NOTE

Screening of Track Driver’s Sleep Apnea by Objective Measure and Subjective Sense of Sleep Quality

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Abstract: Usefulness of subjective sleep quality assessment by a questionnaire (OSA-MA sleep inventory) was examined in ten track drivers (age, 42 ± 12 y, range, 23-62 y) in reference to the objective measure of sleep apnea by cyclic variation of heart rate (CVHR) in electrocardiogram (ECG) during sleep. Total CVHR suggesting moderate-to-severe sleep apnea (average over total time in bed > 15 cycles/h) was observed only in one subject and the transient occurrence of frequent CVHR (> 50 cycles/h) was detected in the same subject and two other subjects. The questionnaire provided the standardized scores of five features of subjective sleep quality, including less sleepiness on rising, good initiation and maintenance of sleep, less frequency of dreaming, refreshing feeling, and subjective sleep length as factors 1-5, respectively. The subject with high average CVHR showed factor scores < -1 SD for factors 1, 2, and 3 and reported subjective sleepiness during driving. In the two subjects with transient frequent CVHR, one showed factor score < -1 SD for factors 3 and 5, while the other did not show score < -1 SD for any of the factors. Although this is preliminary study in a small sample size, it suggests the possible associations between the subjective assessment of sleep quality and the objective measure of CVHR.

Keywords: Sleep apnea, Cyclic variation of heart rate, Questionnaire, Sleep quality

1. INTRODUCTION

Sleep apnea syndrome [2-4] is an important cause of traffic accident due to drowsiness during driving [5] and its screening is essential and required for all professional drives. However, since the state of sleep apnea may change day by day depending on the driver’s conditions, it is ideal to evaluate apnea state every night before the day of driving as work. For this purpose, a simple, economical, and repeatable method is necessary for screening sleep apnea.

We examined the possibilities of a subjective evaluation by questionnaire and an objective evaluation by electrocardiogram (ECG) [1,6-9] as the method for daily screening for sleep apnea. For the subjective evaluation of sleep quality, we used the questionnaire of the Oguri-Shirakawa-Azumi sleep questionnaire MA version (OSA-MA sleep inventory) [10], which provided standardized scores for five features of subjective sleep quality. For the ECG screening of sleep apnea, we measured the frequency of cyclic variation of heart rate (CVHR) [6] by the method of automated algorithm of auto-correlated wave detection with adaptive threshold (ACAT) [1,11], which was reported to detect moderate-to-severe sleep apnea (apnea-hypopnea index [AHI] ≥ 15/h) with 83% sensitivity and 88% specificity [1].

2. METHODS

2.1 Subjects
The subjects of this study were 10 healthy workers (age, 42 ± 12 y, age range, 23-62 y, 9 men and 1 women) of a transport company. Seven of them were track drivers. The study was performed according to the protocol that has been investigated and approved by the Institutional Review Board of Nagoya City University Graduate School of Medical Sciences and Nagoya City University Hospital (No. 60160133). All subjects gave their written informed consent to participate in this study.

2.2 Protocol
On the day of ordinary work, subjects were explained about Holter ECG recording and were instructed on how to fill out the OSA-MA questionnaire. After that, Holter ECG electrodes and recorder were attached on their chest wall. The ECG was recorded continuously for 24 h including time in bed. When they drove a car/track during the 24 h, they recorded the time of the start and end by pressing the assigned buttons on the remote switch that was connected to the Holter recorder by Blue Tooth. When they felt drowsiness during driving, they also recorded the time by pressing the assigned button on the remote switch. When they got to sleep during the 24 h, they filled out the OSA-MA questionnaire immediately after getting up.
2.3 Measurements

The 24-h ECG was recorded at 125 Hz with Holter ECG recorder with built-in triaxial acceleration sensors (Cardy 303 pico+, Suzuken Co., Ltd., Nagoya, Japan). This recorder included a remote switch (Cardy Memo, Suzuken Co., Ltd., Nagoya, Japan) for event recording, which was used for recording the times of driving and drowsiness in this study.

Subjective sleep quality was assessed with the Oguri-Shirakawa-Azumi sleep questionnaire MA version (OSA-MA sleep inventory) [10]. OSA-MA is a standardized sleep inventory consisted of 16 items of question with a 4-point Likert scale. It provided 5 factor scores concerning sleep qualities: less sleepiness on rising (factor 1), good initiation and maintenance of sleep (factor 2), less frequency of dreaming (factor 3), refreshing feeling (factor 4)), and subjective sleep length (factor 5). The factor scores had been standardized to have average ± SD of 50 ± 10 for the general population [10].

2.4 Data analysis

For each Holter recording, the sleeping period (time in bed) was estimated from the tri-axial acceleration signals indicating that the subject was in a recumbent position. All QRS waves were detected from ECG during the sleeping period and labeled as sinus or ectopic beats or noises with the ECG analyzer (Cardy Analyzer 5, Suzuken Co., Ltd., Nagoya, Japan). Normal-to-normal R-R intervals (NN intervals) were measured as intervals between consecutive QRS waves in sinus rhythm.

CVHR was detected by the automated algorithm of auto-correlated wave detection with adaptive threshold (ACAT; Figure 1) [1]. The ACAT algorithm detects transient tachycardia (dips in NN interval trend) as CVHR when they meet the following criteria: a) a width of 10 to 120 s, b) depth-to-width ratio >0.7 ms/s, c) depth >40% of the 90% CI of local NN interval variations, d) cycle length (inter-dip interval) of 25 to 120 s, e) similar waveforms among 5 consecutive dips (morphological correlation coefficients >0.4) and f) three equivalent consecutive cycle lengths with a tolerance of 22% against the mean cycle length.

We calculated the frequency of CVHR (Fcv) as the average number of CVHRs (dips meeting the criteria) per hour of time in bed. We used Fcv ≥ 15 that had been determined by a previous study [1] as the criterion for identifying subjects with moderate-to-severe sleep apnea. We also calculated the mean of NN interval (MNN) and their SD (SDNN) for the entire time in bed.

3. RESULTS

3.1 CVHR in sleep time ECG

CVHR and other indices from ECG during time in bed are presented in Table 1. Increased Fcv suggesting moderate-to-severe sleep apnea (average >15 cycles/h) was observed only in one subject (008) and transient high Fcv (>50 cycles/h) in a limited time (Fcv max) was detected in the same subject and two other subjects (003 and 006).

3.2 Subjective sleep quality

Subjective sleep quality assessed by the OSA-MA sleep inventory was presented in Table 2. The subject with increased Fcv (subject 008) showed factor scores < -1 SD for 3 factors and reported subjective sleepiness for 3 times during driving. In the two subjects with transient high Fcv max, one subject (006) showed factor score < -1 SD for factors 3 and 5, while the other subject (003) did not show score < -1 SD for any of the factors.

Table 1: Cyclic variation of heart rate (CVHR) in each subject

<table>
<thead>
<tr>
<th>Subject</th>
<th>TIB min</th>
<th>Mean NN ms</th>
<th>SDNN ms</th>
<th>Fcv /h</th>
<th>Fcv max /h</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>279</td>
<td>1030</td>
<td>75</td>
<td>3.6</td>
<td>11</td>
</tr>
<tr>
<td>002</td>
<td>473</td>
<td>1219</td>
<td>157</td>
<td>6.7</td>
<td>33</td>
</tr>
<tr>
<td>003</td>
<td>423</td>
<td>936</td>
<td>116</td>
<td>14.5</td>
<td>50</td>
</tr>
<tr>
<td>004</td>
<td>282</td>
<td>945</td>
<td>104</td>
<td>1.2</td>
<td>11</td>
</tr>
<tr>
<td>005</td>
<td>605</td>
<td>1189</td>
<td>131</td>
<td>5.9</td>
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<td>006</td>
<td>437</td>
<td>996</td>
<td>100</td>
<td>12.3</td>
<td>50</td>
</tr>
<tr>
<td>007</td>
<td>497</td>
<td>895</td>
<td>105</td>
<td>5.3</td>
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<tr>
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<td>949</td>
<td>88</td>
<td>23.5</td>
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</tr>
<tr>
<td>009</td>
<td>113</td>
<td>1013</td>
<td>80</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>010</td>
<td>297</td>
<td>1096</td>
<td>112</td>
<td>7.5</td>
<td>36</td>
</tr>
</tbody>
</table>

TIB = time in bed, NN = normal-to-normal R-R interval, SDNN = standard deviation of NN interval, Fcv = frequency of CVHR.

Figure 1: Trend graph of R-R interval showing cyclic variation of heart rate (CVHR). Vertical gray lines indicate the temporal positions of CVHR detected by auto-correlated wave detection with adaptive threshold (ACAT) algorithm [1].
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Table 2: Subjective sleep quality assessed by OSA-MA sleep inventory

<table>
<thead>
<tr>
<th>Subject</th>
<th>Standardized factor score</th>
<th>Drowsiness</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>F1</td>
<td>F2</td>
</tr>
<tr>
<td>001</td>
<td>53</td>
<td>57</td>
</tr>
<tr>
<td>002</td>
<td>61</td>
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<td>006</td>
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<tr>
<td>009</td>
<td>36</td>
<td>54</td>
</tr>
<tr>
<td>010</td>
<td>44</td>
<td>59</td>
</tr>
</tbody>
</table>

* Factor scores were standardized to have mean ± SD of 50 ± 10. Factor 1 reflects less sleepiness on rising, factor 2 good initiation and maintenance of sleep, factor 3 less frequency of dreaming, factor 4 refreshing feeling, and factor 5 subjective sleep length. Cells marked with orange indicate scores < -1 SD.

Conversely, three subjects (004, 009, and 010) showed < -1 SD factor score for at least one feature of subjective sleep quality, while they had neither increased Fcv nor max Fcv nor drowsiness during driving.

4. DISCUSSIONS

We examined the usefulness of subjective sleep quality assessment by a questionnaire (OSA-MA sleep inventory) in reference to the objective measure by CVHR in sleep time ECG. We observed that subject with increased CVHR suggesting moderate-to-severe sleep apnea reported significantly decreased scores (< -1 SD) of subjective sleep quality including sleepiness on rising, poor initiation or maintenance of sleep, and frequent dreaming. Additionally, one subject with transient increase of CVHR reported significantly decreased scores (< -1 SD) for frequent dreaming and subjective length of sleep. Another subject with high max Fcv, however, reported decreased score for none of the features of subjective sleep quality. Also, three subjects who reported decreased score for at least one feature of sleep quality had increase in neither Fcv nor max Fcv. These observations suggest that there is no consistent relationship between objective measure of sleep apnea and subjective sense of sleep quality. It may be said that the presence of sleep apnea does not always manifest as a subjective decline in sleep quality.

In this study, we used the frequency of CVHR as an objective measure of sleep apnea. In a previous study of 887 consecutive subjects undergone a diagnostic polysonomography, we observed that CVHR measured by the ACAT algorithm with cutoff criteria > 15/h detected patients with apnea-hypopnea index ≥ 15 with 83% sensitivity and 88% specificity [1]. Another previous study among track drivers [11] showed that if Fcv of 15-30/h is observed, the probability that sleep apnea with AHI > 15 exists is 73% and if Fcv is > 30/h, the probability is 100%. Conversely, when Fcv is 10-15/h, the probability that sleep apnea with AHI > 15 exists is 7% and when Fcv is < 10, the probability is 2%. Thus, Fcv is thought to be a useful means of moderate-to-severe sleep apnea for screening the disease.

This study had several limitations. First, the sample size is too small to draw a clear conclusion. Confirmation with larger samples is required. Second, we use CVHR as the objective measure of sleep apnea. CVHR is, however, a surrogate measure of sleep apnea and thus, the presence of sleep apnea in this study was probabilistic and not an actually observed fact. Finally, we used OSA-MA inventory to assess subjective sleep quality. Using other questions may yield different results.

Although this is preliminary study in a small sample size, it suggests that there is no consistent relationship between objective measure of sleep apnea and subjective sense of sleep quality. The presence of sleep apnea may not always manifest as a subjective decline in sleep quality.

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REFERENCES


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