The Risk of Night Shift Workers to the Glucose Blood Levels, Saliva, and Dental Caries

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Abstract

Objective This study aimed to provide the correlation of circadian rhythms of night shift workers with blood glucose levels, saliva, and dental caries.

Materials and Methods This study was conducted on night shift and nonshift workers to measure fasting blood glucose (FBG), 2-hour postprandial blood glucose (2-PP BG), saliva flow rate, pH saliva, and caries with the decay-missing-filled total (DMF-T) index. Data analysis was done using independent t-test and correlation test with Pearson correlation.

Results There were significant differences in night shift and nonshift workers in FBG (p = 0.000), 2-PP BG (p = 0.000), flow rate saliva (p = 0.000), and DMF-T index (p = 0.001). Correlation test showed positive correlation between FBG and pH saliva (r = 0.42, p = 0.029) and DMF-T index (r = 0.521, p = 0.005) of night shift workers. The 2-PP BG also showed positive correlation with pH saliva (r = 0.493, p = 0.009) and DMF-T index (r = 0.743, p = 0.000). The DMF-T index showed negative correlation with flow rate saliva (r = −0.398, p = 0.04). In the nonshift workers, correlation test showed a correlation between FBG and DMF-T index (r = 0.384, p = 0.048). The DMF-T index showed correlation with flow rate saliva (r = 0.6, p = 0.001).

Conclusion There is a circadian rhythm correlation between night shift workers to blood glucose levels, flow rate saliva, pH saliva, and dental caries.

Introduction

In the era of globalization, the needs of humans keep getting increased. The development of technology encourages people to explore their potential to fulfill their needs, both physically and psychologically, by working. Shift working is a human resource management in the working system to maximize work productivity and to complete the customer’s needs.¹ Currently, the shift working system has been applied in various industrial, manufacturing, and service sectors. In industrialized countries, more than 20% of the population works in the shifts. As many as 15 to 25% of workers in the world work in the shift system.²

Regulation of human body metabolism is influenced by a system known as circadian rhythm. Circadian rhythm is the daily oscillations of biological processes, which is influenced by the body’s biological clock. The circadian rhythm is centrally controlled by the suprachiasmatic nucleus, located in the hypothalamus, which is linked to the dark–light cycle and transmits information to peripheral organs including peripheral cycles to modulate the waking up–sleeping rhythms every

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Night shift workers experience schedule changes differently from usual people with regard to mealtime, temperature, exercise, or other environmental factors and is known as zeitgeber. The synchronization between the circadian system and zeitgebers of night shift workers can cause circadian misalignment, which is detrimental to their health. The night shift workers are known to have a bad effect on their general health, which is associated with several diseases related to lifestyle. A study reports that night shift workers have more systemic diseases, one of these is type 2 diabetes mellitus. Diabetes mellitus is a disease characterized by high blood glucose levels, caused by an increase in cellular resistance to insulin performance, leading to various metabolic disorders. Diabetes mellitus is a metabolic disease that often occurs in Indonesia. The prevalence of diabetes mellitus in Indonesia by the year 2007 was 5.7% and by the year 2013 was 6.9%. The night shift workers with type 2 diabetes mellitus have differences in pancreatic \( \beta \) cell response, glucose and lipid metabolism, and increased risk of developing syndrome metabolic. Sleeping time changes in night shift workers cause impaired glucose tolerance and reduced insulin response.

Diabetes mellitus is a predisposing factor for caries. Caries prevalence in Indonesia increased from 43.4% in 2007 to 53.2% in 2013. Caries can occur in patients with poorly controlled diabetes mellitus, because carbohydrate fermentation in the saliva increases, causing increased acid production that promotes caries. In patients with diabetes, the state of saliva also changes, such as flow rate and pH saliva. Patients with type 2 diabetes mellitus experience polyuria that causes intensive fluid loss, reduction in response to infection, disorders of connective tissue metabolism, and various microvascular changes that can cause dental caries. Management of circadian rhythms has been studied previously using melatonin therapy. Existing melatonin therapy is used to improve sleep quality in night shift workers. However, there has been no previous study of the circadian rhythms related to the risk of diabetes mellitus and the risk of dental caries in night shift workers.

Aims or Objective
The aim of this study was to determine the correlation between circadian rhythm of night shift workers and the risk of diabetes mellitus and caries risk. Flow rate saliva, pH saliva, and decay-missing-filled total (DMF-T) index were analyzed to describe the risk of caries. The fasting blood glucose (FBG) and 2-hour postprandial blood glucose (2-PP BG) were used to describe the risk of diabetes mellitus.

Materials and Methods
The type of research in this study was observational analytic with a cross-sectional design. Ethical approval was obtained from the Ethics and Law Committee of Universitas Airlangga Hospital, Surabaya (185/KEH/2018).

Blood Glucose Measurement
Fasting blood glucose and 2-PP BG measurements were performed using glucometer (Accu-Chek; Roche Diabetes Care Inc., United States). On FBG examination, the subjects were asked to fast 8 hours (not allowed to eat and drink except drinking water) before blood glucose examination. Then, after 8 hours, an FBG examination was performed with glucometer. Criteria for FBG for diabetes mellitus are fasting \( \geq 126 \) mg/dL. 2-PP BG examination was performed after FBG measurement. Subjects were allowed to eat and drink, and after 2 hours 2-PP BG examination was performed. Blood glucose criteria of 2-PP for diabetes mellitus are \( \geq 200 \) mg/dL.

Flow and pH Saliva Measurement
Saliva samples were collected for measuring salivary pH using a pH strip-meter (Whatman; PH1170–11A; GE Healthcare). Saliva samples were collected from each participant in the morning between 9 and 11 am using passive drool methods. For the collection of these samples, all participants were requested to be as quiet as possible. They were instructed to allow the saliva to flow into the mouth as normally as possible and expectorate into the large test tubes provided. In all, 6 mL of sample was collected from each participant. The pH of each sample was determined within the first half an hour after collection.

DMF-T Index Examination
DMF-T index examination was performed using a dental explorer and dental mirror, followed by examining of decayed teeth due to caries (decay), missing/removed teeth due to caries (missing), teeth that were patched or filled with caries and were filled were examined. Calculation of DMF-T index was done by the formula:

\[
DMF = T - \frac{D + M + F}{\text{number of subject}}
\]

with criteria:
1. 0–1.1 = very low
2. 2–2.6 = low
3. 3–4.4 = moderate
4. 4.5–6.5 = high
5. > = very high

Statistical Analysis
The data were analyzed statistically using SPSS 19. Independent t-test was used for analysis between two groups. Pearson correlation was used for correlation analysis between the two groups.
Results

Fifty-four subjects in this research were males: 27 as night shift workers and 27 as nonshift workers. Night shift workers had an average age of 32.26 ± 4.53 years and nonshift workers had an average age of 33.08 ± 5.09 years. There were no age differences between night shift worker and nonshift workers (p = 0.537). Night shift workers also had a significantly higher body weight than nonshift workers (p = 0.000). There were no differences in the body height showed no differences, but the body mass index (BMI) showed a significant difference (p = 0.000). Both groups had experience of working for more than 5 years (48.1 and 44.4%, respectively). The highest frequency of working in the night shift workers was thrice a week (44.5%), followed by once a week (33.3%) and once a month (22.2%) (►Table 1).

The night shift workers had higher FBG (121.56 ± 31.82 mg/dL) and 2-PP BG (91.22 ± 13.25 mg/dL) than FBG (163.06 ± 60.44 mg/dL) and 2-PP BG (98.67 ± 19.8 mg/dL) in nonshift workers (p = 0.000) (►Table 2).

The mean flow rate of saliva was found to be significantly lower in the night shift workers than that in nonshift workers (p = 0.000). The night shift workers had high DMF-T index and nonshift workers had moderate DMF-T index (p = 0.000). The saliva pH showed no differences between night shift workers and non-night shift workers (p = 0.710) (►Table 3).

In the correlation analysis, there was a significantly positive correlation of FBG and 2-PP BG to saliva pH and DMF-T index in night shift workers (►Table 4). There was a negative correlation between DMF-T index and saliva flow rate (p = 0.04; r = -0.398) (►Table 5).

In nonshift workers, there was only a significantly positive correlation of FBG with DMF-T index (p = 0.048; r = 0.384) (►Table 6). The DMF-T index had a positive correlation with saliva flow rate (p = 0.001; r = 0.6) (►Table 7).

Discussion

This is the first study to analyze the circadian rhythms related to the risk of diabetes mellitus and the risk of dental caries in night shift workers. This study was conducted on night shift and nonshift workers at Universitas Airlangga Hospital. Surabaya is one of the biggest cities in Indonesia, which is a tropical country. Tropical populations generally work from morning to evening and sleep at night. Night shift workers

Table 1  Demographic of all subjects

| Variables          | Night shift worker (n = 27) Mean ± SD | Nonshift worker (n = 27) Mean ± SD | p-Value |
|--------------------|-------------------------------------|-----------------------------------|---------|
| Sex                | Male                                | Male                              | –       |
| Ages (years)       | 32.26 ± 4.53                        | 33.08 ± 5.09                      | 0.537   |
| Body weight (kg)   | 84.00 ± 10.03                       | 53.93 ± 6.87                      | 0.000*  |
| Body height (cm)   | 168 ± 6.29                          | 167.37 ± 5.79                     | 0.531   |
| BMI                | 29.52 ± 1.89                        | 19.17 ± 1.32                      | 0.000*  |
| Lifetime of working|                                     |                                   |         |
| <1 y               | 4 (14.8%)                           | 5 (18.5%)                         |         |
| 1–5 y              | 10 (37%)                            | 10 (37%)                          |         |
| >5 y               | 13 (48.1%)                          | 12 (44.4%)                        |         |
| Lifetime for night shift|                                |                                   |         |
| 3 times a wk       | 12 (44.5%)                          |                                   |         |
| 1 time a wk        | 9 (33.3%)                           |                                   |         |
| 1 time a mo        | 6 (22.2%)                           |                                   |         |

Abbreviations: BMI, body mass index; SD, standard deviation.

*Results of independent t-test in the comparison between the case and the control groups, significant at p < 0.05

Table 2  FBG and 2-PP BG value in both groups

| Variables          | Night shift worker (n = 27) Mean ± SD | Nonshift worker (n = 27) Mean ± SD | p-Value |
|--------------------|-------------------------------------|-----------------------------------|---------|
| FBG (mg/dL)        | 121.56 ± 31.82                      | 91.22 ± 13.25                     | 0.000*  |
| 2-PP BG (mg/dL)    | 163.06 ± 60.44                      | 98.67 ± 19.8                      | 0.000*  |

Abbreviations: FBG, fasting blood glucose; 2-PP BG, 2 postprandial blood glucose; SD, standard deviation.

*Results of independent t-test in the comparison between the case and the control groups, significant at p < 0.05.
work in the opposite of the usual conditions, which fight the normal circadian rhythm. When these workers are awake at night, they receive light by the retina. Furthermore, it is forwarded by the retinal hypothalamic tract to the suprachiasmatic nucleus located in the hypothalamus. The light signal is forwarded to the spinal cord and the superior cervical ganglion toward the pineal gland. The pineal gland receives a light signal, so it does not release norepinephrine to pinealocytes. Then β-adrenergic receptors are not activated so that there is a decrease in melatonin secretion. The decrease in melatonin secretion causes a decrease in antioxidants resulting more production of reactive oxygen species (ROS), which is in body fluids and saliva. Increased ROS forms oxidative stress that is followed by an increase in malondialdehyde (MDA), which continues to create imbalance in the body and affect disease progression. Increased blood glucose can be affected by insulin, which experiences resistance that is influenced by levels of ROS, namely excessive MDA in the cell. Free radicals (MDA) are formed disproportionately by oxidation of nonenzymatic proteins and oxidative degradation of glycated proteins (advanced glycation end products) in type 2 diabetes mellitus.

In physiological conditions, pancreatic β cells produce insulin in normal amounts that can transport glucose from the blood into the cell. However, in night shift workers with insulin resistance receptors, insulin receptors are not sensitive leading to increased levels of blood glucose. Chronic increase in the blood glucose levels can increase the risk of diabetes and caries. 

### Table 3 Flow rate saliva, pH saliva, and DMF-T index in all groups

| Variables          | Night shift worker (n = 27) Mean ± SD | Nonshift worker (n = 27) Mean ± SD | p-Value |
|--------------------|--------------------------------------|-----------------------------------|---------|
| Flow rate saliva (mL/min) | 0.24 ± 0.15                           | 0.57 ± 0.27                       | 0.000* |
| pH saliva          | 5.89 ± 1.48                           | 5.74 ± 1.43                       | 0.710   |
| DMF-T              | 9.74 ± 5.07                           | 3.52 ± 2.46                       | 0.001+  |

Abbreviations: DMF-T, decay-missing-filling total; SD, standard deviation.
*Results of independent t-test in the comparison between the case and the control groups, significant at p < 0.05.

### Table 4 Correlation between FBG and 2-PP BG to flow rate saliva, pH saliva, and DMF-T in night shift workers

|                      | Flow rate saliva | pH saliva | DMF-T |
|----------------------|------------------|-----------|-------|
| FBG                  | 0.109            | 0.420*    | 0.521*|
| 2-PP BG             | 0.020            | 0.493*    | 0.743*|

Abbreviations: DMF-T, decay-missing-filling total; FBG, fasting blood glucose; 2-PP BG, 2 postprandial blood glucose.
*Correlation is significant at the level 0.05.
*Correlation is significant at the level 0.01.

### Table 5 Correlation between flow rate saliva to pH saliva and DMF-T in night shift workers

| Flow rate saliva | pH saliva | DMF-T |
|------------------|-----------|-------|
| Person correlation | 0.205    | −0.398* |
| p-Value           | 0.306    | 0.04   |

Abbreviation: DMF-T, decay-missing-filling total.
*Correlation is significant at the level 0.05.

### Table 6 Correlation between FBG and 2-PP BG to flow rate saliva, pH saliva, and DMF-T in nonshift workers

|                      | Flow rate saliva | pH saliva | DMF-T |
|----------------------|------------------|-----------|-------|
| FBG                  | 0.334            | 0.286     | 0.384*|
| 2-PP BG             | 0.243            | 0.197     | 0.371  |

Abbreviations: DMF-T, decay-missing-filling total; FBG, fasting blood glucose; 2-PP BG, 2 postprandial blood glucose.
*Correlation is significant at the level 0.05.

### Table 7 Correlation between flow rate saliva to pH saliva and DMF-T in nonshift workers

| Flow rate saliva | pH saliva | DMF-T |
|------------------|-----------|-------|
| Person correlation | 0.182    | 0.6   |
| p-Value           | 0.364    | 0.001 |

Abbreviation: DMF-T, decay-missing-filling total.
*Correlation is significant at the level 0.01.
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exchanged process with calcium saliva that surrounds teeth. The diabetic condition showed low levels of calcium. Another factor that stimulates the caries in diabetic patient is high glucose concentration in saliva. Highest glucose concentration in saliva affected the presence of Streptococcus mutans and Lactobacillus, which play important role in caries.37

In the present study, there was significant correlation (p = 0.04) between the flow rate of saliva and DMF-T index in night shift worker. But the DMF-T index and pH saliva are influenced by blood glucose status (p < 0.05). The hyperglycemia condition as diabetes mellitus patients, they had significant decrease in flow rate saliva and causes the lower pH saliva. But this condition was not found in this research. The lower pH saliva is not correlated with the reduced flow rate of saliva (p = 0.306). This could be caused by increased fluid intake by diabetics due to polydipsia. Because buffering capacity is dependent on the pH levels, diabetic condition had salivary buffering capacity correlating with the pH saliva.38

The nonshift worker only showed the correlation between FBG to DMF-T index (p = 0.048). The DMF-T index has positive correlation with flow rate of saliva (r = 0.6, p = 0.001). This result is opposite to Shetty et al who in her study showed that there is correlation between decreased saliva flow rate and increased DMF-T index.39 During rest, saliva flow rate is only to keep the mouth moist and lubricate the mucous membrane. Generally, greater the flow rate, better the cleansing action of saliva on tooth surface; hence, it lessens the chance of dental caries. The results suggest the lesser DMF-T status could be having similar flow rates. The conditions found in this study may be influenced by other factors not examined such as dietary patterns and the habit of maintaining oral hygiene.

A strength of this study is the evaluation of multiple factors (FBG, 2-PP BG, BMI, lifetime of working, lifetime of night working, saliva, and caries status) in the night shift worker in hospital. However, there are limitations. Sleep quality, dietary assessments, and naps were not available; data on exercise and medication compliance were not available; and light exposure at night was not measured. The night shift workers were recruited from different hospitals, and there are possibly other confounders not controlled for that could affect blood glucose control.

In summary, night shift workers are associated with higher FBG and 2-PP BG status, which can lead to diabetic development. The oral health status including flow rate of saliva, pH saliva, and caries is also affected and has correlation with blood glucose status. The management of night shift working and maintaining the oral health in night workers is very important to be considered as risk factor of diabetes and dental caries.

The night shift workers experience a change in time orientation due to changes in the time of working and duration of sleep. Most of night shift worker will experience the disturbance of sleep. Sleep disturbance will affect food intake, water, and metabolic processes that may play a role in the process of developing diabetes. The night shift worker received more light in the night than non-night shift worker. The increased light received will reduce the production of melatonin. Research by Sadeghniaiat-Haghighi et al showed that the melatonin treatment on night shift worker is able to increase the sleep quality and sleep efficiency.40 This result supports the administration of melatonin therapy to night shift workers, so it is able to regulate circadian rhythm that results in control of diabetes risk and caries risk

Conclusion

There is a circadian rhythm correlation between night shift workers and blood glucose levels, flow rate saliva, pH saliva, and dental caries. The results of this study can provide insight into caries control and diabetes in night shift workers. Further, there exists a possibility that maintaining good blood glucose can improve the health status of night shift workers. In addition, improving sleep quality so that the risk of diabetes and caries is also lower and melatonin therapy may also be options for night workers.

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Conflict of Interest

None declared.

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