Indian J Physiol Pharmacol 2019; 63(1) : 8–15

Original Article

Study of Association between Body Mass Index and Sleep Quality Among Indian College Students

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Abstract

The prevalence of overweight, indicated by Body Mass Index (BMI: 23-24.9 kg/m^2), pre-obese (25-29.9 kg/m^2) and obesity (>30 kg/m^2) has increased in recent years. There has been a change in sleeping patterns (reduction in number of hours of sleep, quality of sleep, delay in onset of nighttime sleep) with the increase in BMI in Asian population, but studies are limited.

Study included 230 college students from 18 to 24 years of which 171 were males. They were screened for major diseases and psychological problems. Subjects having sleep disorders who are under medication were excluded. Sleep patterns, latency, duration, habitual sleep efficiency, sleep disturbances and daytime dysfunction were assessed using Pittsburgh Sleep Quality Index (PSQI).

Association between PSQI components and BMI as per Asian criteria was assessed using Likelihood Ratio. Among all the studied 7 individual components, association of BMI code as per Asian criteria with sleep latency and sleep disturbance component were significant ($p<0.05$). The awareness about sleep habits is needed for good sleep quality.

Introduction

It is well established that main responsible factors for obesity are imbalance between calorie intake and physical activity (1-2). Many evidences suggest other factors such as alcohol intake, improper diet which are responsible for obesity, (2-4). Recently emerging knowledge points to sleep as a contributing factor (5-10). With increase in BMI, there is variation in sleep patterns such as reduction in hours of sleep, delay in onset of sleep during nighttime, quality of sleep (2).

In normal sleep, during the first part of the night, glucose production and glucose utilization drop

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(Received on July 1, 2018)

simultaneously and during later, it increases simultaneously (11-12). In one study, it was found that glucose utilization is altered but glucose production was constant throughout night in sleep deprived person. They analyzed plasma glucose level, insulin secretion rate (ISR), plasma growth hormone ,cortisol level in normal subjects receiving constant glucose infusion during nocturnal sleep, nocturnal sleep deprivation and daytime recovery sleep. Major difference in glucose and ISR profile seen in sleep deprivation as glucose and ISR remained stable in first part of night and then decreased significantly (11). Disturbance in normal sleep patterns, leads to obesity, cardiovascular diseases, insulin resistance and diabetes (10, 12). Studies suggest that the association between BMI and sleep might be multilayered due to associated metabolic changes (13-15). In American adolescents, likelihood of obesity increased by 80% for each hour of lost sleep (14). In European adolescents, it was found that short sleep duration was associated with obesity, sedentary behavior and increase food intake also increased but not associated with physical activity (15). There is no association between BMI and sleep duration in certain studies (16-18). BMI cut off values as recommended by World Health Organization (WHO) were widely accepted to determine nutritional status and obesity. However Asian body composition is different from American or European body composition. Therefore WHO criteria must be modified to fit the Asian body composition. Thus the Asian Criteria of nutritional status determination based on BMI was adopted by several Asian countries (19-25). There is some difference between BMI cut off for nutritional status in WHO and Asian criteria. Underweight category BMI cut off (<18.5 kg/m^2) is same for both criteria. However in normal category BMI cut off in Asian criteria (BMI 18.5-22.9 kg/m^2) is decreased as compared to WHO criteria (BMI 18.5-24.9 kg/m^2). In overweight category also BMI cut off in Asian criteria (23-24.9 kg/m^2) is low as compared to WHO criteria (25-29.9 kg/m^2). BMI cut off in pre-obese category is 25-29.9 kg/m^2 in Asian criteria where as there is no pre-obese category in WHO criteria. BMI cut off in obese category is ≥30 kg/m^2 in both criteria. Obese category is again divided in to 3 type in both the criteria. In Obese type 1 BMI cut off is 30-40 kg/m^2, Obese type 2 (morbid obese) is 40. 1-50 kg/m^2, Obese type 3 (super obese) is >50 kg/m^2 in both the criteria. Buysse and colleagues proposed scoring of seven components and cut off score of good and poor quality sleep in Pittsburgh Sleep Quality Index (26-29).

Method

The study included 230 college students from the age groups 18 to 24 years (Mean±SD: 18.86±1.23 years) of which 59 were females and 171 were males. The subjects were screened for major diseases and psychological problems. Subjects having serous disorder were excluded from the study. Informed consent was obtained from participating students. Ethical approval for the study protocol was obtained from participating institution VSS Institute of Medical Sciences and Research. Permission to use PSQI questionnaire was obtained from concern authority (Daniel J Buysse, Professor of Psychiatry and clinical Translational sciences, University of Pittsburgh School of Medicine). Obesity was determined by calculating the BMI (weight in kg divided by height in meter squared). Weight was measured in light clothing and recorded to the nearest kg. Height was measured to the nearest centimeter without shoes. Obesity was graded as per Asian criteria (19).

Sleeping patterns along with, latency, duration, habitual sleep efficiency, sleep disturbances and daytime dysfunction was determined and assessed by using a standardized and validated questionnaire: Pittsburgh Sleep Quality Index (26-29).

PSQI is quantitative measure of sleep quality with high levels of consistency, reliability and validity. In this 19 self reported questions and 5 questions rated by the bed partner are filled up by subjects and from this 7 component scores and global score were calculated. The seven components were scored following the algorithm proposed by Buysse (26). According to which each component score is weighted equally on 0-3 scale higher score indicates that severe problem and lower score indicates that no problem as follows: 1. subjective sleep quality (very good to very bad), 2. sleep latency (≤ 15 minutes to > 60 minutes), 3. sleep duration (≥ 7 hours to < 5 hours), 4. sleep efficiency (≥ 85% to < 65% hours sleep/hours in bed), 5. sleep disturbances (not during the past month to ≥ 3 times per week), 6. use of sleeping medications (none to ≥ 3 times a week), and 7. daytime dysfunction (not a problem to a very big problem). Bussye and colleagues proposed a cut off score for clinical use ≤ 5 to indicate good quality sleep and > 5 to indicate poor sleep quality, extremely poor sleep quality (≥ 8). Sleep duration >7 hours- score 0,6-7 hours-score 1,5-6 hours-score 2, < 5 hours-score 3. Habitual sleep efficiency % score as follows >85%-score 0,75-84%-score 1,65-74%-score 2, <65%-score 3 (26). All the 7 component are scored on 0-3 scale are compared with BMI coded as follows <18.5 kg/m^2 coded as 1 which comes as underweight category in both WHO as well as Asian criteria, 18.5-22.9 kg/m^2 coded as 2 which is normal category according to Asian criteria, 23-24.9 kg/m^2 coded as 3 which is overweight category according to Asian criteria, 25-29.9 kg/m^2 coded as 4 which is pre-obese according to Asian criteria, ≥ 30 kg/m^2 coded as 5 which is obese category according to both Asian and WHO criteria (19-25).

The data was analyzed using SPSS (Statistical Package for the Social Sciences) version 20. The relation between BMI code and various parameters was studied using Likelihood Ratio. The likelihood ratio was used in place of chi-square test as the minimum expected count in any of the cell of the contingency table was less than 5, which violates the assumption required for chi-square test (30, 31). The correlation between BMI and selected variables was determined using Spearman & Pearson correlation. Statistical significance was chosen at p-value (2-tailed) ≤0.05.

Results

Among 230 participants 103 (44.8%) had a BMI ≥ 23 kg/m^2. Among these participants 41(17.8%) were classified as overweight (23-24.9 kg/m^2) and 48 (20.9%) were pre-obese (25-29.9 kg/m^2), whereas only 14 (6.1%) participants were obese (≥ 30 kg/m^2) based on Asian criteria. Most of the participants 110 (47.8%) were in normal category (18.5-22.9 kg/m^2) where as 17 participants (7.4%) were underweight (<18.5 kg/m^2) based on Asian criteria.

PSQI results are presented in Table I. Among all the 230 participants, 74(32.2%) participants experienced poor sleep quality (>5PSQI<8), and only 15 (6.5%)

TABLE I: Relation between BMI Code and PSQI Code among the studied subjects.

BMI Code	*Parameters*	*PSQI Code*			*Total*	*P-value*
		≤ 5	*> 5 to < 8*	*≥ 8*		
<18.5 kg/m2	Count	7	9	1	17	
	% within row	41.2%	52.9%	5.9%	100.0%	
	% within column	5.0%	12.2%	6.7%	7.4%	
18.5-22.9 kg/m2	Count	76	30	4	110	
	% within row	69.1%	27.3%	3.6%	100.0%	
	% within column	53.9%	40.5%	26.7%	47.8%	
23-24.9 kg/m2	Count	24	13	4	41	
	% within row	58.5%	31.7%	9.8%	100.0%	
	% within column	17.0%	17.6%	26.7%	17.8%	
25-29.9 kg/m2	Count	28	17	3	48	.174
	% within row	58.3%	35.4%	6.2%	100.0%	
	% within column	19.9%	23.0%	20.0%	20.9%	
≥30 kg/m2	Count	6	5	3	14	
	% within row	42.9%	35.7%	21.4%	100.0%	
	% within column	4.3%	6.8%	20.0%	6.1%	
Total	Count	141	74	15	230	
	% within row	61.3%	32.2%	6.5%	100.0%	
	% within column	100.0%	100.0%	100.0%	100.0%	

Likelihood Ratio

participants experienced extremely poor sleep quality (PSQI ≥8). Among 7 components most important components contributing poor sleep quality includes restricted sleep duration, long sleep latency, poor sleep efficiency, daytime dysfunction, sleep disturbances. Table II showed 23.9% of participants reported taking more than 30 minutes to fall asleep after going to bed. Table III showed 92.2% of participants reported with >85% of habitual sleep efficiency (percent of the time asleep after going to bed until get up from asleep) and only around 7.8% reported less than 85% of habitual sleep efficiency. Table IV showed that around 78.7% reported sleep disturbances less than once a week and around

TABLE II: Relation between BMI Code and Sleep Latency Score among the studied subjects.

BMI Code	*Parameters*	*Sleep Latency Score*				*Total*	*p-value*
		0	*1*	*2*	*3*		
<18.5 kg/m^2	Count	4	6	5	2	17	
	% within row	23.5%	35.3%	29.4%	11.8%	100.0%	
	% within column	5.1%	6.2%	11.4%	18.2%	7.4%	
18.5-22.9 kg/m^2	Count	42	47	19	2	110	
	% within row	38.2%	42.7%	17.3%	1.8%	100.0%	
	% within column	53.2%	49.0%	43.2%	18.2%	47.8%	
23-24.9 kg/m^2	Count	14	13	8	6	41	
	% ithin row	34.1%	31.7%	19.5%	14.6%	100.0%	
	% within column	17.7%	13.5%	18.2%	54.5%	17.8%	
25-29.9 kg/m^2	Count	8	20	9	1	48	.038*
	% within row	37.5%	41.7%	18.8%	2.1%	100.0%	
	% within column	22.8%	20.8%	20.5%	9.1%	20.9%	
≥30 kg/m^2	Count	1	10	3	0	14	
	% within row	7.1%	71.4%	21.4%	0.0%	100.0%	
	% within column	1.3%	10.4%	6.8%	0.0%	6.1%	
Total	Count	79	96	44	11	230	
	% within row	34.3%	41.7%	19.1%	4.8%	100.0%	
	% within column	100.0%	100.0%	100.0%	100.0%	100.0%	

*p-value ≤0.05: Significant; Likelihood Ratio.

TABLE III: Relation between BMI Code and Habitual Sleep Efficiency Score among the studied subjects.

BMI Code	*Parameters*	*Habitual Sleep Efficiency Score*				*Total*	*p-value*
		0	*1*	*2*	*3*		
<18.5 kg/m^2	Count	17	0	0	0	17	
	% within row	100.0%	0.0%	0.0%	0.0%	100.0%	
	% within column	8.0%	0.0%	0.0%	0.0%	7.4%	
18.5-22.9 kg/m^2	Count	104	3	2	1	110	
	% within row	94.5%	2.7%	1.8%	0.9%	100.0%	
	% within column	49.1%	42.9%	33.3%	20.0%	47.8%	
23-24.9 kg/m^2	Count	33	2	3	3	41	
	% within row	80.5%	4.9%	7.3%	7.3%	100.0%	
	% within column	15.6%	28.6%	50.0%	60.0%	17.8%	
25-29.9 kg/m^2	Count	47	1	0	0	48	.112
	% within row	97.9%	2.1%	0.0%	0.0%	100.0%	
	% within column	22.2%	14.3%	0.0%	0.0%	20.9%	
≥30 kg/m^2	Count	11	1	1	1	14	
	% within row	78.6%	7.1%	7.1%	7.1%	100.0%	
	% within column	5.2%	14.3%	16.7%	20.0%	6.1%	
Total	Count	212	7	6	5	230	
	% within row	92.2%	3.0%	2.6%	2.2%	100.0%	
	% within column	100.0%	100.0%	100.0%	100.0%	100.0%	

Likelihood Ratio.

11.7% reported sleep disturbances once or twice a week. Table V showed that most of the participants reported day time dysfunction which may be due to poor sleep quality in night. 50% reported daytime dysfunction once in a week. Table VI showed 14.3% participants reported sleep duration of < 5 hours, 35.7% participants reported sleep duration of 5-6 hours, 44.3% participants reported sleep duration of 6-7 hours, however only 5.7% participants reported >7 hours that is the recommended sleep duration for adults. No participants has taken any sleep medication in last 1 month of the study.

TABLE IV : Relation between BMI Code and Sleep Disturbance Score among the studied subjects.

BMI Code	*Parameters*	*Sleep Disturbance Score*			*Total*	*P-value*
		0	1	2		
<18.5 kg/m^2	Count	1	10	6	17	
	% within row	5.9%	58.8%	35.3%	100.0%	
	% within column	4.5%	5.5%	22.2%	7.4%	
18.5-22.9 kg/m^2	Count	13	91	6	110	
	% within row	11.8%	82.7%	5.5%	100.0%	
	% within column	59.1%	50.3%	22.2%	47.8%	
23-24.9 kg/m^2	Count	4	33	4	41	
	% within row	9.8%	80.5%	9.8%	100.0%	
	% within column	18.2%	18.2%	14.8%	17.8%	
25-29.9 kg/m^2	Count	4	33	11	48	.003**
	% within row	8.3%	68.8%	22.9%	100.0%	
	% within column	18.2%	18.2%	40.7%	20.9%	
=, > 30 kg/m^2	Count	0	14	0	14	
	% within row	0.0%	100.0%	0.0%	100.0%	
	% within column	0.0%	7.7%	0.0%	6.1%	
Total	Count	22	181	27	230	
	% within row	9.6%	78.7%	11.7%	100.0%	
	% within column	100.0%	100.0%	100.0%	100.0%	

**p-value ≥0.01: Highly significant; Likelihood Ratio.

TABLE V : Relation between BMI Code and Daytime Dysfunction Score among the studied subjects.

BMI Code	*Parameters*	*Day Time Dysfunction Score*				*Total*	*p-value*
		0	*1*	*2*	*3*		
<18.5 kg/m^2	Count	4	9	4	0	17	
	% within row	23.5%	52.9%	23.5%	0.0%	100.0%	
	% within column	5.3%	7.8%	10.8%	0.0%	7.4%	
18.5-22.9 kg/m^2	Count	41	49	18	2	110	
	% within row	37.3%	44.5%	16.4%	1.8%	100.0%	
	% within column	54.7%	42.6%	48.6%	66.7%	47.8%	
	% of Total	17.8%	21.3%	7.8%	0.9%	47.8%	
23-24.9 kg/m^2	Count	16	19	6	0	41	
	% within row	39.0%	46.3%	14.6%	0.0%	100.0%	
	% within column	21.3%	16.5%	16.2%	0.0%	17.8%	
25-29.9 kg/m^2	Count	10	32	5	1	48	.407
	% within row	20.8%	66.7%	10.4%	2.1%	100.0%	
	% within column	13.3%	27.8%	13.5%	33.3%	20.9%	
≥30 kg/m^2	Count	4	6	4	0	14	
	% within row	28.6%	42.9%	28.6%	0.0%	100.0%	
	% within column	5.3%	5.2%	10.8%	0.0%	6.1%	
Total	Count	75	115	37	3	230	
	% within row	32.6%	50.0%	16.1%	1.3%	100.0%	
	% within column	100.0%	100.0%	100.0%	100.0%	100.0%	

Likelihood Ratio.

TABLE VI : Relation between BMI Code and Sleep Duration Score among the studied subjects.

BMI Code	*Parameters*	*Sleep Duration Score*				*Total*	*p-value*
		0	*1*	*2*	*3*		
<18.5 kg/m2	Count	1	10	5	1	17	
	% within row	5.9%	58.8%	29.4%	5.9%	100.0%	
	% within column	7.7%	9.8%	6.1%	3.0%	7.4%	
18.5-22.9 kg/m2	Count	5	41	48	16	110	
	% within row	4.5%	37.3%	43.6%	14.5%	100.0%	
	% within column	38.5%	40.2%	58.5%	48.5%	47.8%	
23-24.9 kg/m2	Count	1	23	13	4	41	
	% within row	2.4%	56.1%	31.7%	9.8%	100.0%	
	% within column	7.7%	22.5%	15.9%	12.1%	17.8%	
25-29.9 kg/m2	Count	4	19	15	10	48	.120
	% within row	8.3%	39.6%	31.2%	20.8%	100.0%	
	% within column	30.8%	18.6%	18.3%	30.3%	20.9%	
e”30 kg/m2	Count	2	9	1	2	14	
	% within row	14.3%	64.3%	7.1%	14.3%	100.0%	
	% within column	15.4%	8.8%	1.2%	6.1%	6.1%	
Total	Count	13	102	82	33	230	
	% within row	5.7%	44.3%	35.7%	14.3%	100.0%	
	% within column	100.0%	100.0%	100.0%	100.0%	100.0%	

Likelihood Ratio.

Relationship between BMI and Sleep quality

The relation between code (BMI) and various parameters was studied using Likelihood Ratio. Among all the studied 7 individual components, sleep latency and sleep disturbance component were significant ($p<0.05$). According to Asian criteria BMI cut off for overweight 23-24.9 kg/m^2, for pre-obese 25-29.9 kg/m^2, for obese ≥ 30 kg/m^2. Association between BMI code with sleep latency was significant, p=0.038 (Table II). Association between BMI and sleep disturbance was highly significant, p=0.003 (Table IV).

TABLE VII : Correlation between BMI and studied variables among the subjects (n=230).

Variables		*BMI*
PSQI (global score)	Correlation coefficient^	.105
	p-value	.111
Latency Code	Correlation coefficient	.042
	p-value	.523
Efficiency Code	Pearson correlation	.098
	p-value	.138
Disturb Code	Correlation coefficient	.032
	p-value	.631
Day Time Code	Correlation coefficient	.062
	p-value	.353
Sleep Duration Code	Correlation coefficient	–.034
	p-value	.610

Spearman correlation; ^Pearson correlation.

Discussion

This study showed relation between BMI and 7 components of PSQI, from which association between sleep disturbance with BMI and sleep latency with BMI were significant. Pilcher et al discussed that in many other studies, sleep duration and disturbances are combined to study sleep quality, due to which there arises difficulty to evaluate association of each component (32). In this study individual component of PSQI with BMI were shown. Studies showed that poor sleep quality and short sleep duration were associated with increased BMI (6, 7, 14, 15). The present study showed no significant association between sleep duration and BMI. Studies showed sleep disturbances are associated with BMI (2). This study also showed association between BMI and sleep disturbances which was highly significant as in other studies. This study also showed significance association between sleep latency and BMI. This pattern in the study showed that irrespective of sleep duration, sleep disturbance may have significant influence on BMI and weight. Sleep restrictions alter the circulating levels of hormones such as leptin and ghrelin which affects glucose homeostasis and appetite regulation (9, 10, 33, 34). Studies also showed that in insomniacs, sleeping problems start early in life. Poor-quality of sleep is associated with many health problems and it can also lead to obesity which leads to increased risk of diabetes, cardiovascular diseases and some cancer.

Study limitation

Temporal relationship between sleep habits and obesity cannot be established because this was a cross-sectional study, to establish it further longitudinal studies are needed. Since college student are the study participants, the applicability of the present result to general population is limited. All the information in the study except anthropometric measurement was collected based on self reporting through questionnaire so this is another limitation. Further studies can be done by collecting multiple data points prospectively, using objective measurement of sleep and casual mechanism between all the variables can be explored.

Conclusion

This study found highly significant association between sleep disturbances and BMI code irrespective of sleep duration. This study also showed significant association between sleep latency and BMI code as per Asian criteria. Sleep habits awareness is necessary for good quality of sleep.

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