Original Article

# Sleep quality and insulin resistance in adolescent subjects with different circadian preference: A cross-sectional study

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## Abstract

**Background:** Studies have shown that alterations in the sleep cycle can predispose to several disorders. Most of the previous studies were done on the adults. Hence, the aim of the study was to see the effect of circadian disruption on the health of adolescent population. **Materials and Methods:** In this cross-sectional study, 203 subjects were enrolled. Study subjects were divided into three groups: definite evening chronotype, intermediate chronotype, and definite morning chronotype. Sleep quality was measured by Pittsburgh Sleep Quality Index (PSQI). Daytime sleepiness and chronotype were measured by Epworth Sleepiness Score and Morningness-Eveningness Questionnaire Self-Assessment version, respectively. Two hours postprandial glucose was measured after oral glucose tolerance test. Fasting blood glucose and fasting insulin were measured. Homeostasis model of assessment for insulin resistance (HOMA-IR) was calculated. Data were summarized as mean ± standard deviation. Crude odds ratios and Karl Pearson's correlation coefficient of metabolic parameters with poor sleep were calculated. **Results:** Statistically significant difference was found in the mean value of poor sleep quality, 2 h postprandial blood glucose level, and insulin resistance among subjects of three groups. Subjects of evening chronotype have more significant positive correlation of 2 h postprandial blood glucose level and HOMA-IR value with poor sleep quality when compared with subjects of intermediate and morning chronotypes. **Conclusion:** Subjects with evening chronotype are more prone for development of metabolic syndrome compared with subjects of intermediate and morning chronotypes if proper health policies are not adopted for adolescents.

**Keywords:** Daytime sleepiness, insulin resistance, morningness–eveningness, sleep quality

## Introduction

Three types of circadian typology have been described in human beings: morning (larks), evening (owls), and intermediate. Each type shows individual preferences for activity realization during a specified period of the day.[1] The evening-type individuals showed worse quality of sleep when compared with the morning and intermediate types.[2,3] Sleep modulates metabolic-[4,5] and endocrine[5] -related functions of human beings. Epidemiological and clinical studies on adults have shown that poor sleep quality and alterations in the sleep cycle can predispose to several disorders, such as impaired glucose metabolism and diabetes.[4,5] Therefore, healthy sleep is necessary for body functions. Since the past few years, prevalence of obesity and impaired glucose tolerance and type 2 diabetes mellitus has increased in children.[6,7] Studies conducted in the United States[8] and India[9] have shown that high school–aged students and adolescents do not get

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enough sleep, and the average total sleep duration has decreased to less than 8 h.

Disrupted circadian rhythm changes sleep–wake habits that lead to poor sleep quality. Disrupted sleep–wake cycle and poor sleep quality can lead to alteration in glucose metabolism and metabolic syndrome[10-12] But most of the previous studies were done on the adult and middle-aged population. Hence, the aim of the study is to see the consequences of circadian disruption and sleep quality on the health of adolescent population so that early measures can be adopted to prevent the development of metabolic syndrome in future life.

## Materials and Methods

In this cross-sectional study, a total of 203 subjects were enrolled on the basis of inclusion and exclusion criteria. All study subjects were divided into three groups: group 1 (definite evening chronotype), group 2 (intermediate chronotype), and group 3 (definite morning chronotype) on the basis of morningness–eveningness score.[13] Subjects with any known sleep problem, oronasal disease, and head injury were excluded from the study. Subjects with known case of any chronic illness (such as diabetes, hypertension, and chronic respiratory disease) were also excluded from the study. Informed written consent was taken from all subjects after ethical clearance by institutional ethical committee. Anthropometric measurements such as height, weight, body mass index (BMI), and blood pressure were taken by trained nursing staff. Sleep quality and sleep duration were measured by Pittsburgh Sleep Quality Index.[14] Daytime sleepiness and chronotype were measured by Epworth Sleepiness Score[15] and Morningness-Eveningness Questionnaire Self-Assessment version,[13] respectively. Two-hour postprandial glucose was measured after oral glucose tolerance test (OGTT) with 75 g oral glucose. OGTT was performed after overnight fasting.[16] Fasting blood glucose and 2 h postprandial blood glucose were measured by glucose oxidase and peroxidase method based on commercially available kit with semi-autoanalyzer, and fasting insulin was by commercially available kit by enzyme-linked immunosorbent assay method. Homeostasis model of assessment for insulin resistance (HOMA-IR) was calculated (HOMA-IR = fasting insulin × fasting glucose/22.4).[17] The Statistical Package for Social Sciences (SPSS) (IBM SPSS Statistics, Armonk, NY, USA), version 21 was used for data analysis. Data were summarized as mean ± standard deviation, and the crude odds ratio (OR) and Karl Pearson's correlation coefficient of metabolic parameters with poor sleep quality were calculated for all the three groups.

## Results

On comparison of the three groups according to circadian typology, we found that statistically significant difference was found in the mean value of BMI, poor sleep quality, short sleep duration, fasting blood glucose level, 2 h postprandial blood glucose level, insulin resistance, and daytime sleepiness among subjects of groups 1, 2, and 3. We found that group 1 subjects had higher mean value of BMI, fasting blood glucose level, 2 h postprandial blood glucose level, insulin resistance, and daytime sleepiness compared with subjects of groups 2 and 3. Similarly, we also found that group 2 subjects had higher mean value of the above parameters compared with subjects of group 3. We also observed that group 1 and 2 subjects exhibited poor sleep quality and short sleep duration compared with group 3 subjects. There were more number of subjects in group 1 (90.4%) who exhibited poor sleep quality compared with subjects of group 2 (76.16%) and group 3 (39.34%) [Table 1].

Crude OR of fasting blood glucose, 2 h postprandial blood glucose level, and HOMA-IR for poor sleep quality are shown in Table 2. Subjects who had high fasting blood glucose level showed significant association for poor sleep quality with an OR of 0.033 (0.01–0.11). Similarly, we found that subjects with high HOMA-IR values had significant association for poor sleep quality.

On comparison of the three groups according to circadian typology, we found that the subjects of group 1 had more significant positive correlation of BMI, 2 h postprandial blood glucose level, fasting glucose level, fasting insulin level, and

**Table 1: Comparison of mean value of demographic factors, sleep quality, 2 h postprandial blood glucose level, insulin resistance, and daytime sleepiness of study subjects**

| | Group 1 (*n*=73) | Group 2 (*n*=87) | Group 3 (*n*=43) | *P* |
|---|---|---|---|---|
| Age (years) | 18.21±0.67 | 18.90±0.68 | 18.05±0.65 | 0.395 |
| Sex | | | | |
| Male | 47 (64.38%) | 57 (65.52%) | 27 (62.79%) | 0.9538 |
| Female | 26 (35.62%) | 30 (34.48%) | 16 (37.21%) | |
| Weight (kg) | 64.49±8.53 | 63.62±8.35 | 61.95±8.30 | 0.293 |
| Height (cm) | 167.27±8.17 | 168.02±8.17 | 168.21±8.57 | 0.793 |
| BMI | 23.06±2.45 | 22.50±2.15 | 21.89±2.27 | 0.029* |
| Neck circumference (cm) | 37.41±2.40 | 37.47±2.36 | 37.30±2.58 | 0.933 |
| Sleep quality | | | | |
| Good | 7 (9.6%) | 19 (21.84%) | 26 (60.46%) | <0.001** |
| Poor | 66 (90.4%) | 68 (78.16%) | 17 (39.54%) | |
| Sleep duration (h) | | | | |
| ≥7 | 8 (10.99%) | 10 (11.5%) | 10 (23.25%) | <0.001** |
| 6-7 | 15 (20.55%) | 16 (18.4%) | 25 (58.14%) | |
| <6 | 50 (68.5%) | 61 (70.1%) | 8 (18.6%) | |
| OGTT | | | | |
| 2 h blood glucose (mg/dL) | 131.84±8.24 | 124.61±9.23 | 126.62±8.23 | <0.001** |
| HOMA | | | | |
| Fasting glucose (mmol/L) | 5.63±0.48 | 5.40±0.55 | 5.21±0.58 | <0.001** |
| Fasting insulin (μIU/L) | 11.50±5.42 | 11.04±6.29 | 9.29±5.09 | 0.126 |
| HOMA-IR | 2.97±1.51 | 2.76±1.75 | 2.19±1.28 | 0.038* |
| ESS | 8.84±4.31 | 7.13±3.76 | 5.05±1.50 | <0.001** |

Data are represented as mean±SD, *n* (%) and ratio. BMI=body mass index; OGTT=oral glucose tolerance test; HOMA-IR=homeostasis model of assessment for insulin resistance; ESS=Epworth Sleepiness Score; SD=standard deviation. **$P$<0.001; *$P$<0.05

HOMA-IR value with poor sleep quality when compared with subjects of groups 2 and 3. Similarly, we also observed that group 2 subjects had significant positive correlation of BMI, 2 h postprandial blood glucose level, fasting insulin level, and HOMA-IR value with poor sleep quality compared with subjects of group 3. However, group 3 subjects showed significant correlation with BMI only [Table 3].

## Discussion

On comparison of the three groups according to circadian typology, we found that evening chronotype exhibited poor sleep quality and short sleep duration compared with morning chronotype individuals. These findings are corroborated by previous studies.[2,18] Poor sleep quality in the evening chronotype may be due to substance abuse like alcohol[19] and incongruity between intrinsic sleep–wake cycle and actual bedtime, because of social factors.[20,21] Consistent with earlier findings, we found that evening chronotype was associated with a higher BMI, fasting blood glucose level, 2 h postprandial blood glucose level, and insulin resistance compared with intermediate and morning chronotype subjects, and the difference in the mean value of the above parameters was statistically significant among subjects of three groups.[22,23] Few community-based,[10] clinic-based studies,[11,12] and epidemiological studies[24-26] also confirmed our findings that the subjects with evening chronotype have more significant positive correlation of BMI, 2 h postprandial blood glucose level (OGTT), fasting glucose level, fasting insulin level, and HOMA-IR value with poor sleep quality when compared with subjects of intermediate and morning chronotypes. Mechanisms that impair insulin sensitivity and glucose tolerance due to sleep curtailment include increase in the level of circulating cortisol,[27,28] enhanced sympathetic activation,[28] and decreased leptin and increased ghrelin levels which affect appetite and food intake.[29,30] Altered ratio of leptin and ghrelin leads to a change in BMI and insulin resistance.

The present research highlighted that evening chronotype adolescents have unhealthy sleep habits and are at higher risk of development of insulin resistance in future. Our findings have public health importance for the subjects who are sleep-deprived. So, history regarding sleep habits should be asked in outpatient department (OPD) from the adolescents who are coming to the OPD for other than sleep disorders to decrease the chances of development of insulin resistance in high-risk adolescents. Sleep habits can be monitored in OPD by maintaining sleep diaries and by asking few questionnaires. It is also very necessary to promote awareness in the medical field, as well as in the society, regarding importance of circadian typology, sleep hygiene, and the negative cost of challenging our internal clock.

## Conclusion

Study subjects have significant association of BMI with poor sleep quality. Although HOMA-IR is significantly associated with poor sleep quality among subjects of evening chronotype compared with subjects of intermediate and morning chronotypes. So it can be concluded that subjects with evening chronotype are more prone for development of metabolic syndrome compared with subjects of intermediate and morning chronotypes if the management of poor sleep quality is not there.

**Table 2: Crude OR of fasting blood glucose, 2 h postprandial blood glucose level, and HOMA-IR for poor sleep quality**

| | Poor sleep quality Frequency *n* (%) | OR (CI) | *P* |
|---|---|---|---|
| Blood glucose (fasting), mg/dL | | | |
| ≤100 | 24 (22.64%) | 1 | - |
| >100 | 93 (95.88%) | 0.033 (0.01-0.11) | <0.001** |
| Blood glucose (2 h postprandial), mg/dL | | | |
| ≤140 | 105 (55.56%) | 1 | - |
| >140 | 12 (85.71%) | 1.601 (0.17-15.57) | 0.0658 |
| HOMA-IR | | | |
| ≤2.5 | 21 (22.11%) | 1 | - |
| >2.5 | 96 (88.89%) | 0.159 (0.06-0.42) | <0.001** |

OR=odds ratios; HOMA-IR=homeostasis model of assessment for insulin resistance; CI=confidence interval. **$P$<0.001

**Table 3: Correlation of body mass index and metabolic parameters with poor sleep quality in subjects of groups 1, 2, and 3**

| | Group 1 (Karl Pearson's correlation coefficient) | Group 2 (Karl Pearson's correlation coefficient) | Group 3 (Karl Pearson's correlation coefficient) |
|---|---|---|---|
| BMI | 0.479** | 0.552** | 0.638** |
| OGTT | | | |
| Blood glucose (2 h) | 0.280* | 0.226* | 0.130 |
| HOMA | | | |
| Fasting glucose (mmol/L) | 0.423** | 0.222 | 0.214 |
| Fasting Insulin (μIU/L) | 0.518** | 0.279* | 0.205 |
| HOMA-IR | 0.514** | 0.301* | 0.222 |

BMI=body mass index; OGTT=oral glucose tolerance test; HOMA-IR=homeostasis model of assessment for insulin resistance. **Correlation is significant at the 0.01 level (two-tailed); *correlation is significant at the 0.05 level (two-tailed)

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## Conflicts of interest

There are no conflicts of interest.

## Presentation at a meeting

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