LETTERS TO THE EDITOR

Relationship between Sleep Variables and Urinary Excretion of Adrenaline in Nocturnal Sleep

Key words: Adrenaline excretion—Sleep variables—Nocturnal sleep

Urinary excretion of adrenaline during sleep is thought to be low.¹⁾ However, adrenaline excretion in day sleep has often been noted to be high.^{2,3)} Day sleep is characterized by shorter sleep length, a large number of awakenings and an increased amount of stage 1 sleep.^{4,5)} Torsvall *et al.*⁶⁾ showed that high adrenaline excretion during day sleep was associated with shorter sleep length, longer sleep latency and less stage 4 sleep.

Recently we examined the relationship between urinary excretion of adrenaline and sleep efficiency under prolonged bed-rest conditions for one week.⁷⁾ Adrenaline excretion during time allotted for sleep was negatively correlated with sleep efficiency. The study suggested that adrenaline excretion could be an effective indicator of sleep disturbance.

We attempted to examine the relationship between sleep efficiency and the urinary excretion of adrenaline during usual nocturnal sleep. We also examined the relationships between the stages of sleep and adrenaline excretion.

This experiment was performed on six healthy male subjects (aged 21–23 years). The subjects came to the laboratory at 20 : 00 and urinated at 23 : 00 before they went to bed. We collected urine at 7 : 00 after they got up. They were instructed not to engage in any hard physical exercise during the daytime.

Electroencephalograms, electromyograms and electro-oculograms were recorded for seven consecutive nights. Sleep stages were scored according to the criteria of Rechtschaffen and Kales.⁸⁾ Sleep efficiency was defined as the percentage of total sleep time to time in bed. The amount of free adrenaline in the urine for eight hours was measured by high-performance liquid chromatography with fluorometric detection using the trihydroxyindole method.⁹⁾

Table 1 shows mean values, standard deviations and coefficients of variation of sleep efficiency and adrenaline excretion for each subject and across all subjects for one week. Table 2 shows Pearson product moment correlation coefficients between adrenaline excretion and sleep efficiency for each subject and across all subjects. The group mean correlation coefficient was not significantly negative between sleep efficiency and adrenaline excretion, though three of the subjects showed a negative correlations. Subjects 2 and 5 who did not have a negative correlation showed that the coefficients of variation of adrenaline excretion were small (Table 1). In addition, their sleep efficiency was more than 90%. Subjects

Table 1. The mean values, standard deviations and coefficients of variation of sleep efficiency and adrenaline excretion

		Sub. 1	Sub. 2	Sub. 3	Sub. 4	Sub. 5	Sub. 6	Group ^a
Sleep efficiency (%)	Mean	94.4	91.8	84.4	94.6	97.8	88.4	91.9
	S.D.	4.9	4.3	9.1	3.8	1.2	14.9	4.8
	C.V.	5.2	4.7	10.8	4.0	1.2	16.9	5.2
Adrenaline excretion (ng/min)	Mean	1.32	1.71	0.96	1.04	0.86	1.25	1.19
	S.D.	0.38	0.15	0.37	0.25	0.10	0.84	0.31
	C.V.	28.8	8.8	38.5	24.0	11.6	67.2	26.1

^a Group shows the values across six subjects.

Table 2. Correlation coefficients between sleep efficiency and adrenaline excretion, and between each stage and adrenaline excretion

Variables	Correlation coefficients within each subject ^a						Group mean ^b correlation
	Sub. 1	Sub. 2	Sub. 3	Sub. 4	Sub. 5	Sub. 6	
Adrenaline excretion vs sleep efficiency ^c	-0.64	0.75	-0.91**	-0.96***	0.04	-0.97***	-0.45±0.70
Adrenaline excretion vs stage awake	0.64	-0.75	0.91**	0.96***	-0.04	0.97***	0.45±0.70
1	0.14	0.78*	0.47	-0.81*	-0.22	0.60	0.16±0.60
2	-0.60	0.58	-0.78*	-0.68	0.12	-0.86*	-0.37±0.58
3+4	0.27	-0.61	-0.25	0.46	0.24	-0.94**	-0.14±0.56
REM	0.03	0.56	-0.60	-0.17	-0.17	-0.91**	-0.21±0.51

^a The number of samples within each subject is seven. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. This probability indicates reliability of correlation within each subject.

^b The group mean correlation shows average correlation coefficients across six subjects. Mean±Standard deviation. The probability of the group mean correlation was evaluated at 0.05 significance level by using zero μ t test.

^c A negative correlation between sleep efficiency and adrenaline excretion means a positive correlation between stage awake and adrenaline excretion.

3 and 6 who had a significant negative correlation showed that the coefficients of variation were large in adrenaline excretion and sleep efficiency. The failure to observe a negative correlation between sleep efficiency and adrenaline excretion, might have been due to the fact that the range of adrenaline excretion was narrow and sleep efficiency was high.

Subject 3 urinated within approximately two hours after going to bed on three nights during the week. His urine samples taken in the middle of the time in bed were mixed with the sample taken at the end of the time in bed. He had difficulty in initiating and maintaining sleep. His sleep efficiency ranged from 73.8% to 95.0%, and adrenaline excretion ranged from 1.40 ng/min to 0.44 ng/min. The first night effect was observed in subject 6. His sleep efficiency on the first night was 55.2% and adrenaline excretion was 3.14 ng/min. The mean

value of his sleep efficiency for the other six days was as high as 93.9%, and adrenaline excretion was as low as 0.93 ng/min. Urinary excretion of adrenaline at night was high during disturbed sleep. The results for subjects 3 and 6 supported those of our previous study that adrenaline excretion could be an effective indicator of sleep disturbance.

The relationship between each stage and adrenaline excretion were examined (Table 2). The relationship between stage awake and adrenaline excretion was opposite to that between sleep efficiency and adrenaline excretion. The group mean correlation coefficients were not significant between each stage and adrenaline excretion.

In this study, we did not observe any negative correlation between sleep efficiency and adrenaline excretion. Torsvall *et al.*⁽⁶⁾ reported that adrenaline excretion in night sleep was not related to sleep length, sleep latency, the number of stage shifts, the number of awakenings and the stages of sleep. However, our study of prolonged bed-rest showed that there was a negative correlation between sleep efficiency and adrenaline excretion at night.⁽⁷⁾ The mean value of sleep efficiency during the prolonged bed-rest (65.6%) was lower than that during usual nocturnal sleep (91.9%). It is inferred from the results of subjects 3 and 6 that urinary excretion of adrenaline at night is negatively correlated with sleep efficiency when sleep is disturbed during usual nocturnal sleep.

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