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

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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, 23-62 yr) in reference to the objective measure by cyclic variation of heart rate (CVHR) in electrocardiogram (ECG) during sleep. Total CVHR suggesting moderate-to-severe sleep apnea (average >15 cycles/h) was observed only in one subject and frequent CVHR in a limited time was detected in the same subject and two other subjects. Subjective sleep quality assessed 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 total CVHR showed factor scores <-1 SD for factors 1, 2, and 3 and reported subjective sleepiness during driving. In the two subjects with frequent CVHR in limited time, one showed factor score <-1 SD for factors 3 and 5, while the other subject 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 [1-3] is an important cause of traffic accident due to drowsiness during driving [4] and its screening is essential among professional drives. However, since the state of sleep apnea may change day by day depending on the driver's condition, it is ideal to evaluate apnea state every night before the day of driving. For this purpose, a simple and repetitively-measurable method is necessary for screening sleep apnea. We examined the possibilities of a subjective evaluation by questionnaire and an objective evaluation by electrocardiogram (ECG) [5-9] as the method for daily screening for sleep apnea.

2. METHODS

2.1 Subjects

The subjects of this study were 10 healthy workers (age, 42±12 [23-62] yr, 9 male and 1 female) of a transport company. Seven of them were track drivers.

2.2 Protocol

The protocol of this study has been approved by 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.

On the day of ordinary work, subjects were told about notes on Holter ECG recording and were instructed on how to fill out the questionnaire. After that, they wore Holter ECG electrodes and started working. The ECG was recorded continuously for 24 h. When they drove a car/track during the 24 h, they recorded the time they felt drowsy by pressing the buttons on the remote switch connected to the ECG recorder by Blue Tooth. When they got to sleep during the 24 h, they filled out the 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 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 noise 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 of sinus rhythm. CVHR was detected by the automated algorithm of auto-correlated wave detection with adaptive threshold (ACAT) [9].

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 [9] 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 high Fcv in a limited time (Fcv max) was detected in the same subject and two other subjects (003 and 006).

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

Subject	TIB min	Mean NN ms	SDNN ms	Fcv /h	Fcv max /h
001	279	1030	75	3.6	11
002	473	1219	157	6.7	33
003	423	936	116	14.5	50
004	282	945	104	1.2	11
005	605	1189	131	5.9	36
006	437	996	100	12.3	50
007	497	895	105	5.3	22
008	427	949	88	23.5	58
009	113	1013	80	0.0	0
010	297	1096	112	7.5	36

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

Table 2. Subjective sleep quality assessed by OSA-MA sleep inventory

Subject	F1	F2	F3	F4	F5	Drowsiness
001	53	57	45	49	52	0
002	61	63	58	61	59	2
003	50	45	58	52	59	0
004	43	43	58	47	34	0
005	57	50	58	51	50	0
006	42	41	35	51	35	0
007	43	44	50	51	59	0
008	36	35	38	49	43	3
009	36	54	58	52	27	4
010	44	59	58	38	43	0

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.

2.4 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 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.

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 (<-2 SD) of subjective sleep quality including sleepiness on rising, poor initiation or maintenance of sleep, and frequent dreaming.

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 polysomnography, 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 [9].

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.

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REFFERENCES

[1] Young T, Finn L, Peppard PE, Szklo-Coxe M, Austin D, Nieto FJ, Stubbs R, Hla KM. Sleep disordered breathing and mortality: Eighteen-year follow-up of the wisconsin sleep cohort. Sleep;31:1071-1078, 2008

[2] Punjabi NM. The epidemiology of adult obstructive sleep apnea. Proc Am Thorac Soc;5:136-143, 2008

[3] Somers VK, White DP, Amin R, Abraham WT, Costa F, Culebras A, Daniels S, Floras JS, Hunt CE, Olson LJ, Pickering TG, Russell R, Woo M, Young T. Sleep apnea and cardiovascular disease: An american heart association/american college of cardiology foundation scientific statement from the american heart association council for high blood pressure research professional education committee, council on clinical cardiology, stroke council, and council on cardiovascular nursing. In collaboration with the national heart, lung, and blood institute national center on sleep disorders research (national institutes of health). Circulation;118:1080-1111, 2008

[4] Tregear S, Reston J, Schoelles K, Phillips B. Obstructive sleep apnea and risk of motor vehicle crash: Systematic review and meta-analysis. J Clin Sleep Med;5:573-581, 2009

[5] Guilleminault C, Connolly S, Winkle R, Melvin K, Tilkian A. Cyclical variation of the heart rate in sleep apnoea syndrome. Mechanisms, and usefulness of 24 h electrocardiography as a screening technique. Lancet;1:126-131, 1984

[6] Penzel T, McNames J, Murray A, de Chazal P, Moody G, Raymond B. Systematic comparison of different algorithms for apnoea detection based on electrocardiogram recordings. Med Biol Eng Comput;40:402-407, 2002

[7] Khandoker AH, Palaniswami M, Karmakar CK. Support vector machines for automated recognition of obstructive sleep apnea syndrome from ecg recordings. IEEE Trans Inf Technol Biomed;13:37-48, 2009

[8] Roche F, Celle S, Pichot V, Barthelemy JC, Sforza E. Analysis of the interbeat interval increment to detect obstructive sleep apnoea/hypopnoea. Eur. Respir. J.;29:1206-1211, 2007

[9] Hayano J, Watanabe E, Saito Y, Sasaki F, Fujimoto K, Nomiyama T, Kawai K, Kodama I, Sakakibara H. Screening for obstructive sleep apnea by cyclic variation of heart rate. Circ Arrhythm Electrophysiol;4:64-72, 2011

[10] Yamamoto Y, Tanaka H, Takase M, Yamazaki K, Azumi K, Shirakawa S. Standardization of revised version of osa sleep inventory for middle age and aged. Brain Science and Mental Disorders;10:401-409, 1999