Relationship between Self-rating and Polygraphic Sleep Parameters — Analysis of Compiled Data from 12 Young Japanese Adults —

Tomoyuki KAWADA, KIRYU Yasuo and Shosuke SUZUKI

Department of Public Health, Gunma University School of Medicine, Maebashi

Abstract

An examination of the relationship of the self-rating sleep score to polygraphic sleep parameters was conducted. The self-rating sleep questionnaire, OSA, includes five sleep quality factors: sleepiness (F1), sleep maintenance without interruption (F2), worry about daily life or poor emotional condition (F3), integrated or perceived sleep feeling (F4) and sleep initiation or induction (F5). Polygraphic sleep parameters including each sleep stage in minutes were used. If intercorrelation coefficients exceeded 0.8, only one of the related parameters was selected for multivariate analysis. Twelve male students slept a total of 88 nights, among which the first night was not included, in an experimental room. When absolute values of Spearman's rank correlation coefficient of not less than 0.4 were tentatively selected, the following pairs were extracted: F2 score and S1 (-0.423) or S3+S4 (0.409), F5 score and sleep latency (-0.439). Deeper sleep was closely associated with sleep maintenance without interruption. Agreement between self-rating and a polygraphic sleep parameter was recognized between the F5 score and sleep latency. Each OSA factor score was predicted by other polygraphic sleep parameters using multiple regression analysis. MT significantly contributed to the F1, F3 and F4 scores. The number of stage shifts per night significantly contributed to the F1 and F3 scores, and the number of sleep spindles significantly contributed to the F5 score. Though prediction of sleep quality by polygraphic sleep parameters is limited, the association between concrete subjective and objective sleep parameters was clarified as mentioned above, and their practical meaning was partially elucidated.

Key words: Sleep polygraph, Sleep stage, Self-rating sleep, Awakening, Sleep spindle

Introduction

Difficulty in falling asleep, awakening during sleep, light sleep, difficulty in re-induction of sleep and early awakening are regarded as sleep disturbances when subjects perceive them as being unpleasant.

The usual sleep parameters are mainly self-rating and polygraphic sleep parameters. The former are reported the following morning and some pertinent questionnaires have been recommended¹⁻³⁾. In Japan, Oguri, Shirakawa and Azumi's Sleep Inventory (OSA) is often used⁴⁾. Electroencephalograms (EEG), electrooculograms (EOG) and electromyograms (EMG) obtained

during sleep are recorded mainly to calculate polygraphic sleep parameters.

Awakening during the night and sleep latency are detected by sleep polygraphy and by self-reporting^{5,6)}. Self-reported sleep scores sometimes underestimate the actual value, which is expressed by objective sleep parameters derived from sleep polygraphy⁷⁾.

Previously, the authors reported a case study on the association between subjective and objective sleep⁸⁾. In the report, sleep onset reported by the sleeper himself was strongly related to the sleep latency using sleep polygraphy. In the past, this kind of research has been conducted in Western countries⁹⁻¹²⁾ and the validity of a subjective sleep inventory conducted in Japan has not been assessed. If a standard sleep inventory made up of several factors on sleep feeling is used, the above mentioned relationship will become more comprehensive. To resolve this issue, use of the OSA is appropriate for evaluating the association between subjective and objective sleep.

In actuality, self-rating and polygraphic sleep parameters complement each other, and each parameter reflects a different

Reprint requests to:
Tomoyuki Kawada,
Department of Public Health, Gunma University School of Medicine,
Showa 3-9-22, Maebashi 371, Japan
Tel: 0272-20-8011, Fax: 0272-20-8016
e-mail: kawada@sb.gunma-u.ac.jp

component of sleep. One of the authors reported that objective sleep parameters were not always more sensitive to noise than subjective sleep parameters¹³⁾. In this report, the relationships between the self-rating sleep score and polygraphic sleep parameters were examined. This procedure has the capacity to clarify the relationship of polygraphic sleep parameters and sleep quality, as reported by the sleeper himself, in a sleep study. Furthermore, we speculated as to the mechanisms of agreement and disagreement between subjective and objective sleep in order to derive a preventive strategy aimed at assuring a good night's sleep.

Subjects and Methods

This experiment involved 12 male students aged 19 to 21 years. Alcoholic beverages and napping before the experiment were prohibited.

Each subject went to bed in an experimental room at 11 PM, and got up no later than 7 AM at the prompting of an alarm clock. Total recording time was 8 hours on average. This sleep schedule was not dissociated from the subjects' daily lives. Each subject was paid 10,000 yen per night.

EEG electrodes were positioned according to the international 10-20 method (C3-A2). EEG, EOG at the outer eye canthi, and EMG at the submental muscle were recorded using telemetry (Nihon Kohden Co., Ltd., Tokyo). The sleep polygraphic parameters in this study were sleep Stage 1 (S1), Stage 2 (S2), Stage 3+4 (S3+S4), Stage REM (SR), Movement Time (MT) in minutes, sleep latency (SL), REM latency (RL), total sleep time (TST), awakening during sleep in minutes (TW) and frequency (FW), sleep efficiency (%) (EF), number of stage shifts per night (SFT), REM duration (RD), REM cycle (RC), total number of sleep spindles per night (SP1) and density in minutes (SP2) according to the sleep EEG atlas of Rechtschaffen & Kales¹⁴⁾. Visual judgment of sleep stage in each epoch, which was 20 seconds, was made by an experienced medical doctor, who had been making such judgments for the past 10 consecutive years. Stages 3 and 4 were divided by the percentage of delta waves at 20% of one epoch, but there was a difficulty in distinguishing the two stages even for the sleep specialist. In addition, the percentage of Stage 4 in this study was relatively small. For these reasons, we

combined the two stages into one. SL was defined as time in minutes from lights out until the first appearance of stage 2. Sleep spindles were detected with an original computer system¹⁵⁾. The period-amplitude method was selected for the analysis. Specifically, the frequency was 11.5 to 15.5 Hz with a duration exceeding 0.3 seconds and 10 μ V amplitude. SP2, TST and EF were not used for multivariate analysis, since higher intercorrelation coefficients for each parameter over 0.8 led to multicollinearity. SP1 represented SP2, and SL represented TST and EF.

Five OSA factor scores, sleepiness (Factor 1, F1), sleep maintenance without interruption (Factor 2, F2), worry about daily-life or poor emotional condition (Factor 3, F3), integrated or perceived sleep feeling (Factor 4, F4) and sleep initiation or induction (Factor 5, F5), were used to assess the quality of self-rated sleep. The basis for calculating factor scores was derived from a previous analysis of responses to the sleep inventory by Oguri et al.⁴⁾. The more the quality of sleep improves, the greater is each factor score. The English version of the OSA is shown in the Appendix.

The experiment was conducted from May to July, and October to December, in 1992, 1993 and 1994. The background noise level in the experimental room was Leq 30 dBA. Room temperature did not exceed 28 °C. The humidity was not monitored. Data from the first night were not used for analysis^{16,17)}. Data from 88 night for 12 subjects were pooled to form the database for analysis. Each subject participated in seven or eight experiments. Inter-individual and intra-individual variation should be considered simultaneously to exclude confounding factors. Sex, age, club activity, and the number of experiments were nearly the same for the 12 subjects in this study. As the sample size for stratified analysis was small, all the data were compiled.

Spearman's correlation coefficient (r_s) and multiple regression analysis were selected for analysis using the statistical software program, NAP¹⁸⁾. Each sleep parameter was normally distributed, and no transformation was conducted for the multiple regression analysis.

Results

Spearman's correlation coefficients between the scores of

Table 1 Spearman's rank correlation coefficients between the five OSA factor scores and other sleep parameters

	SP1	SP2	S1	S2	S3+S4	SR	MT	SL
F1	0.212*	0.206	-0.078	-0.026	0.109	0.030	-0.156	-0.061
F2	0.290**	0.298**	<u>-0.423</u> **	0.052	<u>0.409</u> **	0.190	-0.283**	-0.298**
F3	0.205	0.178	-0.076	-0.159	0.276**	0.224*	-0.354**	0.017
F4	0.150	0.142	-0.272*	0.155	0.325**	0.181	-0.251*	-0.342**
F5	0.393**	0.387**	-0.295**	0.187	0.258*	0.225*	0.050	<u>-0.439</u> **
	RL	TST	TW	FW	EF	SFT	RD	RC
F1	0.132	-0.020	-0.085	-0.089	0.019	0.070	0.017	-0.047
F2	-0.063	0.194	-0.115	-0.099	0.266*	0.135	0.107	0.058
F3	0.127	0.036	-0.237*	-0.286**	-0.041	-0.010	0.178	-0.139
F4	0.013	0.289**	-0.126	-0.075	0.314**	0.118	0.060	-0.059
F5	0.096	0.328**	0.014	0.039	0.350**	0.176	0.057	0.027

Absolute values over 0.4 are boxed.

SP1, total number of sleep spindles; SP2, spindle density per minute; S1-4, stage 1-4 in minutes; SR, stage REM in minutes; MT, movement time in minutes; SL, sleep latency; RL, REM latency; TST, total sleep time; TW, awakening in minutes; FW, frequency of awakening; EF, sleep efficiency (%); SFT, number of stage shifts per night; RD, REM duration in minutes; RC, REM cycle in minutes. Other abbreviations are listed in the Appendix.

*, $p < 0.05$; **, $p < 0.01$

Table 2 Contributions of objective sleep parameters to each OSA factor using multiple regression analysis

	Standardized partial regression coefficient				
	F1	F2	F3	F4	F5
SP1	0.169	0.179	0.158	0.116	0.343**
S1	-0.107	-0.246	0.107	-0.152	-0.189
S2	-0.027	0.023	0.058	0.164	0.107
S3+S4	-0.403	0.179	-0.149	-0.038	-0.014
SR	-0.366	-0.098	0.118	0.090	-0.047
MT	-0.378*	-0.127	-0.403**	-0.259*	-0.026
SL	-0.291	-0.243	0.016	-0.195	-0.331
RL	-0.079	-0.108	0.015	0.034	-0.003
TW	0.259	-0.033	0.248	0.010	0.226
FW	-0.127	0.002	-0.191	-0.065	0.128
SFT	0.452*	-0.124	0.373*	0.162	-0.020
RD	0.409	0.128	0.242	0.050	0.210
RC	-0.336	-0.053	-0.283	-0.183	-0.243
R ²	0.161	0.381	0.265	0.371	0.383
Significance		**	*	**	**

Some parameters, which were deleted from the analysis, had intercorrelation coefficients exceeding 0.8, leading to the problem of multicollinearity.

R²: Coefficient of determination, Other abbreviations are listed in the Appendix and Table 1. *, $p < 0.05$; **, $p < 0.01$

the OSA and those of other sleep parameters are listed in Table 1. No significant relationships between OSA factor scores and RL, RD, RC, SFT or S2 were recognized. When an absolute r_s of not less than 0.4 was tentatively selected, the following pairs showed correlations: F2 score and S1 (-0.423) and with S3+S4 (0.409), and F5 score and SL (-0.439). The F5 score and SL showed a fairly good correspondence between self-rated sleep and polygraphic sleep.

Each OSA factor could be predicted by other objective sleep parameters using multiple regression analysis (Table 2). The coefficients of determination of F2 to F5 were all significant, although relatively low. Self-rated sleep scores such as F1 and F3 appeared to be difficult to predict by other sleep parameters. MT significantly contributed to the F1, F3 and F4 scores. SFT significantly contributed to the F1 and F3 scores. SP1 significantly contributed to the F5 score. These results differed somewhat from those obtained by simple statistical analysis.

Discussion

This study showed a partial though significant correlation between OSA factor scores and polygraphic sleep parameters. Some of the polygraphic sleep parameters also correlated significantly with each OSA factor score using multiple regression analysis. The highest coefficient of determination or square value of the correlation coefficient was under 0.2, however, and the highest multiple coefficient of determination or square value of the multiple correlation coefficient was under 0.5. There is also a limitation in predicting sleep quality by polygraphic sleep parameters, and some dissociation between the results of simple and multivariate analyses was recognized. We therefore must consider

the psychophysiological meaning if a significant result is obtained by simple or multivariate analysis.

Lewis reported the relationship between self-rating and polygraphic sleep parameters to be weak in terms of TST, SL and the number of awakenings⁹. In contrast, Spearman's correlation coefficient showed that subjective sleep initiation or induction (F5 of OSA) had highly significant associations with objective sleep parameters, especially with sleep latency. The memory of good sleep initiation or induction was retained until the next day. Stage 3+4, total sleep time and sleep efficiency were also associated with F5. Considering the latter result, early sleep initiation or induction may partly be related to long, deep and restful sleep. The association between SP1 and sleep initiation or induction (F5) can be explained by the earlier onset of S2. Chan et al. reported that those subjectively experiencing good sleep have longer sleeping durations than those who sleep poorly¹⁰. As to this point, our data showed TST to have a significant association with sleep initiation or induction (F5) in the OSA.

Integrated or perceived sleep feeling (F4 of OSA) appeared to have a relationship with objective sleep parameters, as did F5. That is, Stage 3+4, total sleep time and sleep efficiency were associated with F4. Decreased MT also related to a feeling of having experienced good sleep. An integrated or perceived feeling of having experienced good sleep may be related to long, deep and restful sleep.

Eberhardt et al. and Bonnet et al. reported increases in awakening with subjective worsening of sleep^{11, 12}. We recognized the same results, such as worry about daily-life or poor emotional condition (F3), by r_s . Decreased MT contributed to ameliorating worries. This result shows that intermittent awakening affects emotional condition the next day.

Spindles function to maintain sleep¹⁹. This fact was reconfirmed in our study by the association of F2 with SP1 and with SP2. The relationship between the number of frequency of awakenings and F2 was however, found to be weak. Stage 3+4 and sleep latency were associated with F2. Sleep maintenance without interruption may be related to early sleep onset and deep sleep.

As to awakening within several minutes, there is a possibility that subjects cannot make this identification and that daytime profound sleepiness occurs if the frequency increases²⁰. In our study, there was no association between sleepiness (F1) and either TW or FW. Decreased MT did, however, contribute to decreased sleepiness.

Polygraphic sleep parameters monitored during sleep are regarded as primary indicators while self-rated sleep the following morning is secondary. In general, polygraphic sleep parameters and self-rated sleep differ in meaning^{21, 22}. The quantitative relationship between the two may be essential to the assessment of sleep quality.

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Appendix Each OSA sleep inventory item and its relation to five OSA factors

Items	Factor number		Factor number
1) Slept well last night	F4	16) Not worrying about sleep last night	F2
2) Readiness to respond to this sheet	F1	17) Sleep time last night was adequate	F4
3) Bedding comfortable last night	F2	18) Able to concentrate this morning	F1
4) Feeling well this morning	F3	19) Not worried about sound and light last night	F2
5) Everything seems to be going well today	F3	20) Recovered from fatigue this morning	F1
6) Good quality of sleep	F4	21) Less tossing and turning in bed	F2
7) Good appetite this morning	F1	22) Have vitality this morning	F1
8) Fell asleep quickly last night	F5	23) Good physical condition this morning	F1
9) Good mood this morning	F1	24) Comfortable temperature and humidity last night	F5
10) Took a short period to become clear-headed	F1	25) Not worrying excessively this morning	F3
11) Feeling stress-free this morning	F1	26) Had a deep sleep last night	F2
12) Low frequency of awakening last night	F2	27) Not getting irritated this morning	F3
13) Refreshed this morning	F1	28) Not feeling inflexible	F3
14) Good feeling this morning as a whole	F1	29) Sleep latency was short	F5
15) Not sleepy this morning	F1	30) The amount of dreaming last night	

F1 to F5 are the five OSA factors; sleepiness, sleep maintenance without interruption, worry about daily-life or poor emotional condition, integrated or perceived feeling of having experienced good sleep, and sleep initiation or induction.

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