Association of sleep duration and sleep quality with body mass index among young adults

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Abstract

Background: It is evident from the research in recent years that short sleep has been found as a risk factor for obesity. However, we still need enough evidence in this field. Therefore, we explored the directionality of the association between sleep duration and sleep quality with body mass index (BMI). Aims: The aim of this study is to evaluate the association of sleep duration and sleep quality with BMI among young adults. Objectives: (a) To assess the association of sleep duration with BMI. (b) To assess the quality of sleep with BMI. Methods: In this cross-sectional study, 88 individuals selected from King George’s Medical University were taken as participants. Majority of patients were males (67%). There were 29 (33.0%) females. Sex ratio of study was 2.03, and we used Pittsburgh sleep quality index (PSQI) questionnaire to assess time spent in bed and sleep quality. BMI was divided into 3 categories. Underweight (BMI <18.5 kg/m²), normal weight (18.5–22.9 kg/m²), overweight (23–24.9 kg/m²), obese grade I (25–34.9 kg/m²), obese grade II (25–34.9 kg/m²), and above. Results: We observed that short sleep duration ± SD (h) <6 h/day f = 9.04; P < 0.001 is associated with greater chances of being overweight and obese and mean sleep quality (mean PSQI ± SD) f = 12.24; P < 0.001 was poor in obese grade I and II. Mean neck and waist circumference also showed a significant increasing trend with increasing BMI category (P < 0.001). Conclusion: This study concludes that short sleep duration and poor sleep quality were associated with overweight obesity among young adults.

Keywords: BMI, circumference, neck circumference, PSQI, sleep duration, sleep quality, waist

Introduction

Importance of sleep, both in terms of adequacy as well as quality, has been emphasized upon for the maintenance of physical as well as psychological well-being of all the living beings in general and human beings in particular. Sleep helps to update the brain as well as other bodily mechanisms such as metabolism, appetite regulation, immune system, hormonal, and cardiovascular system. The importance of sleep in maintenance of good health, particularly that of adolescents and young adults is widely being recognized in recent years in view of changing lifestyle, growing emphasis on night-life, television, media, and internet use. Sleep is now being considered a critical component of healthy development and well-being.

A healthy sleep is characterized by adequacy of sleep duration, good quality, appropriate timing, and freedom from sleep disorders. A healthy human adult requires an average of 7 to 9 h of sleep per day. Adults sleeping for shorter duration show higher body mass index (BMI), increased weight, and neck circumference compared with those who sleep 8 h/day emphasizing the association between short sleep duration, BMI, and central adiposity. BMI is considered as an indicator of...
general health. Moreover, it is also considered to be an indicator of lifestyle. While most of the times the association between BMI and sleep are studied at a stage when they take form of a disorder or in an altered state of health, there are limited studies to assess the sleep pattern in context with BMI in otherwise healthy adults. There is an extreme risk to the population of young adults as their lifestyle and academic demands can lead to insufficient sleep duration as well as sleep quality. An understanding of this relationship will be helpful for the primary healthcare providers to link the physical and psychological health related problems in young adults with a possible poor quality of life and to suggest specific lifestyle changes commensurate with their BMI.

### Materials and Methods

This study was carried out at Department of Physiology, King George’s Medical University, Lucknow. Study design was cross-sectional study.

A total of 88 cases were included in the study. The study was carried out as per the guidelines of good medical research as ensued by Helsinki Declaration. Participation in study was entirely voluntary and the participants were included in the study after obtaining informed consent following detailed description about the study procedure and possible benefits and risks involved. The project was approved by the Institutional Ethics Committee too before the enrolment of participants began, No. 853/Ethics/19, Dated: 14/06/19. Apparently, healthy adults were taken with age group as 20 to 40 years, without diabetes, hypertension, renal disease, psychiatric problems, those who were not taking medication of any sort, and any other chronic illness.

### Methodology

Participants were selected from amongst the apparently healthy individuals visiting the facility, medical students. After explaining the purpose of study and sleep assessment procedure, a total of 88 willing volunteers were invited for the sleep assessment. The sample size was calculated using the following formula (Daniel, 1999)\(^5\):

Weight and height of the volunteers were measured, and neck circumference and waist circumference were also measured. BMI was calculated using the formula:

\[
\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height (m)}^2}
\]

On the basis of BMI, the volunteers were categorized as follows using the definitions of obesity proposed for Asian Indians\(^6\)\(^,\)\(^7\): “Underweight (BMI <18.5 kg/m\(^2\)), Normal weight (BMI 18.5–22.9 kg/m\(^2\)), Overweight (BMI 23.0–24.9 kg/m\(^2\)), Obese Grade I (BMI 25.0–34.9 kg/m\(^2\)), and Obese Grade II (BMI >35.0 kg/m\(^2\)).” The sleep assessment was done using Pittsburgh Sleep Quality Index (PSQI) [Table 1].

#### Sleep quality

“The screening of sleep quality was done using PSQI. PSQI is a 19-item inventory with each item having a score ranging from 0 to 3 with higher score indicating more severe sleep problem. The 19 items are grouped into 7 components. The sleep component scores are summed to yield a total score ranging from 0 to 21 with the higher total score (referred to as global score) indicating worse sleep quality. In distinguishing good and poor sleepers, a global PSQI score >5 was considered to be indicator of sleep disturbances.\(^8\) The grading of quality of sleep

### Table 1: Comparison of demographic profile and anthropometric parameters of patients in different BMI categories

| Characteristic                  | Normal weight (n=19) | Overweight (n=14) | Obese Grade I (n=39) | Obese Grade II (n=16) | Statistical significance |
|--------------------------------|---------------------|-------------------|----------------------|-----------------------|--------------------------|
| Mean age±SD (years)            | 30.00±6.09          | 31.64±7.30        | 33.51±5.97           | 34.00±6.52            | F=1.711; P=0.171         |
| Gender                         |                     |                   |                      |                       |                          |
| Male                           | 12 (63.2%)          | 9 (64.3%)         | 31 (79.5%)           | 7 (43.8%)             | χ\(^2\)=6.84; P=0.077    |
| Female                         | 7 (36.8%)           | 5 (35.7%)         | 8 (20.5%)            | 9 (56.3%)             |                          |
| Mean neck circumference±SD (cm)| 34.11±2.89          | 35.57±2.56        | 40.36±2.89           | 42.00±3.88            | F=29.42; P<0.001         |
| Mean waist circumference±SD (cm)| 76.53±4.60         | 87.64±8.10        | 103.03±11.87         | 122.38±12.56          | F=64.86; P<0.001         |

### Table 2: Association of BMI with sleep duration and quality

| Parameter                  | Under-weight/Normal weight (n=18) | Overweight (n=6) | Obese Grade I (n=47) | Obese Grade II (n=17) | Statistical significance |
|----------------------------|-----------------------------------|-----------------|----------------------|-----------------------|--------------------------|
| Mean Sleep duration±SD (hr)| 8.00±0.59                         | 7.08±0.74       | 6.85±0.95            | 6.62±0.99             | F=9.04; P<0.001          |
| <6 h                       | 0                                 | 0               | 4 (8.5%)             | 4 (23.5%)             | χ\(^2\)=19.66; P=0.003   |
| 6-7 h                      | 0                                 | 2 (33.3%)       | 19 (40.4%)           | 6 (35.3%)             |                          |
| 7-9 h                      | 18 (100%)                         | 4 (66.7%)       | 24 (51.1%)           | 7 (41.2%)             |                          |
| Sleep Quality (PSQI scores)|                                   |                 |                      |                       |                          |
| <5                         | 12 (63.2%)                        | 5 (35.7%)       | 2 (5.1%)             | 1 (6.3%)              | χ\(^2\)=34.07; P<0.001   |
| 5-10                       | 7 (36.8%)                         | 8 (57.1%)       | 22 (56.1%)           | 8 (50.0%)             |                          |
| >10                        | 0                                 | 1 (7.1%)        | 15 (38.5%)           | 7 (43.8%)             |                          |
| Mean PSQI±SD               | 4.53±1.50                        | 6.07±2.46       | 8.82±2.70            | 9.50±3.14             | F=16.84; P<0.001         |

Mean sleep duration was significantly associated with increasing BMI being lesser in obese grade II.
Table 3: Correlation of Total sleep duration, PSQI with BMI and other anthropometric measures

|         | BMI | Neck circumference | Waist circumference |
|---------|-----|--------------------|---------------------|
| Total sleep duration | $-0.399$ | $-0.285$ | $0.007$ | $-0.419$ | $<0.001$ |
| PSQI    | $0.484$ | $0.234$ | $0.028$ | $0.490$ | $<0.001$ |

BMI and waist circumference showed significance correlation with total sleep duration and sleep quality. Neck circumference showed a significant correlation with total sleep duration, PSQI, BMI, and waist circumference.

using PSQI was done as follows: Score <5: No sleep problem, Score 5–10: Mild disturbances, Score >10: Moderate-to-severe disturbances, respectively”.

Sleep Duration: “The duration of sleep was taken according to PSQI questionnaire. Self-reported and time spent in bed was calculated ‘GO TO BED TIME’ being subtracted from ‘GET UP TIME’. Numerical value of sleep duration calculated by subtracting time spent in bed with sleep latency. Subjective sleep duration has been calculated by asking PSQI questionnaire, the value being subtracted from time spent in bed calculated total sleep duration numerical value was divided into categories 1.<6 h, 2.6–7 h, 3.7–9 h. We took 7 to 9 h as referent value a <7 h and ≥9 h in young adults have negative consequences to health such as metabolic, cardiovascular, and musculoskeletal disorders.”

Neck circumference: “Neck circumference is described as a valid marker for identifying obese individuals, and is known to correlate well with other anthropometric measurements. This circumference is measured at mid-neck, between the midcervical spine and the mid anterior neck, on subjects standing upright and facing forwards, and with shoulders relaxed. Neck circumference is said to be very convenient and valid alternative measure of BMI.”

Waist circumference “is considered a good estimate of body fat, especially internal fat deposits, and chances of developing weight-related diseases.”

Data Analysis: “Data analysis was done using SPSS (Statistical package for Social Sciences) Version 21.0 statistical analysis software. Chi-square test, ANOVA, and Pearson correlation-coefficient were used to analyze the data. A ‘$r$’ value less than 0.05 was considered as significant. Strength of bivariate correlation using Pearson correlation coefficient was considered as weak at an ‘$r$’ value <0.3, mild at ‘$r$’ value 0.3–0.5, moderate at ‘$r$’ value 0.5–0.7, and strong at ‘$r$’ value >0.7. The ‘+’ or ‘-’ sign before ‘$r$’ value denoted positive/direct or negative/inverse correlations.”

Discussion

Sleep is an active state of unconsciousness produced by the body where the brain is in a relative state of rest and is reactive primarily to internal stimulus. Importance of sleep, both in terms of adequacy as well as quality has been emphasized upon for the maintenance of physical as well as psychological well-being of all the living beings in general and human beings in particular. Sleep helps to update the brain as well as other bodily mechanisms such as metabolism, appetite regulation, immune system, hormonal, and cardiovascular system.[14][15] The duration and quality of sleep of an individual is affected by a number of factors including genetic, environmental, occupational, lifestyle, and health status. BMI is considered as an indicator of general health.[16][17] Both underweight and overweight/obese conditions have been shown to be associated with vitiated health and lifestyle. While most of the times the association between BMI and sleep are studied at a stage when they take the form of a disorder or in an altered state of health. There are limited studies to assess the sleep pattern in context with BMI in otherwise healthy individuals.

Hence, the present study was carried out with an aim to find out association between sleep duration and sleep quality with BMI. The association of sleep quality with body mass has been assessed in a varied population profile in different studies conducted in recent years. Most of these studies have been performed in young adults aged 20 to 30 years and mean age below 30 years, as they have mainly been conducted in college going or medical students. In this study, we went beyond this age profile and studied it in a rather diversified adult population that not only included student volunteers but other volunteers too. The purpose was not to restrict the study in a set of student population of young adults but to include young adults in general. Moreover, it was also assumed that including an all-student young adult population gives a biased view of picture as young adults, particularly medical students, owing to their study compulsions have altered sleep behaviors which cannot be generalized as a representative of adults but is specifically related with that particular group of population only.

With respect to the use of tools to study the sleep pattern, in this study we used both screening tool (PSQI). It is one of the popular tools for screening purposes and has been used extensively in different studies to study the sleep pattern in young adults.[18][21] PSQI covers 7-different domains to calculate a comprehensive sleep pattern. In this study, we found that proportion of those with PSQI score >5 was 63.8%, 64.3%, 94.9%, and 93.7%, respectively, in normal weight, overweight, obese grade I, and obese grade II subjects, respectively. Mean PSQI of normal weight, overweight, obese grade I, and obese grade II subjects were 4.53 ± 1.50, 6.07 ± 2.46, 8.82 ± 2.70, and 9.50 ± 3.14, respectively; thus showing a significant incremental trend with increasing BMI.

Results

Total of 88 subjects falling in sampling frame were enrolled in the study and were divided according to their BMI status. The demographic profile, anthropometric and sleep characteristics of study population Age of participants ranged from 20 to 40 years. Mean age of participants was 32.55±6.40 years. Majority
of patients were males (67%). There were 29 (33.0%) females. Sex ratio of study was 2.03. Body mass index of study population ranged from 18.02 to 48.77 kg/m². According to BMI criteria used, 2 (2.3%) were underweight, 17 (19.3%) were in normal weight, 14 (15.9%) were in overweight, 39 (44.3%) were in obese grade I and 16 (18.2%) were in obese grade II category. Mean BMI of study population was 28.52 ± 6.36 kg/m². Neck circumference of participants ranged from 28 to 48 cm. Mean neck circumference was 38.55 ± 4.28 cm. Waist circumference of participants ranged from 69 to 140 cm with a mean of 98.38 ± 18.48 cm [Table 1].

Mean neck and waist circumference also showed a significant increasing trend with increasing BMI category (p<0.001). BMI showed a significant correlation with all the parameters. Waist circumference showed significant correlation with all the parameters. Neck circumference showed a significant correlation with total sleep duration and PSQI. As there were only 2 cases in underweight category, having BMI 18.02 and 18.37 kg/m², hence they were clubbed with normal weight category for the purpose of subsequent analysis.

As a measure of sleep duration
Mean sleep duration was demographically associated. [Table 1], in [Table 2] also mean sleep duration was significantly associated with increasing BMI being lesser in obese grade II. Statistical significance of total sleep duration with BMI is shown in [Table 3], also correlations with neck and waist circumference are shown (p<0.001).

As a measure of sleep quality
PSQI scores ranged from 3 to 13 with a mean of 7.58 ± 3.17. A total of 20 (22.7%) had PSQI <5 while remaining 68 (77.3%) had PSQI ≥5 [Table 2].

Majority of patients in normal weight category had PSQI score <5 (63.2%) as compared to 35.7% overweight, 5.1% obese grade I and 6.3% obese grade II patients. On the other hand, proportion of those with PSQI >10 was 0%, 7.1%, 38.5% and 43.8% respectively in normal weight, overweight, obese grade I and obese grade II categories. Statistically, with increasing BMI category, the proportion of those with PSQI >5 showed a significant increase (p<0.001). Mean PSQI scores of normal weight, overweight, obese grade I and obese grade II subjects were 4.53 ± 1.50, 6.07 ± 2.46, 8.82 ± 2.70 and 9.50 ± 3.14 respectively, thus showing a significant incremental trend with increasing BMI (p<0.001) [Table 3].

Mild to moderate significant correlation of BMI was observed with PSQI. Findings similar to this study have been shown in other studies too. Kumar and Nagar (2017) in their study found that majority of overweight and obese students had PSQI ≥7, whereas majority of underweight and normal weight students had PSQI <7. A significant incremental trend of higher PSQI with increasing BMI was also seen by Israel et al. in their study. Young et al. in their study among 463 young adult women aged 23 years also found PSQI >5 to be associated with higher mean BMI.

BMI of study population in our study ranged from 18.02 to 48.77 kg/m². According to BMI criteria used, 2 (2.3%) were underweight, 17 (19.3%) were in normal weight, 14 (15.9%) were in overweight, 39 (44.3%) were in obese grade I, and 16 (18.2%) were in obese grade II category. Mean BMI of study population was 28.52 ± 6.36 kg/m². Thus, this study was marked by a high prevalence of overweight and obese participants. One of the reasons for this high prevalence of overweight and obese participants could be the utilization of BMI criteria proposed for Asian Indians, which tends to classify obesity at a BMI of 25.0 kg/m² itself. Compared to this study that had 69/88 (78.4%) overweight and obese participants, Vargas et al. too had only 33.3% overweight and obese participants. Israel et al. too had only 24% participants in obese category using BMI >30 kg/m² as the criteria for such differentiation. However, Khullar et al. who used a criteria similar to ours reported the proportion of overweight and obese in their study as 49.3%, still in their study as many as 17.2% underweight participants were enrolled.

In this study, no significant difference among different BMI categories was observed for age and sex, thus indicating that the confounding effect of these factors, if any, was even in all the BMI categories.

Other anthropometric parameters such as neck circumference and mean waist circumference also showed an incremental trend with increasing BMI categories, thus implying that progression of obesity proposed by BMI was in consonance with other anthropometric measures too. Sleep disturbance, which negatively impacts chronobiology of hormonal rhythms and metabolism, is also associated with obesity, insulin insensitivity, diabetes, hormonal imbalance, and appetite dysregulation. Circadian disruption, typically induced by shift work and sleep disturbance, may also have a negative effect on health due to impaired glucose and lipid homeostasis, reversed melatonin and cortisol rhythms, and loss of clock gene rhythmicity.

Thus, impact of lifestyle as well as occupational commitments on sleep pattern as well as on BMI could not be ignored. All these relationships are complex and need a larger sample size with inclusion of more variables to study this relationship further. Hence, we recommend further studies on a larger sample size, preferably with a longitudinal design to evaluate these relationships further.

Limitations of study
1. A larger sample size is needed for the study for sleep quality.
2. An objective assessment is more appropriate to assess sleep duration by knowing the sleep latency.
3. One of the reasons for absence of a strong positive correlation between PSQI and BMI in our study may be the fact that we had relatively fewer cases in lower BMI category.
4. In underweight category, we had only 2 (2.3%) cases which probably were too few to have an independent existence.

Conclusion

This study was carried out to assess the association between sleep duration, quality, and BMI. For this purpose, a total of 88 subjects (20–40 years; mean age 32.55 ± 6.40 years; 67% males) were enrolled in the study and were divided according to their BMI status and their sleep pattern was studied using PSQI. Following were the key findings of the study:

1. BMI of the study population ranged from 18.02 to 48.77 kg/m². According to BMI criteria used, 2 (2.3%) were underweight, 17 (19.3%) were normal weight, 14 (15.9%) were overweight, 39 (44.3%) were obese grade I, and 16 (18.2%) were obese grade II category. Mean BMI of study population was 28.52 ± 6.36 kg/m².

2. No significant difference in mean age and gender profile of subjects in different BMI categories was observed.

3. Mean neck and waist circumference showed a significant increasing trend with increasing BMI.

4. Proportion of those with PSQI score >5 was 63.8%, 64.3%, 94.9%, and 93.7%, respectively, in normal weight, overweight, obese grade I, and obese grade II subjects. Mean PSQI of normal weight, overweight, obese grade I, and obese grade II subjects were 4.53 ± 1.50, 6.07 ± 2.46, 8.82 ± 2.70, and 9.50 ± 3.14, respectively; thus showing a significant incremental trend with increasing BMI.

5. There was a mild significance between total sleep duration and BMI. Persons sleeping <6 h tend to have higher BMI than those sleeping for 7 to 9 h.

The findings of the study showed that higher BMI is associated with a poor quality of sleep in young adults. These findings indicate the need of a healthy lifestyle, dietary, and physical activity intervention among young adults with higher BMI to prevent them from sleep disorders.

Mean neck and waist circumference also showed a significant increasing trend with increasing BMI category ($P < 0.001$). Majority of participants in all the BMI categories except for Obese Grade II were males. In Obese Grade II BMI category, majority of participants were females (56.3%). However, on evaluating the data statistically, the difference was not found to be significant ($P = 0.077$).

Statistically, with increasing BMI category, the proportion of those with PSQI >5 showed a significant increase ($P < 0.001$). Mean PSQI scores of normal weight, overweight, obese grade I, and obese grade II subjects were 4.53 ± 1.50, 6.07 ± 2.46, 8.82 ± 2.70, and 9.50 ± 3.14, respectively; thus showing a significant incremental trend with increasing BMI ($P < 0.001$).

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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