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Research Article

The Relationship Between Sleep Quality, Sleep Duration, Social Jet Lag and Obesity in Adolescents

Yıldız F et al. Sleep and Obesity

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What is already known on this topic?
Previous studies have shown a relationship between obesity and sleep quality and sleep duration, but the issue of social jetlag, which represents shifts in circadian rhythm, and its effects on adolescents are still being investigated.

What this study adds?
This study shows a correlation between social jet lag and body mass index. Sleep history should be a part of the anamnesis in routine outpatient clinic examinations of overweight and obese adolescents to heal and prevent obesity.

Abstract
Objective: The frequency of obesity and poor sleep quality among adolescents is increasing and causes many chronic problems. The objective was to investigate the correlation between body mass index (BMI), sleep quality, sleep duration and social jet lag (SJL) among adolescents.
Methods: This study is cross-sectional. A cohort of 416 adolescents, ranging in age from 12 to 18 participated in the study. Adolescents were divided into three groups according to BMI SDS: adolescents with normal weight, adolescents with overweight and adolescents with obesity. The Pittsburgh Sleep Quality Index (PSQI) questionnaire was used to determine the sleep quality of the adolescents. The calculation of SJL and sleep-corrected social jet lag (SJLsc) was performed.
Results: The mean age of the adolescents was 15.0 ± 2.9 years.There were 222 males (53.4%). SJL and PSQI scores were significantly higher in the adolescents with obesity compared to the adolescents with normal weight and overweight ($p < 0.001$). An analysis of the relationship between the PSQI and BMI SDS revealed a correlation that was statistically significant ($r = 0.667$; $p < 0.001$).
Conclusion: Adolescents with obesity reveal poorer sleep quality and a longer duration of SJL compared to adolescents with normal-weight. Moreover, increased SJL was linked to an increase in BMI. Maintaining good sleep quality and less exposure to SJL may help reduce the risk of obesity.
Keywords: Adolescents, sleep quality, social jet lag, obesity

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Introduction
Sleep disorders are linked to disabilities, dangerous behaviors, depression, morbidity and even mortality. According to the researches, children who sleep less are more prone to become overweight and obesity later in life. Adolescents are at a significant risk of developing sleep disorders, and severe sleep deprivation is related with long-term consequences (1). The relationship between sleep disorders and adolescent obesity is not entirely understood. Trends in sleep problems parallel trends in obesity. Adolescent obesity may result in significant health issues. These conditions may include diabetes, hypertension, cardiovascular disease, respiratory illnesses, and musculoskeletal disorders (2). The intricate nature of the correlation between sleep duration and body weight is due to the fact that both sleep and appetite are regulated by the daily circadian rhythm (3). Biologically, a lack of sleep alters the hormonal processes that control hunger, resulting in decreased levels of leptin and heightened levels of ghrelin. This inevitably leads to an increased consumption of food. Night-eating syndrome may arise due to sleep deprivation (4). During this condition, individuals display a tendency to consume food excessively and without inhibition upon awakening during the night. Overconsumption of calories can heighten the probability of getting obese. Insufficient sleep duration is significantly associated with adverse changes in BMI among infants, children, and adolescents, according to a meta-analysis (5). The quality of sleep is determined by the effectiveness and depth of an individual's sleep during their period of rest. A range of methodologies is employed by researchers in order to assess the quality of sleep. PSQI is a widely acknowledged and scientifically proven method for assessing the quality of sleep (6). Studies have shown a correlation between obesity and the quality of sleep. SJL is defined as the discrepancy between the sleep timing imposed by external/social obligations (i.e. work - school days) and free days. Sleep deprivation occurs by waking up early on weekdays and going to bed late at night, and attempts are made to compensate for this by waking up late and sleeping too much on the weekends. This causes a discrepancy between biological and social circadian rhythms. SJL refers to a persistent and detrimental pattern of sleep disruption and inconsistent sleep. This sleep pattern can result in metabolic, physiological, and psychological complications (7). Recent findings indicate a correlation between social jetlag and obesity, suggesting that children who undergo social jetlag are at a higher risk of developing obesity (8). Nevertheless, the correlation between poor sleeping habits and obesity among adolescents remains poorly comprehended. The aim of this research was to examine the correlation between body mass index, sleep quality, social jet lag status, and sleep duration among adolescents.

Materials and Methods

Study Participants and Procedure

This study is cross-sectional. The study included 416 adolescents between the ages of 12 and 18 who were admitted to a tertiary hospital without any diagnosis of psychiatric disorder, chronic disease or drug use and who agreed to participate in the study. Both written and verbal consent was obtained from the adolescents included in the study and their parents. The adolescents' age, weight, height, and BMI at the time of admission were recorded and they were asked to fill out a PSQI questionnaire, and their sleep-wake times on school days and weekends were noted.

Measures and Sleep Assesment

During the examinations of patients in the outpatient clinic, their height was measured using a Harpenden stadiometer, and their weight was measured using a standard electronic scale (Beurer brand) that can detect changes as little as 100 grams. BMI was calculated as weight (in kg) over the square of height (in meters) and converted to BMI standard deviation score (BMI-SDS) using the national data. Adolescents were divided into three groups according to BMI: adolescents with normal weight, adolescent with overweight and adolescent with obesity. The adolescents with obesity group was defined as BMI ≥95 percentile, the adolescents with overweight group was defined as BMI 94.9-85 percentile, and the adolescents with normal weight group was defined as BMI 5-84.9 percentile (9).

The PSQI questionnaire was used to determine the sleep quality in adolescents. The validity and reliability study for Turkish children was conducted by Agargun et al. (10) PSQI is a 19-question survey with seven components (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleeping pills, daytime dysfunction). If the total PSQI score is five or less, it indicates good sleep quality. If it is more than five, it indicates poor sleep quality. As the score increases, sleep quality worsens. In addition, to determine the average number of hours the adolescent sleeps the participant was asked exactly when he/she sleeps and at what time he/she wakes up in the morning, and then the duration of sleep was calculated. If the adolescent had a nap during the day, this is added. Both school days and free days followed a similar routine. In order to calculate SJL and SJLsc, prior researches were consulted (11,12). SJL is found by the absolute value of the difference between the middle hour of sleep on free days (midsleep on free days-MSF) and the middle hours of sleep on school days (midsleep of school days-MSS). The midpoint of sleep is the time between night sleep start time and morning wake-up time. Half of the weekly mean sleep duration is added to both the sleep start time on free days and the sleep start time on school days, and then the values found are subtracted from each other, and the absolute difference is found and named as SJLsc.

Statistical Analysis

The variables were analyzed utilizing SPSS 25.0 (IBM Corporation, Armonk, New York, United States) and Medcalc 14 (Acacialaan 22, B-8400 Ostend, Belgium) software. The assessment of whether the data followed a normal distribution was conducted using the Shapiro-Wilk-Francia test, while Levene's test was utilized to determine the homogeneity of variance. Mann U. Whitney We compared two groups using Monte Carlo simulation outcomes and quantitative variables. We utilized Monte Carlo simulation results in conjunction with the Kuruskal-Wallis H test, one of the nonparametric tests, to compare more than two groups based on quantitative variables. Post-hoc analysis was subsequently conducted utilizing Dunn's test. We utilized the Monte Carlo simulation method to examine the Pearson Chi-Square test and the Fisher Freeman Halton test in order to compare categorical variables. We assessed the correlation between two quantitative variables using the Spearman rho test. The research investigated the sensitivity, specificity, positive predictive ratio (Positive Predictive, Positive Predictivity), and negative predictive ratio (Negative Predictive, Negative Predictivity) in relation to the social jetlag variables-calculated cut-off value that separates the classifications. Analysis of the ROC (receiver operating curve) curve was performed to quantify the PSQI outcome variable and the actual classification. Categorical variables were denoted as n (percent), whereas quantitative variables were represented as median (minimum-maximum). With a confidence level of 95%, variables were analyzed, and a p value below 0.05 was deemed to indicate statistical significance.

Results

A total of 416 adolescents comprised the study group, wherein the mean age was 15.0 ± 2.9 years. The study group consisted of 222 males (53.4%) and 194 females (46.6%). A significant proportion of both males and females rated their overall health as good or very good. Only 23.3% of all adolescents had good sleep quality. The average weekly sleep duration of all adolescents was 6.78 ± 0,67 hours. The difference in total PSQI scores between the groups was statistically significant ($p < 0.001$). The adolescents with obesity had a significantly higher median PSQI total score compared to both the adolescents with normal weight and overweight ($p < 0.001$). In addition, the adolescents with overweight group had a significantly higher median PSQI total score ($p = 0.001$) than the adolescents with normal weight group. There was a statistically significant difference in SJL between the adolescents with obesity, owerweight and normal weight groups ($p < 0.001$). The average duration of sleep per week was considerably shorter in the adolescents with obesity group in comparison to both the normal weight and overweight groups ($p < 0.001$). A significant statistical correlation ($p < 0.001$) was observed between the groups and the daytime dysfunction score. Daytime dysfunction score I was found to be prevalent at a rate of 61.5% in the adolescents with normal weight group, 8.6% in the adolescents with overweight group, and 1.5% in the adolescents with obesity group ($p < 0.001$). Daytime dysfunction scores were 8.6% prevalent in the adolescents with overweight group and 1.5% prevalent in the adolescents with obesity group ($p = 0.007$). Additionally, a statistically significant difference was found in the daytime dysfunction score II prevalence rates among the following groups: the adolescents with overweight (70.9%), the adolescents with obesity (53.3%), and the adolescents with normal weight (23.8%) ($p < 0.001$) (Table 1). The prevalence of daytime dysfunction score III was significantly greater in the adolescents with obesity group (45.2%) compared to the adolescents with overweight group (20.5%) ($p < 0.001$) and the adolescents with normal weight group (0.8%) ($p < 0.001$). An examination of the connection between PSQI and BMI SDS revealed a statistically significant and strong correlation ($r = 0.667$; $p < 0.001$) (Table 2). The groups did not show any statistically significant differences when analyzed based on gender ($p = 0.472$), habitual sleep efficiency score ($p = 0.127$), and sleep medication use score ($p = 0.095$). The sensitivity rate of sleep quality according to social jetlag was 74.6%, specificity rate was 88.7%, +PV rate was 95.6%, and -PV rate was 51.5%. The predictive power for optimal cut-off >1 hour was very good ($p < 0.001$) (Table 3).

Discussion

The results of this cross-sectional study suggest that adolescents with obesity have poorer sleep quality, have a longer period of SJL, and have a shorter duration of sleep per week compared to adolescents with normal weight. Additionally, there was a connection observed between SJL and a decrease in the quality of sleep. Furthermore, a moderate correlation was found between PSQI score and BMI. Optimizing sleep quality is a crucial objective for adolescents. The decline in sleep quality has been specifically linked to compromised social, decreased immunity, obesity, and poor performance in school (13). According to the National Sleep Foundation Sleep in America Poll, 75% of 12th graders reported getting less than 8 hours of sleep a night. However, research generally shows that it is important for young people to get at least 8 to 9 hours of sleep a night (14). The optimal duration of sleep can vary based on individual variations and may be influenced by the age, physical, and mental requirements of young individuals. An investigation on the correlation between the amount of sleep adolescents get and their body fat levels revealed that a decrease in sleep duration was linked to an increase in body fat among adolescents. Furthermore, a meta-analysis investigating the impact of alterations in sleep length on the likelihood of obesity in adolescents revealed that there was a direct correlation between decreasing sleep duration and an increased risk of obesity (15). We found that the adolescents who participated in our study had an average weekly sleep duration of 6.63 hours. This amount of time appears to be lower than the recommended duration. Studies indicate that insufficient sleep time and poor sleep quality elevate the likelihood of developing obesity (16). In individuals with suboptimal sleep patterns, factors such as disturbances in hormone control, heightened appetite, reduced energy expenditure, and an elevated propensity for weight gain may be operative. Insufficient sleep can heighten the inclination to consume larger quantities of food due to its impact on appetite-regulating hormones like leptin and ghrelin. Insufficient sleep can result in reduced metabolic function, insulin resistance, and alterations in body composition (17,18). Studies indicate a correlation between social jet lag and obesity (19). Social jet lag refers to the difference between weekdays and weekend sleep hours. In other words, it is the habit of waking up early and staying awake until late on weekdays, going to sleep later, and sleeping longer on weekends. This change in sleep patterns can disrupt sleep patterns and affect the body's biological clock. Research has shown that individuals who experience more social jet lag generally have a higher BMI and are more prone to obesity (20). However, researchers have yet to determine the precise mechanism by which social jet lag affects obesity. However, it is known that social jet lag negatively affects sleep duration and sleep quality. Decreased sleep duration and quality can lead to disruption of hormonal balance, increased appetite, and an irregular metabolism (8). This increases the risk of obesity. Our investigation revealed a notable correlation between heightened social jet lag and elevated BMI, consistent with existing literature. The quality of sleep can be influenced by different factors. Additional variables, including age, gender, lifestyle, and genetic predisposition can influence the quality of sleep (21). The association between BMI and PSQI score remained statistically significant even after controlling for age and gender variables in the study.

Study Limitations

The participants' sleep-wake times were determined by their own and their parents' verbal declarations. If actigraphy could be used, we would be able to obtain accurate results for sleep duration and social jet lag. Additionally, food consumption records and physical activity scores were not included in this study. There is a bidirectional relationship between short sleep duration and obesity. We also found that even if the total weekly sleep duration was at normal values, adolescents' exposure to more social jet lag increased BMI. We believe that this bidirectional relationship will be useful both in outpatient clinic administrations for the prevention of obesity and in sleep studies related to circadian rhythm.

Conclusions

This study demonstrates a relationship between inadequate sleep quality, increased exposure to SJL, and a higher BMI in adolescents. We predict that improving sleep quality during adolescence may have a protective effect in preventing obesity. We recommend that all adolescents, especially those with overweight and obesity, be questioned about their sleep habits during their routine outpatient clinic examinations and that their sleep history be a part of the anamnesis. However, additional study is required to develop suitable guidelines for sleep recommendations for adolescents.

Authorship Contribution

Concept: Funda Yıldız, Melike Zeynep Tuğrul Aksakal, Firdevs Baş, Design: Funda Yıldız, Melike Zeynep Tuğrul Aksakal, Firdevs Baş, Data Collection or Processing: Funda Yıldız, Melike Zeynep Tuğrul Aksakal, Analysis or Interpretation: Funda Yıldız, Raif Yıldız, Firdevs Baş, Literature Search: Funda Yıldız, Melike Zeynep Tuğrul Aksakal, Raif Yıldız, Firdevs Baş, Writing: Funda Yıldız, Melike Zeynep Tuğrul Aksakal, Raif Yıldız, Firdevs Baş.

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Table 1. Characteristic features of adolescents and relationship between PSQI, sleep habits and the adolescents' BMI

	Total, n(%)	Normal weight	Overweight	Obese	p
	(n=416)	(n = 130)	(n = 151)	(n = 135)	
	Med (Min/Max) or n(%)	Med (Min/Max) or n(%)	Med (Min/Max) or n(%)	Med (Min/Max) or n(%)	
Age (decimal)	15.06 (12.28/17.97)	14.55 (12.28 / 17.82)	15.05 (12.38 / 17.82)	15.44 (12.38 / 17.97) [A]	**0.006** [k]
Gender (Female)	194 (46.6)	61 (46.9)	65 (43)	68 (50.4)	0.472 [c]
BMI	25.02 (16.49/32.6)	-	-	-	-
BMI SDS	1.18 (-1.16/2.57)	-	-	-	-
PSQI ≤5 (Good Sleep Quality)	97 (23.3)	96 (73.8)	1 (0.7) [A]	-	**<0.001** [c]
PSQI Total score	7 (1/14)	4 (1 / 12)	7 (4 / 12) [A]	9 (5 / 14) [A B]	**<0.001** [k]
Subjective sleep quality score					**<0.001** [ff]
0	82 (19.7)	81 (62.3)	1 (0.7) [B]	-	
I	199 (47.8)	47 (36.2)	102 (67.5) [A]	50 (37) [B]	
II	131 (31.5)	1 (0.8)	48 (31.8) [A]	82 (60.7) [A B]	
III	4 (1)	1 (0.8)	-	3 (2.2)	
Sleep latency score					**<0.001** [ff]
0	8 (1.9)	7 (5.4)	-	1 (0.7) [A]	
I	145 (34.9)	84 (64.6)	37 (24.5) [A]	24 (17.8) [A]	
II	163 (39.2)	32 (24.6)	75 (49.7) [A]	56 (41.5) [A]	
III	100 (24)	7 (5.4)	39 (25.8) [A]	54 (40) [A B]	
Sleep duration score					**<0.001** [ff]
0	115 (27.6)	93 (71.5)	15 (9.9) [A]	7 (5.2) [A]	
I	259 (62.3)	37 (28.5)	123 (81.5) [A]	99 (73.3) [A]	
II	42 (10.1)	-	13 (8.6)	29 (21.5) [B]	
Habitual sleep efficiency score					0.127 [ff]
0	407 (97.8)	130 (100)	145 (96)	132 (97.8)	
I	8 (1.9)	-	5 (3.3)	3 (2.2)	
II	1 (0.2)	-	1 (0.7)	-	
Sleep disturbance score					**<0.001** [ff]
0	11 (2.6)	11 (8.5)	-	-	
I	386 (92.8)	116 (89.2)	148 (98) [A]	122 (90.4) [B]	
II	19 (4.6)	3 (2.3)	3 (2)	13 (9.6) [A B]	
Sleep medication use score					0.095 [ff]
0	408 (98.1)	130 (100)	147 (97.4)	131 (97)	
I	6 (1.4)	-	2 (1.3)	4 (3)	
II	2 (0.5)	-	2 (1.3)	-	
Daytime dysfunction score					**<0.001** [c]
0	18 (4.3)	18 (13.8)	-	-	
I	95 (22.8)	80 (61.5)	13 (8.6) [A]	2 (1.5) [A B]	
II	210 (50.5)	31 (23.8)	107 (70.9) [A]	72 (53.3) [A B]	
III	93 (22.4)	1 (0.8)	31 (20.5) [A]	61 (45.2) [A B]	
Social jet lag	1.25 (0/4)	0.5 (0 / 2.25)	1.5 (0.5 / 3) [A]	2 (0.5 / 4) [A B]	**<0.001** [k]
Sleep corrected social jet lag	1 (0/4)	0.5 (0 / 2)	1.5 (0 / 3) [A]	1.5 (0 / 4) [A]	**<0.001** [k]
Midpoint of sleep on school days	3:45 (2:00/4:45)	3:30 (2:00-4:30)	3:45 (2:00-4:45) [A]	4:00 (2:00-4:45) [A B]	**<0.001** [k]
Midpoint of sleep on free days	5:07 (3:00/7:30)	4:00 (3:00-6:00)	5:15 (3:00-7:00) [A]	5:30 (4:00-7:30) [A B]	**<0.001** [k]
Average weekly sleep duration	6.45 (4.3/8.45)	7.3 (6.15 / 8.45)	6.4 (5.25 / 8) [A]	6.3 (4.3 / 7.45) [A B]	**<0.001** [k]

[k] Kruskal Wallis H Test (Monte Carlo); post hoc: Dunn's Test, [c] Pearson Chi Square Test (Monte Carlo); post hoc: Benjamin-Hochberg Test
[c] Fisher Freeman Halton Test (Monte Carlo); post hoc: Benjamin-Hochberg Test
[A] Indicates significance compared to the Normal Weight group., [B] Indicates significance compared to the Overweight group.
Med: Median, Min:Minimum, Max: Maximum

Table 2. Correlation analysis between PSQI, sleep habits and BMI, BMI SDS, and age

	BMI		BMI SDS		Age (decimal)		BMI *		BMI SDS *		BMI ′		BMI SDS ′		BMI ″		BMI SDS ″	
	r	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**
PSQI Total score	0.623	**<0.001**	0.667	**<0.001**	0.145	**0.003**	0.597	**<0.001**	0.655	**<0.001**	0.637	**<0.001**	0.661	**<0.001**	0.636	**<0.001**	0.654	**<0.001**
Subjective sleep quality score	0.604	**<0.001**	0.622	**<0.001**	0.128	**0.009**	0.572	**<0.001**	0.593	**<0.001**	0.589	**<0.001**	0.600	**<0.001**	0.591	**<0.001**	0.593	**<0.001**
Sleep latency score	0.337	**<0.001**	0.418	**<0.001**	0.01	0.845	0.399	**<0.001**	0.409	**<0.001**	0.362	**<0.001**	0.404	**<0.001**	0.387	**<0.001**	0.406	**<0.001**
Sleep duration score	0.575	**<0.001**	0.565	**<0.001**	0.197	**<0.001**	0.507	**<0.001**	0.530	**<0.001**	0.541	**<0.001**	0.544	**<0.001**	0.516	**<0.001**	0.532	**<0.001**
Habitual sleep efficiency score	0.025	0.609	0.077	0.117	-0.088	0.073	0.074	0.130	0.085	0.084	0.048	0.332	0.067	0.174	0.092	0.061	0.082	0.097
Sleep disturbance score	0.192	**<0.001**	0.234	**<0.001**	0.023	0.633	0.184	**<0.001**	0.212	**<0.001**	0.196	**<0.001**	0.210	**<0.001**	0.203	**<0.001**	0.209	**<0.001**
Sleep medication use score	0.015	0.758	0.062	0.209	-0.02	0.742	0.013	0.794	0.053	0.282	0.019	0.701	0.047	0.343	0.028	0.573	0.050	0.313
Daytime dysfunction score	0.614	**<0.001**	0.631	**<0.001**	0.192	**<0.001**	0.584	**<0.001**	0.641	**<0.001**	0.641	**<0.001**	0.649	**<0.001**	0.623	**<0.001**	0.639	**<0.001**
Social jet lag	0.573	**<0.001**	0.582	**<0.001**	0.179	**<0.001**	0.530	**<0.001**	0.559	**<0.001**	0.563	**<0.001**	0.570	**<0.001**	0.546	**<0.001**	0.559	**<0.001**
Sleep corrected social jet lag	0.522	**<0.001**	0.541	**<0.001**	0.152	**0.002**	0.504	**<0.001**	0.535	**<0.001**	0.531	**<0.001**	0.545	**<0.001**	0.519	**<0.001**	0.535	**<0.001**
Midpoint of sleep on school days	0.477	**<0.001**	0.429	**<0.001**	0.302	**<0.001**	0.392	**<0.001**	0.399	**<0.001**	0.458	**<0.001**	0.427	**<0.001**	0.384	**<0.001**	0.406	**<0.001**
Midpoint of sleep on free days	0.687	**<0.001**	0.674	**<0.001**	0.296	**<0.001**	0.637	**<0.001**	0.670	**<0.001**	0.686	**<0.001**	0.678	**<0.001**	0.648	**<0.001**	0.672	**<0.001**
Average weekly sleep duration	-0.57	**<0.001**	-0.563	**<0.001**	-0.171	**<0.001**	-0.538	**<0.001**	-0.556	**<0.001**	-0.574	**<0.001**	-0.570	**<0.001**	-0.547	**<0.001**	-0.558	**<0.001**

Spearman rho correlation Test, r: correlation coefficient, * Partial Correlation (Controlling for age (decimal)), ′ Partial Correlation (Controlling for gender), ″ Partial Correlation (Controlling for gender and age (decimal))

Table 3. ROC analysis according to PSQI

Reference PSQI >5 (Bed Sleep Quality)	Cut off	Specificity	Sensitivity	-PV	+PV	AUC ± SE.	P value
All participants							
Social jet lag	>1	88.7	74.6	51.5	95.6	0.886 ± 0.017	**<0.001**
Sleep corrected social jet lag	>1	96.9	51.7	37.9	98.2	0.837 ± 0.021	**<0.001**
Male							
Social jet lag	>1	90.6	77.5	55.8	96.3	0.901 ± 0.021	**<0.001**
Sleep corrected social jet lag	>1	54.7	95.9	80.6	87.1	0.851 ± 0.029	**<0.001**
Female							
Social jet lag	>1	86.4	71.3	46.9	94.7	0.867 ± 0.026	**<0.001**
Sleep corrected social jet lag	>1	97.7	50.7	36.8	98.7	0.821 ± 0.031	**<0.001**
Normal Weight							
Social jet lag	>1	88.5	35.3	79.4	52.2	0.627 ± 0.060	**0.034**
Sleep corrected social jet lag	>1	49.0	64.7	79.7	31	0.580 ± 0.058	0.170

ROC (Receiver Operating Curve) Analysis (Honley&Mc Nell - Youden index J), AUC: Area under the ROC curve, SE: Standard Error, +PV: Positive Predictive Value, -PV: Negative Predictive Value