features of metabolic syndrome (BMI, cardiovascular problems, type II diabetes mellitus) among a sample of Egyptian workers.

Patients and methods

Patients

A cross-sectional comparative study was conducted on employees at a factory located in Helwan District in Cairo, Egypt. The factory is engaged in the manufactures of railway sleepers, rubber, pottery, and cement bricks. The current study was approved by the Research Committee of the Department of Occupational and Environmental Medicine, Faculty of Medicine, Cairo University, Egypt. It was conducted in accordance with the ethical guidelines of the Declaration of Helsinki October 2013.

Methods

Workers were divided into three groups according to shift work, and they were interviewed using a special questionnaire involving occupational history about types of shift work, rotating shifts, and duration of work. Medical history was taken about cardiovascular problems (history of cardiac problems and hypertension) and type II diabetes mellitus. All participants gave their informed consent before inclusion in the study.

All workers were subjected to the following:

(1) Hormone analysis: serum samples were centrifuged, separated, frozen, and stored at $-73°C$ directly until analyzed. Serum melatonin, leptin, testosterone, prolactin, and thyroid-stimulating hormone (TSH) levels were determined by specific immune-fluorometric assay (Autodelphia; Wallac Oy, Turku, Finland) with intra-assay and interassay coefficients of variation of 2.6 and 6.1%, respectively.
(2) Height and weight were measured and BMI was calculated to detect obesity (overweight BMI = 25–30%/obese BMI > 30%).
(3) Participants were assessed using *Diagnostic and Statistical Manual of Mental Disorders*, 4th ed., text revision Diagnostic Criteria for Circadian Rhythm Sleep Disorder (shift work type), and using sleep characteristics, and sleep/sleepiness problems items from Karolinska Sleep Questionnaire [21]. Arabic version is translated and back translated by senior staff. The questions concerning sleep problems were 'snoring', 'exhausted upon awakening', and the indexes were 'disturbed sleep' (containing 'difficulties falling asleep', 'repeated awakenings', 'disturbed sleep', 'premature awakening') and 'sleepiness problems' (containing 'sleepiness during work/leisure', 'involuntary falling asleep at work', 'involuntary falling asleep during leisure time', and 'have to fight against sleep to stay awake'); all used the following response alternatives: 1, always; 2, mostly/several times a week; 3, sometimes/several times per month; 4, seldom; 5 never (during the last 6 months). Other items were 'diurnal type' [1, profound evening type; 4, profound morning type (49)], 'habitual sleep need' (hours and minutes), and 'sufficient sleep?' (1, no, far from sufficient; 5, yes, definitely sufficient). In addition, the questionnaire included questions of whether sleep was disturbed in connection with day sleep (after the night shift) or before the morning shift; the questions concerned whether sleep was 'disturbed' or 'insufficient' and the feeling of 'not being well rested' (scales ranging from 1, never, to 5, always). The shift workers also rated their need of recovery after a work period (how many nights needed to recover: 1, one sleep; 2, two sleeps; 3, three or more sleep periods), as well as their general health (1, very poor; 5, very good).

Statistical analysis

The collected data were statistically analyzed using SPSS 16 program for windows software (Chicago, Illinois, USA). Results are presented as median and percentiles for all parameters. Differences between the three groups of shift workers were analyzed by one-way analysis of variance model to compare the variables between the three groups. The difference was considered statistically significant at *P*-value less than 0.05 levels. A set of multivariate linear regression analyses were conducted to find the best predictors of hormonal levels. All variables significantly related to a hormone ($P<0.05$) were included as predictors.

Results

The mean age for shift workers was 46.8±10.0 years, whereas the mean duration of the work is 18.9±9.2 years.

A total number of 99 male employees were included in this study. They are divided into three groups, which are morning shift workers ($n=36$), afternoon shift workers ($n=19$), and night shift workers ($n=44$). Table 1 represents the distribution of subjects with respect to age, smoking habits, duration of employment, and health problems (BMI, type II diabetes mellitus, and cardiovascular problems). The distribution of studied groups was presented with regard to different shift works. There was no statistically significant difference between three groups as regards age, duration of employment, and smoking habit ($P>0.05$).

Obesity was more prevalent in night workers (27.3%) than in afternoon workers (5.3%) and morning workers (2.8%). Type II diabetes mellitus was more prevalent in night shift workers (25%) compared with afternoon and morning workers (5.3 and 8.3%, respectively), and the differences were statistically significant ($P<0.05$). Night workers had more frequent cardiovascular problems (25%) than other two shifts workers (15.8 and 8.3%), respectively, even though this difference did not reach statistical significance ($P>0.05$).

Table 1 Background data among morning, afternoon, and night shift workers

	Morning shift ($n=36$) [n (%)]	Afternoon shift ($n=19$) [n (%)]	Night shift ($n=44$) [n (%)]	*P*-value
Age group				
20–30	2 (5.6)	1 (5.3)	3 (6.8)	0.945
31–40	8 (22.2)	6 (31.6)	10 (22.7)	
41–60	26 (72.2)	12 (63.2)	31 (70.5)	
Duration of work				
<10	9 (25)	3 (15.8)	10 (22.7)	0.543
10–20	15 (41.7)	12 (63.2)	18 (40.9)	
>20	12 (33.3)	4 (21.1)	16 (36.4)	
Smoking				
Yes	17 (47.2)	9 (47.4)	28 (63.6)	0.267
No	19 (52.8)	10 (52.6)	16 (36.4)	
BMI (kg/m^2)				
Normal (18–25%)	16 (44.4)	7 (36.8)	8 (18.2)	0.006*
Overweight (25–30%)	19 (52.8)	11 (57.9)	24 (54.5)	
Obese (>30%)	1 (2.8)	1 (5.3)	12 (27.3)	
Type II diabetes mellitus				
Yes	3 (8.3)	1 (5.3)	11 (25)	0.048*
No	33 (91.7)	18 (94.7)	33 (75)	
Cardiovascular problems				
Yes	3 (8.3)	3 (15.8)	11 (25)	0.142
No	33 (91.7)	16 (84.2)	33 (75)	

*Significant.

Table 1 showed background data among morning, afternoon, and night shift workers. Night shift workers have higher BMI, type II diabetes mellitus, and cardiovascular problems compared with the other two shifts with a statistical significant difference between groups as regards BMI and type II diabetes mellitus.

Sleep problems were higher in night workers than in morning and afternoon workers. Also, night workers had more disturbed sleep, snoring, recovery need after a work period, sleep problems on day sleep after night shifts, and sleep problems before the morning shift than morning and afternoon workers; the differences between the three groups were statistically significant (Table 2).

Table 3 shows the concentrations for plasma melatonin, leptin, testosterone, prolactin, and TSH in the three groups. The concentrations of melatonin, leptin, and testosterone were lower in those working in the night shift than those in the afternoon and morning shifts. TSH and prolactin levels were higher in the night shift workers than in the other two groups, and the differences between the three groups were statistically significant ($P<0.05$).

The relative influence of independent variables (night shift, obesity, diabetes, blood pressure, sleep problems, and disturbed sleep) on the levels of hormones was tested using multivariate linear regression analysis. The significance for night shift was less than 0.05 (night shift was an independent predictors for hormones) (Tables 4 and 5).

R^2 (%) = determination coefficient and their 95% confidence intervals ($P<0.05$).

Discussion

As night workers often have a hard time sleeping during the day, they are suffering from circadian rhythm disruption caused by night shift that involves exposure to artificial light and sleep problems during the day with its resulting effects on hormonal balance and BMI.

The aim of this study was to determine the impact of shift work on hormonal balance, sleep problems, and features of metabolic syndrome (BMI, cardiovascular problems, type II diabetes mellitus) among a sample of Egyptian industrial workers.

The study showed that the occurrence rate of obesity, type II diabetes mellitus, and cardiovascular problems was significantly higher in night shift workers compared with afternoon and morning workers, and this was consistent with a study by Di Lorenzo *et al.* [22], who revealed higher prevalence of obesity and BMI in night workers compared with day workers. In addition, another study showed that the prevalence of obesity

Table 2 Sleep characteristics and sleep/sleepiness problems items from the Karolinska sleep questionnaire in the studied group among morning, afternoon, and night shift workers

	Morning shift ($n=36$) [n (%)]	Afternoon shift ($n=19$) [n (%)]	Night shift ($n=44$) [n (%)]	P-value
Sleep problems				
Yes	5 (13.9)	10 (52.6)	31 (70.5)	<0.001*
No	31 (86.1)	9 (47.4)	13 (29.5)	
General sleep/sleepiness problems				
Disturbed sleep	7 (19.4)	10 (52.6)	32 (72.7)	<0.001*
Sleep during work	29 (80.6)	9 (47.4)	12 (27.3)	
Snoring	5 (13.8)	10 (52.6)	31 (70.5)	0.000*
Sleep characteristics				
Diurnal type	29 (80.6)	5 (26.3)	9 (20.5)	<0.001*
Habitual sleep need, and recovery need after work	4 (11.1)	11 (57.9)	11 (25)	
Period (days)	3 (8.3)	3 (15.8)	24 (54.5)	
Sleep problems on day sleep after night shifts	5 (13.9)	7 (36.8)	27 (64.4)	0.000*
Sleep problems before the morning shift	5 (13.9)	10 (52.6)	32 (72.7)	0.000*

*Statistically significant.

Table 3 Median and interquartile range of the different hormone concentrations among shift workers

	Morning shift ($n=36$) [median (IQR)]	Afternoon shift ($n=19$) [median (IQR)]	Night shift ($n=44$) [median (IQR)]
6-Sulfatoxymelatonin	18.6 (14.0–23.8)	14.4 (12.0–15.6)	7.9 (5.6–9.8)
Leptin (ng/ml)	8.5 (5.5–11.6)	4.5 (3.5–5.6)	1.9 (1.8–2.3)
Testosterone (nmol/l)	7.0 (6.0–8.2)	4.9 (4.0–5.7)	3.2 (2.5–5.0)
TSH	0.7 (0.5–0.9)	1.4 (1.2–1.7)	2.8 (2.2–3.6)
Prolactin	4.3 (2.8–6.1)	3.7 (2.2–5.1)	4.6 (3.2–15.0)

TSH, thyroid-stimulating hormone.

Table 4 Multivariate linear regression model to explore predictors of 6-sulfatoxymelatonin and leptin level in the studied groups

	6-Sulfatoxymelatonin			Leptin		
Independent variable	β	95% CI of β	P	β	95% CI of β	P
Night shift	−8.776	−3.281–4.270	<0.001*	−8.921	0.454–5.708	<0.001*
BMI	–	–	–	0.014	−5.313–5.340	0.996
Cardiovascular diseases	1.221	−1.880–4.322	0.436	0.459	−2.644–3.562	0.770
Diabetes type II	−3.313	−7.488–0.862	0.118	−1.337	−5.426–2.753	0.518
Sleep problems	1.235	−2.287–4.757	0.488	1.954	−2.026–5.935	0.332
Disturbed sleep	–	–	–	4.421	−0.379–9.221	0.071

$R^2=0.248$ and 0.214, respectively.
*Statistically significant.

Table 5 Multivariate linear regression model to explore predictors of testosterone, prolactin, and thyroid-stimulating hormone levels in the studied groups

	Testosterone			Prolactin			TSH		
Independent variable	β	95% CI of β	P	β	95% CI of β	P	β	95% CI of β	P
Night shift	−3.052	−4.570 to −1.534	<0.001*	3.081	0.454–5.708	0.022*	2.240	1.011–3.469	<0.001*
BMI	−0.920	−2.570–0.729	0.271	–	–	–	0.834	−0.825–2.493	0.320
Diabetes type II	−1.140	−2.446–0.167	0.086	2.416	−0.826–5.658	0.142	−0.523	−1.575–0.530	0.326
Sleep problems	0.199	−1.062–1.460	0.754	–	–	–	−0.566	−1.591–0460	0.276
Disturbed sleep	0.265	−1.224–1.754	0.724	–	–	–	0.834	−1.248–1.150	0.320

$R^2=0.365$, 0.214 and 0.327, respectively.
CI, confidence interval; TSH, thyroid-stimulating hormone.
*Statistically significant.

and weight gain were higher in late-shift workers (night workers) [23]. Others reported that the prevalence of obesity is higher in night shift workers and highlight a positive relationship between BMI and the duration of shift work exposure [24,25]. A study of Suwazono *et al.* [26] on male Japanese workers revealed that alternation/shift work was an independent risk factor for impaired glucose metabolism. Shift work, regardless of models, was significantly associated with metabolic syndrome [27]. A research over 20 years concluded that the risk of cardiovascular disease is increased among shift workers [28].

Other studies have reported that diabetes, insulin resistance, and dyslipidemia also tend to occur more frequently in night shift workers [29]; this could be verified by a study that found that the eating habits of shift workers are altered, and there is a higher caloric intake and an increased consumption of saturated fat and foods with a high glycemic index [30].

Sleep problems

Disruption of both the quality and quantity of the normal sleep cannot be avoided in shift work particularly when night work is involved. The daytime sleep is difficult to be deep or refreshing as sleep at night. The problem is greater if there is no quiet, dark, comfortable place to sleep. This difficulty occurs because the circadian rhythm is no longer synchronized [31].

The study revealed a higher percentage of sleep problems among night shift workers than afternoon and day workers, with statistically significant differences (Table 2), as night workers reported general sleep/sleepiness problems [disturbed sleep (72.7%), snoring (70.5%)], recovery need after a work period, days (54.5), sleep problems before the morning shift (72.7%), and sleep problems on day sleep after night shifts (64.4%).

This finding is supported by Boivin *et al.* [32], who reported that night workers suffer from reduced sleep duration, typically ranging from 4 to 7 h, symptoms of insomnia during the main sleep period, and sleepiness across wake periods. Another study looked at data for 7782 participants in a Norwegian survey conducted during 1997–1999, and found that shift workers reported shorter sleep duration than day workers [33].

The connection between shift work and sleep difficulties is recognized in the *Diagnostic and Statistical Manual of Mental Disorders*, which lists shift work sleep disorders as a subcategory of circadian rhythm sleep disorders [34].

Melatonin

Night shift workers are exposed to artificial light-at-night, which suppresses the normal nocturnal production of melatonin, resulting in sleep disruption and deprivation [35].

In the present study, 6-sulfatoxymelatonin levels in blood of night shift workers were lower than in morning and afternoon shift workers and the differences between the three groups were statistically significant. Multivariate linear regression model to explore predictors of melatonin revealed that night shift is the only significant predictor while sleep problems were insignificant predictors. The results are in agreement with a found decreased 24-h 6-sulfatoxymelatonin levels in nurses working the night shift compared with day shift on a workday and an off-day [36]. Similar results reported significantly decreased urinary 6-sulfatoxymelatonin levels in nurses with increasing number of nights worked before urine collection [37]. The results of other study revealed that night shift work is associated with reduced urinary 6-sulfatoxymelatonin levels during night work as well as daytime sleep and that levels remain low even during night sleep on off-nights [38].

Burch *et al.* [39] reported significantly lower urinary melatonin levels during daytime sleep among men and women who work at night shift; they also reported an altered sleep: work urinary melatonin ratio among the night shift workers, indicating a lack of a robust diurnal melatonin rhythm typically seen in the non-night shift working population. In contrast to our results, studying of rotating night shift nurses (two 12-h days, two 12-h nights, 5 days off) an inverse association between light exposure and urinary melatonin levels and they did not find altered salivary melatonin levels during night work [40]. This may be explained that two nights of rotating shift work may not be sufficient to alter the timing of melatonin production.

Leptin

Concerning leptin levels in blood, nightshift workers showed lower significant leptin levels compared to afternoon and morning shift workers and the significant predictor was night shift contrary to obesity and diabetes. This was in agreement with Scheer *et al.* [41] who stated that circadian misalignment, a condition that is highly prevalent in shift workers, resulted in a decrease in leptin, increase in glucose and insulin resistance and reduced sleep efficiency. On the contrary, shift workers on the early morning shift have lower appetites and leptin concentrations than the workers on night shifts [42].

Testosterone

The relationship between night shift, sleep and testosterone is not only of theoretical interest but it may also contribute to understand the mechanisms behind certain health problems associated with sleep disturbances and shift work which may be related to metabolic changes, lower testosterone levels and fatigue [43]. Night work is also associated with a number of health effects, and it was found that night workers with sleep and fatigue problems had lower testosterone levels than workers without these problems [44]. This is consistent with our results which revealed lower testosterone levels in night workers in comparison to afternoon and morning workers. Testosterone levels were independently influenced by night shift, thus suggesting that the difference in testosterone levels may well be mediated by circadian disruption. In healthy adult men, circulating levels of testosterone have a distinct pattern, with increasing levels during sleep reaching its maximum around the time of awakening and a decrease during the day [45]. Low testosterone levels were associated with a great sleep need, disturbed sleep and sleepiness problems [19]. These results link the main problems in shift workers with its resulting effect on disturbed sleep/alertness to many endocrine variables.

Prolactin

The physiological actions of prolactin in human body are complex and not fully understood. For example, it is known that prolactin levels seem to follow the circadian rhythm. That is, they are increased during sleep through a variety of complex mechanisms. However, most studies have not shown a causal relationship between prolactin levels and sleep in humans [46]. Several studies have shown that many stressors alter prolactin [47], but negative findings have also been reported. Our results revealed unexpected results of higher prolactin levels in night shift workers than those in morning and afternoon shift workers and the differences between the three groups were statistically significant. This may be explained as the samples were taken in the morning which is the time of sleeping of night shift workers. Only seven researches have studied the association between work at night and prolactin secretion. In three of them, lower concentrations of prolactin have been observed in night shift workers in nocturnal samples. Night shift work can modify the profile of prolactin secretion in night workers, probably decreasing the secretion of this hormone at night [19]. TSH levels change according to circadian rhythms and to sleep patterns, and measuring serum TSH level is the most sensitive method for identifying thyroid dysfunction [48]. However, few researches have evaluated the association of thyroid diseases with night shift work. One study that examined thyrotropin rhythm and night shift workers [49] and another study examined a correlation between TSH levels and night shift work [50]. Therefore, we evaluated TSH levels among workers according to their shift status. The present study did observe an increase in TSH levels among night shift workers, compared to non-night shift workers and the differences between the three groups were statistically significant, and night shift was an independent variable. Night shift work might increase the risk of subclinical hypothyroidism [51]. Also, from 2011 to 2015, night shift workers had TSH levels higher than the levels of non-night shift workers after adjusting for age and when using TSH levels of at least 4.5 mIU/l to identify subclinical hypothyroidism, night shift workers exhibited higher risk of subclinical hypothyroidism, compared to their non-night shift counterparts [20]. TSH levels exhibit a normal circadian rhythm, with study-specific peaks at ∼2–4 a.m. and troughs at ∼4–8 p.m. [52]. However, this circadian rhythm assumes that workers have a normal sleep at night, and night shift work-related changes in sleep schedule, timing, and quality may alter the body's normal circadian rhythm and lead to an abnormal TSH circadian rhythm. Furthermore, some authors have suggested that sleep deprivation promotes oscillations in the TSH circadian rhythm [53], which increases the likelihood that TSH levels increase when workers are deprived of sleep after their night shift. Other theories suggest that nocturnal eating may affect hormone levels (e.g. TSH, insulin, and glucagon) [54] and it is possible that night shift work might lead to irregular eating habits and nocturnal eating, which might lead to increases in TSH levels. Some studies have also found that night shift work can increase the risk of autoimmune disease and altered immune system function, which might lead to increased TSH levels among night shift workers [55].

The results shows that night shift was the only independent predictor for hormones imbalance for shift workers rather than other variable (BMI, type II diabetes, cardiovascular problems, disturbed sleep, and sleep problems). This could explain that night shift workers have hormonal changes that may be considered as the main causative factors for sleep problems and occurrence of features of metabolic syndrome in the form of increased BMI, type II diabetes, and cardiovascular problems. In addition, this suggests that the difference in hormonal levels may be well mediated by circadian disruption.

Future studies aim at identifying both work and individual factors that are related to differential health outcomes of shift work. Studies are needed to investigate more details about the mechanisms and chronic effects of the hormonal changes in night shift and to clarify how altered circadian rhythm can affect various physiological systems. Such researches may lead to development of appropriate strategies to prevent or manage the adverse consequences of altered circadian rhythm caused by shift work and understanding how to plan night work to minimize the health consequences of night work when it is inevitable.

Limitation

Limitations of the study include the relatively small sample sizes. Another limitation of this study is the inability to analyze diurnal rhythms of hormone secretion over a 24-h period and its relation to night shifts, and the sleep/wake cycle. Also, it is important to examine the changes in consecutive night shifts and to detect whether these changes also happened in recovery days or not and to determine its relation to sleep pattern.

Conclusion

Shift work is associated with lower level of melatonin, leptin, and testosterone, whereas TSH and prolactin levels were higher. Night shift is associated with increased occurrence of increased BMI, type II diabetes, cardiovascular problems, and sleep problems. Night shift was the only independent predictor for hormone imbalance for shift workers rather than BMI, type II diabetes, cardiovascular problems, disturbed sleep, and sleep problems.

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Conflicts of interest

There are no conflicts of interest.

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