Effect of Sleep-Disordered Breathing on Academic Achievement in Medical Students

Tsuguo Nishijima*, Miki Umetsu, Keisuke Hosokawa, Yoshishiko Kasai, Susumu Takahashi, Tetsuya Kizawa, Fumitaka Mito, Akira Suwabe, and Shigeru Sakurai

Abstract

Background: Obstructive sleep apnea (OSAS) is known to cause excessive daytime sleepiness, resulting in poor academic performance in young children. The present study aimed to determine whether OSAS influences the examination results in medical students.

Methods: Of 95 fifth-year students under a 6-year medical program in our medical university, 94 were enrolled with one exception, who was accidentally absent in the clinical clerkship. All students were instructed to wear a monitoring device overnight at home. The device was retrieved the next day, followed by visual data analysis. Examinations used for the assessment of academic achievement were multiple-choice tests about medical and public health knowledge essential as physicians. They were composed of general questions, clinical questions, and compulsory questions.

Results: Odds ratios (OR) of OSAS for poor achievement by each question type were 3.72 (95% confidence interval [CI], 1.19-11.63; \( P = 0.05 \)) for general questions, 9.18 (95% CI, 0.98-86.0; \( P = 0.07 \)) for clinical questions, and 3.85 (95% CI, 0.85-17.3; \( P = 0.14 \)) for essential questions.

Conclusions: The results of this study suggested that OSAS may adversely affects the achievement of general questions, in which declarative memory is involved, in the medical student population.

Keywords

Obstructive sleep apnea syndrome; Medical students; Examinations; memory

Introduction

Obstructive sleep apnea syndrome (OSAS) is a condition in which marked hypoxemia and/or hypercapnia are repeated due to complete or incomplete obstruction of the upper airway during sleep, thereby resulting in serious organ impairment [1]. An increase in arousal reactions during sleep, in addition to blood gas abnormalities, not only causes cerebral cortical disorders but also decreases concentration and memory due to a lack of deep sleep and fragmented sleep. OSAS is often reported to be associated with memory impairment [2,3].

Naëgelé et al. investigated memory function, in terms of verbal episodic memory, procedural memory, and working memory, in patients with OSAS, reporting that these patients showed abnormal results in episodic memory and procedural memory despite intact maintenance, recognition and forgetfulness, as compared with normal controls [4]. In one study, middle-aged adults with OSAS were reported to show significant impairment in declarative and procedural memory [5]. Another study involving children has shown that OSAS is associated with poor academic performance [6]. Zimmerman et al. reported that a continuous positive airway pressure (CPAP) therapy to patients with OSAS for at least 6 hours per night might improve verbal memory impairment and showed a possibility that this impairment might be reversible [7].

Thus, we investigated the relationships between OSAS and academic achievement on the basis of the results in regular examinations inquiring medical knowledge and judgment, which were performed independently of the present study. Medical students were chosen because they were thought to be a homogeneous young adult population and also to have a relatively similar intellectual ability in cognitive and memory functions.

Methods

Subjects

Of 95 fifth-year students of the Iwate Medical University (under a 6-year medical school program in Japan), 94 (69 men and 25 women; mean age, 24.6 ± 2.9 years; mean body mass index, 22.1 ± 3.0 kg/m²; mean ± S.D) were enrolled. We confirmed that subjects should not have serious mental disorder, drug dependence, alcoholic dependence and insomnia its previous history. One student was excluded because of an accidental absence from the class in the clinical clerkship.

The study was approved by the Ethics Committee of Iwate Medical University School of Medicine.

Sleep study

All subjects were instructed to wear a monitoring device (Smart Watch PMP 300E, PHILIPS RESPIRONICS), corresponding to type 3 according to the American Academy of Sleep Medicine (AASM) criteria, overnight at home (at least six hours) as one of the practices in the clinical clerkship. The device was retrieved the following day. The data were read into the personal computer using a specific software package and visually analyzed by a dedicated medical technologist who was blinded to the subjects' characteristics.

When we instructed explanation of the test result of the student and how to read analysis, we obtained the agreement for using data in this study.

Achievement test

The achievement tests were made according to the guideline of the Ministry of Health, Labour and Welfare in Japan. They were multiple-choice written tests about medical and public health knowledge clinically essential for physicians. They were conducted as regular achievement examinations according to the educational schedule of our university, independently of the present study. The examination

*Corresponding author: Tsuguo Nishijima, MD, Ph.D., School of Medicine, Division of Behavioral Sleep Medicine, Iwate Medical University, 19-1, Uchimaru, Morioka, Iwate, Japan, 020-8505, Tel: 019(651)5111 ext.8495; E-mail: tsuguo@c89.so-net.ne.jp; tsuguo.mei.rei@mac.com

Received: June 02, 2014 Accepted: September 08, 2014 Published: September 11, 2014
The following 5 items were investigated: (1) the prevalence of OSAS in medical students, (2) the proportions of students who failed the achievement tests (failure rates), (3) the proportions of students who failed tests of each question type (general questions, clinical questions, and essential questions) (failure rate by question type), (4) the comparison of scores in the general, clinical, and essential questions by group, and (5) the effect of OSAS on poor achievement in tests of each question type.

A good adherence based on the modified definition by Kribbs et al. [8] into the present study (subjects with use of nCPAP for at least 4 hours per night on 70% of the days and with symptomatic improvement).

Based on the data of the on-board monitor of the CPAP device in subjects receiving an nCPAP therapy, subjects who showed percent days with device usage ≥70% and those who showed percent days with device usage ≥70% for more than 4 hours were assessed as tolerable. On the contrary, subjects who showed percent days with device usage <70% or those who showed percent days with device usage <70% for more than 4 hours were assessed as intolerable.

**Statistical Analysis**

The prevalence of OSAS in medical students and the failure rates in general, clinical, and essential questions both in regular examination and reexamination by the severity of OSAS and also by comparison with controls (students in the non-OSAS group), were determined from the frequency distribution. Odds ratios (ORs) of OSAS for poor achievement were calculated. The mean scores in each group were shown as mean ± S.D. A P value less than 0.05 was considered as statistically significant. StatView 5.0 (Abacus Concepts) was used for analysis of the prevalence and Statmate (Advanced Technology for Medicine & Science) for analysis of the ORs.

**Results**

The prevalence of OSAS in medical students

Data obtained from simple, type 3 monitoring of respiratory states during sleep revealed that 62 (66.0%) students were diagnosed as having no OSAS, 28 (29.8%) were diagnosed as having mild OSAS, 2 (2.1%) as moderate OSAS, and 2 (2.1%) as severe OSAS. The prevalence of OSAS (defined as RDI ≥ 5) in these medical students was 34.0% (32 in 94 students), and the prevalence of treatment-required OSAS (RDI, ≥30) was 2%. Of 32 OSAS students, 2 (6.2%) were diagnosed as having severe OSAS, 2 (6.2%) as moderate OSAS, and 28 (87.0%) as mild OSAS (Figure 2). Both of 2 subjects with severe OSAS had been treated with nCPAP; the student A for one year and the student B for two years. The student A showed percent days with usage ≥70% for more than 4 hours per night on 70% of the days and with symptomatic improvement.

Therefore the treatment of two students was not necessary.

**Assessment**

The following 5 items were investigated: (1) the prevalence of OSAS in medical students, (2) the proportions of students who failed the achievement tests (failure rates), (3) the proportions of students who failed tests of each question type (general questions, clinical questions, and essential questions) (failure rate by question type), (4) the comparison of scores in the general, clinical, and essential questions by group, and (5) the effect of OSAS on poor achievement in tests of each question type.

Subjects are fifth-year students of under 6-year medical school program in Japan. (69 men and 25 women; mean age, 24.6 ± 2.9 years; mean body mass index, 22.1 ± 3.0 kg/m²).

Figure 1: Selection of patients for analysis

The prevalence of OSAS (defined as RDI ≥ 5) in these medical students was 34.0% (32 in 94 students), and the prevalence of treatment-required OSAS (RDI, ≥30) was 2%. Of 32 OSAS students, 2 (6.2%) were diagnosed as having severe OSAS, 2 (6.2%) as moderate OSAS, and 28 (87.0%) as mild OSAS (Figure 2). Both of 2 subjects with severe OSAS had been treated with nCPAP; the student A for one year and the student B for two years. The student A showed percent days with device usage ≥70% and percent days with usage ≥70% for more than

**Selection of patients for analysis**

Of 94 students enrolled in the present study, 62 were classified as the non-OSAS (control) group (respiratory disturbance index [RDI], <5) and 32 as the OSAS group (RDI, ≥5). The subjects in the OSAS group were further divided into the mild subgroup (RDI, 5-15, n = 28) and the moderate subgroup (RDI, 15-30, n = 4) (Figure 1). Furthermore, 2 subjects with RDI ≥ 30 in the moderate subgroup were defined as having severe OSAS. They underwent polysomnography (PSG) at a nearby clinic and began a nasal CPAP (nCPAP) therapy. Because based on the application criteria for the social insurance system of Japan, OSAS patients with apnea hypopnea index (AHI) in PSG of more than 20 events/hr were treated with nCPAP. Two students of moderate group of AHI were less than 20 events/hr. Therefore the treatment of two students was not necessary.

They consisted of three types of questions: 200 general questions, 200 clinical questions, and 100 essential questions. The general questions inquire basic medical knowledge (1 minute per question), the clinical questions inquire clinical practices (2 minutes and 30 seconds per question), and the essential knowledge, basic, learning in medicine to a minimum as a physician (50 general questions in 1 minute per question and 50 clinical practice questions in 2 minutes and 30 seconds per question). All the subjects took the tests at the same time 18 days after completion of the clinical clerkship. The tests were conducted for 4 days. Answers were scored by staff members of the school authorities and a score of 60 or greater in general and clinical questions and a score of 80 or greater in essential question were decided as a passing grade. Common reexaminations were required for unsuccessful students.

Reexaminations were performed in one day a week after completion of the regular tests. The reexaminations consisted of 50 general questions, 50 clinical questions, and 100 essential questions. Answering times were the same with regular tests.

After reexaminations, the students who had passed all three kinds of examinations were permitted to be promoted to the sixth-year grade.

The committee of school affairs of the medical school made the clinical clerkship program and examinations independently of the present study, and no operations related to the study were implemented.

Questions followed a past doctor national examination carried out in Japan and made an original established exam.

The prevalence of OSAS in medical students and the failure rates in general, clinical, and essential questions both in regular examination and reexamination by the severity of OSAS and also by comparison with controls (students in the non-OSAS group), were determined from the frequency distribution. Odds ratios (ORs) of OSAS for poor achievement were calculated. The mean scores in each group were shown as mean ± S.D. A P value less than 0.05 was considered as statistically significant. StatView 5.0 (Abacus Concepts) was used for analysis of the prevalence and Statmate (Advanced Technology for Medicine & Science) for analysis of the ORs.
Frequency distribution was used to determine the prevalence of OSAS in medical students. Prevalence is 34% and Treatment-required rate is 4%.

**Figure 2:** Prevalence of OSAS in medical students.

**Table 1:** Failure rate of examinations.

<table>
<thead>
<tr>
<th></th>
<th>Control group</th>
<th>Mild group</th>
<th>Moderate group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular examination</td>
<td>12.9%(8/62)</td>
<td>25.0%(7/28)</td>
<td>50.0%(2/4)</td>
</tr>
<tr>
<td>Re-examination</td>
<td>12.5%(1/8)</td>
<td>28.5%(2/7)</td>
<td>100%(2/2)</td>
</tr>
<tr>
<td>Assessment for promotion (failure rate)</td>
<td>1.6%(1/62)</td>
<td>7.1%(2/28)</td>
<td>50.0%(2/4)</td>
</tr>
</tbody>
</table>

4 hours and the student B, on the other hand, was intolerable to an nCPAP therapy (Figure 1).

**Failure rates**

The failure rate in the regular examinations was 12.9% in the control group, 25.0% in the mild OSAS group, and 50.0% in the moderate OSAS group, indicating that the higher RDI, the higher failure rate. Eight students in the control group, 2 in the mild OSAS group, and 2 in the moderate OSAS group failed the regular examinations and took the reexaminations. The failure rate in the reexamination was 12.5% in the control group, 28.5% in the mild group and 100.0% in the moderate group, indicating that the failure rate was increased with an increase in the RDI rate. The final decision for promotion was made based both on the scores of the regular examinations and the reexamination and on the learning attitude. The final failure rate for promotion was 1.6% in the control group, 7.1% in the mild OSAS group, and 50.0% in the moderate OSAS group, indicating that a higher RDI is associated with an increase in the failure rate (Table 1).

**Failure rates by question type**

Although the number of the students was too small to obtain conclusive results, of 4 students in the moderate OSAS group, 2 having RDI ≥30 were diagnosed as severe. Moreover, of these two students, one (severe student A) who was tolerable to nCPAP therapy with a normalized RDI after the therapy was defined as normalized, and the other (severe student B) who was intolerable to nCPAP therapy was diagnosed as intolerable. The failure rate of the examinations of general questions was 9.5% in the control group, 50.0% in the mild OSAS group, 50.0% in the moderate group, student A passed after taking CPAP regularly and student B failed as he was not on treatment with possible correlation. The similar trend was shown in the failure rates of the examinations of clinical and essential questions, and in the final failure rate for promotion (Table 2).

**Table 2:** Failure rate of examinations by question type and assessment for promotion.

<table>
<thead>
<tr>
<th></th>
<th>Severe student A (n = 1)</th>
<th>Severe student B (n = 1)</th>
<th>Moderate group (n = 2)</th>
<th>Mild group (n = 28)</th>
<th>Control group (n = 62)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General questions</td>
<td>0.0%(0)</td>
<td>100%(1)</td>
<td>50.0%(1)</td>
<td>25%(7)</td>
<td>9.5%(6)</td>
</tr>
<tr>
<td>Clinical questions</td>
<td>—</td>
<td>100%(1)</td>
<td>50.0%(1)</td>
<td>7.1%(2)</td>
<td>1.6%(1)</td>
</tr>
<tr>
<td>Essential questions</td>
<td>—</td>
<td>100%(1)</td>
<td>50.0%(1)</td>
<td>10.3%(3)</td>
<td>4.8%(3)</td>
</tr>
<tr>
<td>Assessment for promotion</td>
<td>0.0%(0)</td>
<td>100%(1)</td>
<td>50.0%(1)</td>
<td>7.1%(2)</td>
<td>1.6%(1)</td>
</tr>
</tbody>
</table>

**Figure 3A:** Comparison of mean score between OSAS and non-OSAS.

Comparison of scores of general, clinical practice and essential questions among the groups

The total score in three kinds of examinations and each score in general, clinical, and essential questions were compared between the non-OSAS and OSAS groups. The scores in the OSAS group were significantly lower than those in the non-OSAS group (P < 0.05 in the total score, P < 0.01 in general questions, P < 0.05 in clinical questions, and P < 0.05 in essential questions) (Figure 3A).

The OSAS group was then divided using RDI of 15 events/hr as threshold. The total score and each score in general, clinical, and essential questions did not differ significantly between the non-OSAS and OSAS with 5≤RDI<15 groups. However, the total score and each score in general, clinical, and essential questions in the OSAS ≥15 groups were significantly lower than those in both the non-OSAS group and the 5≤RDI<15 group (Figure 3B).
Association between OSAS and poor achievement

An adverse effect of OSAS on test results was investigated in medical students. OSAS was significantly associated with poor achievement in general questions (OR, 3.72; 95% CI, 1.19-11.63; P = 0.05). However, OSAS was not significantly associated with poor achievement in clinical and essential questions, and final assessment for promotion (Table 3).

The effects of OSAS on whether the students finally passed each examination and were promoted to the sixth grade were investigated. OSAS was significantly associated with disqualification in general question (OR, 3.72; 95% CI, 1.19-11.63; P = 0.05). Although p values were close to 0.05, OSAS was not significantly associated with disqualification in clinical and essential questions and final assessment for promotion (Table 3).

Discussion

In this paper, the authors have assessed academic performance in a cohort of Japanese medical students after determining their sleep disordered breathing status with a Type III portable sleep monitor.

Data from the Wisconsin Sleep Cohort study conducted in the state employees in Wisconsin revealed that the prevalence of OSAS, defined as RDI ≥15, was 24% for men and 9% for women. OSAS was suspected in 4% of men and 2% of women who had daytime somnolence.1 In the present study (25 years), the prevalence of OSAS, defined as RDI ≥5, was 34%, and when RDI was ≥30, the prevalence of OSAS was 4%, being similar to the estimates for young adult men(30–60 years) reported by Young et al. [1].

Furthermore, the prevalence of OSAS was 40.0% and 2.6% when defined as RDI ≥5 and RDI ≥30, respectively, for men, and 8.0% and 0.0%, respectively, for women, being more common in men than in women. Thus, although the medical students were chosen, the population in this study was likely to have a disease structure similar to that in the general population.

Sleep is known to play an important role in maintenance of memory. For example, a newly obtained memory is reportedly consolidated during sleep [9,10]. Memory is classified as declarative or procedural. The former is also called explicit memory because it requires conscious recall of learning; the latter is called memory for obtaining certain knowledge or skills through repeated experiences [6]. The former is one of long-term memories and further subdivided into semantic memory and episodic memory [11]. Plihal and Born reported that declarative memory was consolidated during slow wave sleep (corresponding to deep sleep stages 3 and 4) because subjects with sufficient sleep during the first half of sleep dominated by slow wave sleep had a higher memory recall rate and that when slow wave sleep was artificially interrupted, slow wave sleep rarely appeared after sleeping again [12]. In the two-stage model for memory acquisition, memory is formed in the ‘hippocampus’, a part of the brain where memory is easily formed and forgotten and then memory is gradually transmitted to the “cerebral cortex”, a part of the brain where it takes much time to form memory, although memory is not easily forgotten [13].

REM sleep is also said to be involved in memory. Memory consolidation is reportedly inhibited by interruption of REM sleep after learning, suggesting that REM sleep contributes to memory consolidation [14]. Most notably, a recent study pointed out that REM sleep plays an important role in the consolidation of emotional memories [15].

OSAS is a condition characterized by repeated hypoxemia and/or hypercapnia caused by complete or incomplete obstruction of the upper airway during sleep, thereby leading to serious organ impairment [1]. OSAS is often reported to be associated with memory impairment [2,3]. Kloepfer et al. assessed memory performance (procedural mirror-tracing test, declarative visual and verbal memory task) and general neuropsychological performance (neuropsychological test battery) in 15 patients with OSAS with AHI of 19.7 ± 13.7 events/hr and 20 healthy subjects. They reported that OSAS patients showed a reduced consolidation in both of declarative and procedural memories as compared to healthy subjects [5].

In the present study, the achievement results of general questions were thought to reflect semantic memory in declarative memory, that is, conscious recall from stored information; the results of clinical questions were thought to reflect both semantic memory and procedural memory, developed by students in the clinical clerkship. The results of essential questions may have reflected declarative or procedural memory because they were composed of questions asking basic knowledge among general and clinical questions. In students with OSAS, the failure rate increased as the severity of OSAS increased in the process from the regular examinations to the final assessment for promotion. The failure...
rate was 100% in the students with OSAS associated with RDI ≥15 events/hr. According to the question type, the failure rate of clinical and essential questions was 50% in the moderate OSAS group and 100% in the untreated students with severe OSAS. The risk analysis of OSAS in question types revealed that the OR of OSAS for poor achievement in general questions was 3.72, which was statistically significant. OSAS is a condition characterized by a lack of deep sleep and sleep fragmentation due to frequent apnea/hypopnea during sleep. As reported by Phihal and Born et al., [12] when slow wave sleep, which is associated with memory consolidation, is artificially interrupted, it is unlikely to appear after sleeping again. Thus, it is easy to speculate that patients with OSAS have a reduced ability to recall memory, because their deep sleep is interrupted due to apnea/hypopnea. There have been no studies on the association of OSAS with memory or academic achievement in young adults around 25 years of age. The present study is the first to suggest that OSAS is associated with memory impairment even in the young adult population, which is thought to be relatively homogeneous because they had passed a common entrance examination for medical university.

Zimmerman et al. reported that CPAP therapy for at least 6 hours per night might improve verbal memory impairment and thus the impairment might be reversible. In the present study, even a single student who was diagnosed with severe OSAS and appropriately treated with nCPAP acquired the scores similar to those in the control group and successfully passed the examination without problems. Thus, potential memory impairment due to OSAS may be prevented by performing an nCPAP therapy.

Limitation of the Study

The present study suggested that memory impairment associated with OSAS might occur in young adults.

However, overnight polysomnography was not performed in all of the students, and a screening test was merely performed, hampering the study of the association between OSAS and quality of sleep. It is difficult to rule out patients with potential OSAS based on subjective symptoms and medical histories. The study was limited in sensitivity and specificity of the assessment tool for OSAS because only a simple test was used, and normal subjects may have been included in the mild group and vice versa; mild OSAS subjects may have been included in the moderate group.

Furthermore, the present study was a single-year retrospective one; a prospective study over several years is warranted.

Conclusion

As the representative of the young adult population, medical students diagnosed with OSAS may have poorer academic achievement than those without OSAS. This poorer achievement may be associated with OSAS and appears to be improved by therapeutic interventions. In this population, early diagnosis and treatment for OSAS are desirable.

References


Author Affiliations

1Division of Behavioral Sleep Medicine, Iwate Medical University, School of Medicine, Japan
2Department of Neuropsychiatry, Iwate Medical University School of Medicine, Japan
3Department of Laboratory Medicine, Iwate Medical University School of Medicine, Japan

Submit your next manuscript and get advantages of SciTechnol submissions

- 50 Journals
- 21 Day rapid review process
- 1000 Editorial team
- 2 Million readers
- Publication immediately after acceptance
- Quality and quick editorial, review processing