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The Characteristics of Sleep in Headache Patients

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Purpose: To investigate the relationship between headache and sleep by evaluating sleep quality, daytime sleepiness, and specific features related to sleep-disordered breathing (SDB).

Methods: One hundred one subjects with headache and 118 healthy controls were enrolled. To collect various information on headache attacks, headache group completed self-reported questionnaire about the characteristics of headache attacks and the migraine disability assessment (MIDAS) questionnaire. The subjective quality of sleep was evaluated in all of the subjects using the Pittsburgh sleep quality index (PSQI) and Epworth sleepiness scale (ESS). In addition, the following specific features of sleep were evaluated in 28 subjects selected randomly from each group: apnea-hypopnea index (AHI), prevalence of SDB, nocturnal oxygen saturation (SaO_2), and oxygen desaturation index (ODI) as measured using a portable monitoring device.

Results: The global PSQI and the prevalence of poor sleeping (global PSQI >5), ESS scores and the prevalence of daytime sleepiness (ESS score >10) were significantly higher in the headache group (both $p<0.0001$, respectively). The mean scores on the numerical rating scale and the MIDAS were significantly higher in the poor-sleeper group than in the good-sleeper group ($p=0.0347$ and $p=0.0016$, respectively). The global PQSI and prevalence of daytime sleepiness were significantly higher in the chronic-headache group than in the acute-headache group ($p=0.0003$ and $p=0.0312$, respectively).

Conclusions: There is a significant association between headache and sleep. Especially, severity and chronicity of headache were significantly associated with sleep quality and daytime sleepiness.

Key Words: Daytime sleepiness; Headache; Nocturnal hypoxia; Sleep apnea syndromes; Sleep quality

INTRODUCTION

Headache is one of the most common, widespread, and debilitating pain disorders experienced by humans. The relationship between sleep and headache has been widely studied for more than a century, and many population surveys have found an association between sleep and headache. It is well known that a sound sleep can alleviate headache, and that sleep disturbances or a change in sleep patterns can trigger headache.[1,2] Reciprocally, headache might induce various degrees of sleep disruption and sleep disturbances.[3-5] Many clinical studies also suggested that there are numerous sleep disorders related to primary headache syndromes, among which obstructive sleep apnea (OSA) appears to be the most strongly related to headache, especially morning headache.[6-12] So, the International Classification of Sleep Disorders (ICSD) lists morning headache as a feature of OSA syndrome.[13]

Some authors have reported that fluctuation in the nocturnal oxygen saturation (SaO_2) decreases the sleep quality and triggers headache.[14-18] Loh et al.[8] suggested that oxygen desaturation in OSA patients causes cerebral vasodilation, and that this can induce headache. However, other studies have reported no relation between morning headache and OSA[6,19] or between morning headache and nocturnal SaO_2.[20-22] Thus, the exact relationship between the OSA and headache remains controversial.

This study investigated the possible relationship between headache and sleep by evaluating sleep quality, daytime sleepiness, and specific features related to sleep-disordered breathing (SDB)—including nocturnal SaO_2, apnea-hypopnea index (AHI), and oxygen desaturation index (ODI)—in headache patients.

MATERIALS AND METHODS

1. Subjects

A total of 101 subjects (aged 30.3±12.9 years, mean± standard deviation) of both genders (23 males, 78 females) suffering from headache were enrolled in this study. All of the subjects were recruited from the Temporomandibular Joint and Orofacial Pain Clinic, Dental Hospital of Yonsei University College of Dentistry (Seoul, Korea) from June to November 2008. The diagnosis of headache was based on the International Classification of Headache Disorders (ICHD)-II. Subjects who had taken preventive medication for headache or other medications that could affect sleep (e.g., hypnotics, barbiturates, antidepressants, and muscle relaxants) within the previous 3 months were excluded. A total of 118 healthy subjects (aged 31.8±12.6 years) of both genders (56 males, 62 females) without headache were enrolled as a control group. The study protocol was approved by the institutional review of board of Dental Hospital of Yonsei University College of Dentistry (2-2008-0007), and written informed consent was obtained from all subjects.

2. Methods

1) Headache questionnaire

At the first visit, subjects in the headache group completed a self-reported questionnaire in order to collect information on various aspects of headache attacks. The questionnaire included the headache attack frequency, duration, severity, intensity, characteristics of pain (e.g., pressing/tightening or pulsating), localization, accompanying symptoms, and aggravating and alleviating factors, the presence of morning headache, and the chronicity of headache (chronic headache was defined as the presence of headache attacks for 15 days or more per month for at least a 3 month period).

Based on the information obtained from the questionnaires, the headache was diagnosed according to the ICHD-II criteria and the subjects were classified into the following three groups: 1) Migraine (MIG) group: migraine or probable migraine; 2) Tension-type headache (TTH) group: TTH or probable TTH; and 3) Other-headache group: cluster headache, other primary headache, or secondary headache.

2) MIDAS questionnaire

All of the subjects with headache completed the migraine disability assessment (MIDAS) questionnaire. The MIDAS questionnaire is based on the number of days when productivity is reduced by at least half for both work outside the home and household work, as well as the number of days of non-work activities (family, social, and leisure) during a 3-month period. The MIDAS questionnaire comprises five disability questions, with the MIDAS score calculated as the sum of responses to these questions. The MIDAS score is categorized into four disability grades (MIDAS grades). The MIDAS questionnaire exhibits high reliability and internal consistency for estimating migraine-related disability.[23-25]

3) Sleep-related questionnaire

The subjective quality of sleep was evaluated in all of the subjects using the Pittsburgh sleep quality index (PSQI) and Epworth sleepiness scale (ESS).

(1) PSQI

The PSQI assesses sleep quality during the previous month. It consists of 19 self-rated questions that assess a wide variety of factors related to sleep quality, including sleep duration, latency, and/or frequency and severity of specific sleep-related problems. These 19 items are grouped into the following 7 component scores, each weighted on a scale from 0 to 3: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleep medications, and daytime function. The seven component scores are then summed to yield a global PSQI, which ranges from 0 to 21. Relative to clinical laboratory measures, a global PSQI score greater than 5 represents indicates poor sleep quality (i.e., global PSQI=5, good sleeper; global PSQI >5, poor sleeper). The sensitivity and specificity of the PSQI were reportedly 89.6% and 86.5%, respectively.[26]

(2) ESS

The ESS is an 8 item questionnaire that assesses the likelihood of falling asleep or dozing in given situations. The dozing probability is rated from 0 to 3, giving a maximum possible score of 24. Sleepiness is severe when the sum exceeds 10. The ESS scores for healthy people without OSA and for patients with OSA were reportedly 5.9±2.2 and 11.7±4.5, respectively.[27,28]

4) Sleep evaluation using a portable monitoring device

With their consent, 28 subjects selected randomly from each group participated in a sleep evaluation using ApneaLink™ (Resmed Inc., Poway, CA, USA), a portable recording device with three data channels: respiration, oximetry, and pulse. The device consists of a nasal cannula and pulseoximeter attached to a small case that houses a pressure transducer. The ApneaLink™ device has shown high sensitivity and specificity (>80%) compared with polysomnography (PSG).[29] This device was used in the present study to estimate the AHI, ODI, and the mean and lowest nocturnal SaO_2. AHI was calculated by dividing the total number of apnea and hypopnea episodes by the total recording time (in hours). An apnea episode was defined as a decrease in airflow by at least 80% relative to baseline for at least 10 seconds, and a hypopnea episode was defined as a decrease in airflow by 50% to 80% relative to baseline for at least 10 seconds.

5) Analysis

Statistical analyses were performed to compare the PSQI and ESS score and the ApneaLink™ parameters between the headache and control groups. Groups were compared using the t-test for continuous variables and the chi-square test for analyzing cross tabulations. SAS version 9.1 (SAS Institute, Cary, NC, USA) was used for all statistical analyses. The level of significance was set at 95%.

RESULTS

1. Subject Demographics

The characteristics of the headache and control groups are reported in Table 1. In the headache group, 49 subjects (48.5%) were classified into the MIG group (migraine, 30; probable migraine, 19), and 49 subjects (48.5%) were classified into the TTH group (TTH, 38; probable TTH, 11). Three subjects (3%) were classified into the other-headache group (secondary headache, 2; cluster headache, 1; Table 2). The other-headache group was excluded from statistical analyses because of the very small number of subjects.

The gender distribution differed significantly between the migraine and TTH groups (p=0.0155), whereas the age and duration of headache suffering did not. The prevalence of morning headache and chronicity of headache were higher in the MIG group than in the TTH group, but the difference did not reach the level of statistical significance. The scores on the numerical rating scale (NRS) and MIDAS

Table 1. Demographic characteristics in headache and control group

Characteristic	Headache group (n=101)	Control group (n=118)
Age (y)	30.3±12.9	31.8±12.6
Gender (female)	77.2	52.5
Body mass index (kg/m^2)	21.0±3.1	21.9±2.9

Values are presented as mean±standard deviation or %.

Table 2. Diagnostic classification of headache group (n=101)

Group	Headache type	Number (%) of subjects
Migraine (n=49)	Migraine	30 (29.7)
	Probable migraine	19 (18.8)
Tension type headache (n=49)	Tension type headache	38 (37.6)
	Probable tension type headache	11 (10.9)
Other headache (n=3)	Secondary headache	2 (2.0)
	Cluster headache	1 (1.0)
Total		101 (100)

were significantly higher in the MIG group than in the TTH group (NRS: 6.51±1.53 vs 5.02±1.94, p<0.0001; MIDAS score: 31.78±54.29 vs 12.67±22.50, p=0.0263). The characteristics of the headache group are summarized in Table 3.

2. Results for the PSQI

Table 4 presents the PSQI results. The mean global PSQI was significantly higher in the headache group (8.63±3.48) than in the control group (5.80±2.71; p<0.0001). The prevalence of poor sleepers (PSQI >5) was 81.6% in the headache group and 45.8% in the control group (p<0.0001).

According to headache type, there were no significant differences in mean global PSQI (MIG group, 9.12±3.70; TTH group, 8.14±3.20; p=0.1643) and prevalence of poor sleepers (MIG group, 83.7%; TTH group, 79.6%; p=0.6018).

3. Results for the ESS

Table 5 presents the ESS results. ESS scores were significantly higher in the headache group (10.48±4.35) than in the control group (7.57±3.95; p<0.0001). The prevalence of severe daytime sleepiness (ESS >10) was 50.0% in the headache group and 22.0% in the control group (p<0.0001).

According to headache type, there were no significant differences in ESS score (MIG group, 10.37±4.78; TTH group, 10.59±3.92; p=0.7999) and prevalence of severe daytime sleepiness (MIG group, 51.0%; TTH group, 49.0%; p=0.8399).

Table 3. Comparison of headache features in the two subgroups of headache group

Variable	MIG group (n=49)	TTH group (n=49)	p-value
Age (y)	29.8±12.9	30.7±14.3	0.7331
Gender (female)	87.8	67.3	0.0155*
Numerical rating scale	6.51±1.53	5.02±1.94	<0.0001*
Headache duration (y)	6.58±6.16	4.84±5.64	0.1606
Chronicity	40.8	24.5	0.0848
Morning headache	32.7	16.3	0.0602
MIDAS score	31.78±54.29	12.67±22.50	0.0263*

MIG, migraine; TTH, tension-type headache; MIDAS, migraine disability assessment.
Values are presented as mean±standard deviation or %.
*Statistically significant at significance level of 95%.

Table 4. Analysis of PSQI results

Sleep quality	Total headache group (n=98)	Control group (n=118)	p-value	Headache type		p-value
				MIG group (n=49)	TTH group (n=49)	
Global PSQI	8.63±3.48	5.80±2.71	<0.0001*	9.12±3.70	8.14±3.20	0.1643
Poor sleeper	80 (81.6)	54 (45.8)	<0.0001*	41 (83.7)	39 (79.6)	0.6018
Good sleeper	18 (18.4)	64 (54.2)		8 (16.3)	10 (20.4)	

PSQI, Pittsburgh sleep quality index; MIG, migraine; TTH, tension-type headache.
Values are presented as mean±standard deviation or number (%).
*Statistically significant at significance level of 95%.

Table 5. Analysis of ESS results

Daytime sleepiness	Total headache group (n=98)	Control group (n=118)	p-value	Headache type		p-value
				MIG group (n=49)	TTH group (n=49)	
ESS score	10.48±4.35	7.57±3.95	<0.0001*	10.37±4.78	10.59±3.92	0.7999
Severe daytime sleepiness	49 (50.0)	26 (22.0)	<0.0001*	25 (51.0)	24 (49.0)	0.8399
No sleepiness	49 (50.0)	92 (78.0)		24 (49.0)	25 (51.0)	

ESS, Epworth sleepiness scale; MIG, migraine; TTH, tension-type headache.
Values are presented as mean±standard deviation or number (%).
*Statistically significant at significance level of 95%.

4. Analysis of NRS and MIDAS Scores according to PSQI and ESS Score

Table 6 presents the NRS and MIDAS scores according to the PSQI and ESS. According to the PSQI, the NRS score was significantly higher in the poor-sleeper group (5.53±1.93) than in the good-sleeper group (4.92±1.52; p=0.0347). The MIDAS score was also significantly higher in the poor-sleeper group (25.55±46.19) than in the good-sleeper group (7.44±8.75; p=0.0016). However, the NRS (p=0.2218) and MIDAS score (p=0.9060) did not differ significantly between the severe-daytime-sleepiness group and the no-sleepiness group.

5. Analysis of PSQI and ESS Score according to Chronicity of Headache and Presence of Morning Headache

Table 7 presents the PSQI and ESS score according to headache chronicity and severity. The global PSQI was significantly higher in the chronic-headache group (10.69±4.01) than in the acute-headache group (7.64±2.70; p=0.0003). However, the prevalence of poor sleepers did not differ significantly between the chronic-headache group (87.5%) and the acute-headache group (78.8%; p=0.2963).

The ESS score did not differ significantly between the chronic-headache group (11.5±4.78) and the acute-headache group (9.98±4.07; p=0.1063). However, the prevalence of severe daytime sleepiness was significantly higher in the chronic-headache group (65.6%) than in the acute-headache group (42.4%; p=0.0312).

The global PSQI, ESS score, prevalence of poor sleepers, and severe daytime sleepiness did not differ significantly with the presence of morning headache.

6. Results of Evaluation by ApneaLink™

Sleep was evaluated in 32 subjects of the headache group and 28 subjects of the control group using a portable sleep-monitoring device (ApneaLink™). The recording time was insufficient in four subjects in the headache group, so their data were excluded from the analysis. The age, gender, and body mass index did not differ significantly between the headache and control groups. The characteristics of the headache and control groups are presented in Table 8.

AHI was higher in the headache group (5.86±6.26) than in the control group (3.43±3.57), but the difference did not reach the level of statistical significance (p=0.0816). The prevalence of SDB (AHI >5) was 35.7% in the headache group and 25.0% in the control group (p=0.3833). The ODI and mean and lowest nocturnal SaO_2 also did not differ significantly between the two groups.

Table 6. The analysis of NRS and MIDAS score according to PSQI and ESS score among headache subjects

	Global PSQI		p-value	ESS		p-value
	Poor-sleeper (n=80)	Good-sleeper (n=18)		Severe-daytime sleepiness (n=49)	No-sleepiness (n=49)	
NRS	5.53±1.93	4.92±1.52	0.0347*	5.53±1.96	6.00±1.81	0.2218
MIDAS score	25.55±46.19	7.44±8.75	0.0016*	22.74±34.08	21.71±49.78	0.9060

NRS, numerical rating scale; MIDAS, migraine disability assessment; PSQI, Pittsburgh sleep quality index; ESS, Epworth sleepiness scale.
Values are presented as mean±standard deviation.
*Statistically significant at significance level of 95%.

Table 7. The analysis of PSQI and ESS score according to chronicity of headache and presence of morning headache

		Chronic headache (n=32)	Acute headache (n=66)	p-value	Morning headache (n=24)	No-morning headache (n=74)	p-value
PSQI	Mean	10.69±4.01	7.64±2.70	0.0003*	9.00±3.76	8.51±3.40	0.5542
	Poor-sleeper	28 (87.5)	52 (78.8)	0.2963	21 (87.5)	59 (79.7)	0.3930
ESS	Mean	11.50±4.78	9.98±4.07	0.1063	11.08±4.85	10.28±4.19	0.4369
	Daytime sleepiness	21 (65.6)	28 (42.4)	0.0312*	13 (54.2)	36 (48.6)	0.6385

PSQI, Pittsburgh sleep quality index; ESS, Epworth sleepiness scale.
Values are presented as mean±standard deviation or number (%).
*Statistically significant at significance level of 95%.

Table 8. Comparison of ApneaLink™ results between headache group and control group

Characteristic	Headache group (n=28)	Control group (n=28)	p-value
Age (y)	34.0±14.1	29.9±11.5	0.2335
Gender (female)	67.9	50.0	0.1744
Body mass index (kg/m^2)	21.2±2.9	22.2±2.9	0.2376
Mean AHI	5.86±6.26	3.43±3.57	0.0816
AHI=5	35.7	25.0	0.3833
ODI	3.61±4.79	2.29±3.60	0.2486
Average SaO_2	96.10±1.95	95.86±1.72	0.6126
Lowest SaO_2	90±4.19	91.71±3.73	0.1117

AHI, apnea-hypopnea index; ODI, oxygen desaturation index; SaO_2, oxygen saturation.
Values are presented as mean±standard deviation or %.

Table 9. Comparison of ApneaLink™ results according to presence of morning headache

Characteristic	Morning headache (n=8)	No-morning headache (n=20)	p-value
Age (y)	31.4±13.7	35.1±14.5	0.5380
Gender (female)	75.0	65.0	0.6088
Body mass index (kg/m^2)	21.7±4.1	21.0±2.4	0.6288
Mean AHI	7±8.28	5.4±5.44	0.5511
AHI=5	37.5	35.0	0.9007
ODI	3.75±5.15	3.55±4.78	0.9228
Average SaO_2	95.75±1.83	96.20±2.02	0.5500
Lowest SaO_2	89.63±3.81	90.15±4.42	0.7708

AHI, apnea-hypopnea index; ODI, oxygen desaturation index; SaO_2, oxygen saturation.
Values are presented as mean±standard deviation or %.

The AHI, prevalence of SDB, and ODI were slightly higher and the mean and lowest nocturnal SaO_2 were slightly lower in the morning-headache group than in the no-morning-headache group. However, none of these differences reached the level of statistical significance (Table 9).

DISCUSSION

Paiva et al.[4] proposed three mechanisms for explaining the relationship between sleep and headache. The first possible mechanism is that sleep disturbance is the cause of the headache. It is well known that sleep deprivation, excessive sleep, inadequate sleep duration, and poor sleep are common triggering factors for migraine and that a change in sleep patterns is one of the most common precipitating factors of both migraine and TTH.[5] The second possible mechanism is that headache is the cause of the sleep disturbance. Many studies have found that headache can cause sleep disruption and sleep loss.[5,30] The third possible mechanism is that there is an association between sleep disturbance and headache, and that they can occur together for various reasons such as medical conditions (e.g., analgesic overuse) or psychiatric disorders (e.g., depression or anxiety).[15] However, despite many previous studies, the mechanism underlying the relationship between sleep and headache remains unclear.

Many clinical studies have also suggested that numerous sleep disorders—not only sleep deprivation or sleep disturbance—are associated with primary headache syndromes. Among the various types of headache, particularly morning headache (or "awakening" headache) and chronic headache could be strongly related to a sleep disorder, and management of the sleep disorder might improve or resolve the headache.[12] OSA is one of the most common sleep disorders and it includes morning headache as a diagnostic feature.[13] Several studies have investigated the relationship between morning headache and sleep disorders including OSA. Paiva et al.[4] obtained a PSG in 25 patients with morning headache, which revealed sleep disorders including OSA in 13 patients (52%). Ulfberg et al.[31] reported that morning headache was about three times more common in heavy snorers and patients with OSA than in the general population. In the retrospective study of Loh et al.[8] involving 80 consecutive OSA patients, 41% reported morning headache. Those authors suggested that the severity of headache is positively correlated with OSA severity and nocturnal oxygen desaturation. Göder et al.[32] examined morning headache in 432 sleep-disordered patients who underwent PSG and 30 healthy controls, and found that the prevalence of headache was significantly higher in patients with sleep disorder than in controls (34% vs 7%). Alberti et al.[33] also reported that morning headache was present in 74% of OSA patients and that its occurrence was significantly correlated with nocturnal oxygen desaturation and OSA severity.

However, contradicting studies have also been reported. Aldrich and Chauncey[6] reviewed clinical and PSG data of 304 patients with sleep apnea, and compared the findings with normal control subjects. They concluded that the presence of frequent morning headaches is a nonspecific symptom in patients with sleep disorders and hence is not a consistent or reliable indicator of sleep apnea syndrome. Jensen et al.[19] used PSG to examine whether sleep apnea is more prevalent in patients with headache, and found that the frequency of OSA was no higher in patients referred to specialists for headache problems than in the general population. Greenough et al.[20] examined the relationship between nocturnal SaO_2 and headache syndrome, and found that the percentage of time spent with nocturnal hypoxia did not differ between headache patients and non-headache controls. Also, Neau et al.[22] demonstrated that the nocturnal SaO_2 and AHI did not differ significantly between patients with headache and controls without headache. Idiman et al.[21] found no statistically significant relationship between headache and AHI and minimal SaO_2 in 75 patients with sleep apnea syndrome.

The above results together indicate that the exact relationship between headache and sleep is not fully understood, and remains controversial. This prompted the present study to investigate the relationship between headache and sleep quality using self-administered questionnaires including the PSQI and ESS, and to evaluate specific features of sleep (e.g., AHI, ODI, and nocturnal SaO_2) using a portable sleep-monitoring device in headache patients.

As expected, the subjective quality of sleep was significantly worse in our headache group than in our control group. The global PSQI, prevalence of poor sleepers, and severity of daytime sleepiness were higher in the headache group than in the control group. These results are in agreement with the study of Gori et al.[34] on the relationship between headache and sleep quality. They reported that subjective sleep quality was worse in migraine patients than in controls (as evaluated by the PSQI), and that among migraine patients, the morning-headache group showed worse sleep quality and higher MIDAS score.[34]

The present study also investigated the relationships of specific headache features with sleep quality and sleepiness. Sleep quality tended to be worse in patients with more subjectively severe headache (as estimated by the NRS and MIDAS score). The NRS and MIDAS score were higher in the poor-sleeper group than in the good-sleeper group. However, headache severity was not related to the severity of daytime sleepiness. Chronicity of headache also showed some association with sleep quality and daytime sleepiness. The global PSQI was significantly higher in the chronic-headache group than in the acute-headache group. The ESS score was also higher in the chronic-headache group, but the difference did not reach the level of statistical significance. However, the prevalence of severe daytime sleepiness was significantly higher in the chronic-headache group. Therefore, it can be concluded from the present results that sleep quality tends to be worse along those with more chronic and severe headache. However, the presence of morning headache was not significantly associated with sleep quality or daytime sleepiness. Although the sleep quality was worse and the prevalence of daytime sleepiness was higher in the morning-headache group than in the no-morning-headache group, the differences did not reach the level of statistical significance. These findings do not agree with a previous study finding that sleep quality tended to be worse in morning headache sufferers,[34] but the discrepancy might be due to the relatively small morning-headache group. Therefore, further study with a larger number of subjects is needed to clarify the association between morning headache and sleep quality.

The ApneaLink™ data revealed that the AHI, ODI, and both the mean and lowest nocturnal SaO_2 did not differ significantly between the headache and control groups. Although the AHI was slightly higher in the headache group than in the control group, the difference was not statistically significant (p=0.0816). This result is in agreement with the study of Idiman et al.[21] Also, the prevalence of SDB (AHI=5) did not differ significantly between the headache and control groups. The prevalence of SDB in the control group was 25%, similar to the prevalence in normal middle-aged Koreans (men, 16%; women, 27%).[35] The prevalence of SDB in our headache group was 35.71%, but did not differ significantly from that in the control group.

Several previous studies have found a significant relationship between AHI, nocturnal SaO_2, and presence of morning headache,[8,33] whereas the present study found that the AHI, prevalence of SDB, and nocturnal SaO_2 did not differ significantly with the presence or absence of morning headache. These results conflict with the hypothesis that nocturnal hypoxia is a cause of morning headache, and confirm previous studies finding no association between morning headache and nocturnal hypoxia.[20-22]

The present study was subject to some limitations. First, the study was based only on self-reported and subjective information about headache and sleep. Second, the analysis of sleep was not based on PSG. Although the gold standard diagnostic technique for the sleep study is attended overnight PSG, as suggested by the American Sleep Disorders Association, the problems of its high cost, patient agreement, and some clinical regulations led to this study employing a portable sleep-monitoring device. Third, this study included a fairly small number of subjects, which resulted in some difficulties controlling external factors such as the age and gender distributions.

In summary, the present study has confirmed previous studies suggesting that there are significant associations between sleep quality, daytime sleepiness, and headache. On the other hand, nocturnal hypoxia was not found to be associated with headache. Future studies applying PSG to larger samples are needed to further elucidate the association between sleep and headache.

This study investigated the relationship between headache and sleep by evaluating sleep quality, daytime sleepiness, and specific features related to SDB (including mean AHI, prevalence of SDB, nocturnal SaO_2, ODI) in 101 patients with headache and 118 healthy controls without headache. The results are summarized as follows.

1. Sleep quality was significantly associated with headache. The global PSQI and the prevalence of poor sleeping (global PSQI >5) were significantly higher in the headache group than in the control group (both p<0.0001).

2. Daytime sleepiness was significantly associated with headache. ESS scores and the prevalence of daytime sleepiness (ESS score >10) were significantly higher in the headache group than in the control group (both p<0.0001).

3. Sleep quality was significantly associated with headache severity. The mean scores on the NRS and the MIDAS were significantly higher in the poor-sleeper group than in the good-sleeper group (p=0.0347 and p=0.0016, respectively). However, daytime sleepiness was not significantly associated with headache severity.

4. Headache chronicity was significantly associated with sleep quality and daytime sleepiness. The global PQSI and prevalence of daytime sleepiness were significantly higher in the chronic-headache group than in the acute-headache group (p=0.0003 and p=0.0312, respectively). However, morning headache was not significantly associated with sleep quality or daytime sleepiness.

5. The AHI, ODI, prevalence of SDB, and nocturnal SaO_2 did not differ significantly between the headache and control groups.

6. The AHI, ODI, prevalence of SDB, and nocturnal SaO_2 did not differ significantly between the morning-headache group and no-morning-headache group.

The obtained results indicate that there is a significant association between headache and sleep. Among various characteristics of headache, severity and chronicity were significantly associated with sleep quality and daytime sleepiness, while no statistically significant association was evident between headache and nocturnal hypoxia or SDB.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Rasmussen BK. Migraine and tension-type headache in a general population: precipitating factors, female hormones, sleep pattern

and relation to lifestyle. Pain 1993;53:65-72.
2. Silberstein SD. Migraine: preventive treatment. Curr Med Res Opin 2001;17(Suppl 1):s87-s93.
3. Inamorato E, Minatti-Hannuch SN, Zukerman E. The role of sleep in migraine attacks. Arq Neuropsiquiatr 1993;51:429-432.
4. Paiva T, Batista A, Martins P, Martins A. The relationship between headaches and sleep disturbances. Headache 1995;35:590-596.
5. Sahota PK, Dexter JD. Sleep and headache syndromes: a clinical review. Headache 1990;30:80-84.
6. Aldrich MS, Chauncey JB. Are morning headaches part of obstructive sleep apnea syndrome? Arch Intern Med 1990;150:1265-1267.
7. Jennum P, Sjøl A. Self-assessed cognitive function in snorers and sleep apneics. An epidemiological study of 1,504 females and males aged 30-60 years: the Dan-MONICA II study. Eur Neurol 1994;34:204-208.
8. Loh NK, Dinner DS, Foldvary N, Skobieranda F, Yew WW. Do patients with obstructive sleep apnea wake up with headaches? Arch Intern Med 1999;159:1765-1768.
9. Paiva T, Farinha A, Martins A, Batista A, Guilleminault C. Chronic headaches and sleep disorders. Arch Intern Med 1997;157:1701-1705.
10. Poceta JS, Dalessio DJ. Identification and treatment of sleep apnea in patients with chronic headache. Headache 1995;35:586-589.
11. Rains JC, Poceta JS. Sleep-related headache syndromes. Semin Neurol 2005;25:69-80.
12. Rains JC, Poceta JS. Headache and sleep disorders: review and clinical implications for headache management. Headache 2006;46:1344-1363.
13. American Academy of Sleep Medicine. The international classification of sleep disorders: diagnostic and coding manual. 2nd ed. Westchester, IL: American Academy of Sleep Medicine; 2005.
14. Diomedi M, Placidi F, Cupini LM, Bernardi G, Silvestrini M. Cerebral hemodynamic changes in sleep apnea syndrome and effect of continuous positive airway pressure treatment. Neurology 1998;51:1051-1056.
15. Dodick DW, Eross EJ, Parish JM, Silber M. Clinical, anatomical, and physiologic relationship between sleep and headache. Headache 2003;43:282-292.
16. Jennum P, Børgesen SE. Intracranial pressure and obstructive sleep apnea. Chest 1989;95:279-283.
17. Jennum P, Jensen R. Sleep and headache. Sleep Med Rev 2002;6:471-479.
18. Sugita Y, Iijima S, Teshima Y, et al. Marked episodic elevation of cerebrospinal fluid pressure during nocturnal sleep in patients with sleep apnea hypersomnia syndrome. Electroencephalogr Clin Neurophysiol 1985;60:214-219.
19. Jensen R, Olsborg C, Salvesen R, Torbergsen T, Bekkelund SI. Is obstructive sleep apnea syndrome associated with headache? Acta Neurol Scand 2004;109:180-184.
20. Greenough GP, Nowell PD, Sateia MJ. Headache complaints in relation to nocturnal oxygen saturation among patients with sleep apnea syndrome. Sleep Med 2002;3:361-364.
21. Idiman F, Oztura I, Baklan B, Ozturk V, Kursad F, Pakoz B. Headache in sleep apnea syndrome. Headache 2004;44:603-606.
22. Neau JP, Paquereau J, Bailbe M, Meurice JC, Ingrand P, Gil R. Relationship between sleep apnoea syndrome, snoring and headaches. Cephalalgia 2002;22:333-339.
23. Lipton RB, Stewart WF, Sawyer J, Edmeads JG. Clinical utility of an instrument assessing migraine disability: the Migraine Disability Assessment (MIDAS) questionnaire. Headache 2001;41:854-861.
24. Park JW, Shin HE, Kim JS, Lee KS. Assessing migraine disability by diary-based measurement: relationship to the characteristics of individual headache attacks. Eur J Neurol 2008;15:817-821.
25. Stewart WF, Lipton RB, Dowson AJ, Sawyer J. Development and testing of the Migraine Disability Assessment (MIDAS) Questionnaire to assess headache-related disability. Neurology 2001;56(6 Suppl 1):S20-S28.
26. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res 1989;28:193-213.
27. Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. Sleep 1991;14:540-545.
28. Johns MW. Reliability and factor analysis of the Epworth Sleepiness Scale. Sleep 1992;15:376-381.
29. Erman MK, Stewart D, Einhorn D, Gordon N, Casal E. Validation of the ApneaLink for the screening of sleep apnea: a novel and simple single-channel recording device. J Clin Sleep Med 2007;3:387-392.
30. Aaltonen K, Hämäläinen ML, Hoppu K. Migraine attacks and sleep in children. Cephalalgia 2000;20:580-584.
31. Ulfberg J, Carter N, Talbäck M, Edling C. Headache, snoring and sleep apnoea. J Neurol 1996;243:621-625.
32. Göder R, Friege L, Fritzer G, Strenge H, Aldenhoff JB, Hinze-Selch D. Morning headaches in patients with sleep disorders: a systematic polysomnographic study. Sleep Med 2003;4:385-391.
33. Alberti A, Mazzotta G, Gallinella E, Sarchielli P. Headache characteristics in obstructive sleep apnea syndrome and insomnia. Acta Neurol Scand 2005;111:309-316.
34. Gori S, Morelli N, Maestri M, Fabbrini M, Bonanni E, Murri L. Sleep quality, chronotypes and preferential timing of attacks in migraine without aura. J Headache Pain 2005;6:258-260.
35. Kim J, In K, Kim J, et al. Prevalence of sleep-disordered breathing in middle-aged Korean men and women. Am J Respir Crit Care Med 2004;170:1108-1113.