

EFFECTS OF A WEAK DIFFUSE-BRAIN-STIMULATION ON INSOMNIACS WITH VIBRATION SYNDROME

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Key words: sleep, insomnia, diffuse-brain-stimulation, vibration syndrome, human

Abstract. To verify the efficacy of a weak diffuse-brain-stimulation (DBS) method that was specially devised by this research team, a weak DBS was administered to seven male inpatients, who had vibration syndrome due to a prolonged use of a vibratory tool and who were simultaneously complaining of insomnia. Sleep data obtained from the polygraphic recordings on the DBS-treated night were compared with those on the pseudo DBS-treated. As the result, this DBS method proved to be effective in improving patients' sleep initiation and/or maintenance, and also their subjective ratings on the quality of actual sleep. In conclusion, the present DBS was determined to produce a decrease in the sympathetic tone which is needed at the onset of sleep.

Since the works of Gilyarowskii et al. (7), electrosleep therapy has been used for the treatment of several neuroses, insomnia, hypertension, etc. in several countries (5, 8, 19). However, some investigators questioned its effect because of its verbal and/or environmental suggestibility (2, 3, 24). Lately, from the studies of electrosleep on cats, a weak diffuse-brain-stimulation (DBS) was effective to produce sleep through the skull (13, 20). This DBS method was also validated in improving insomnia and essential hypertension in humans (16, 17).

Patients with vibration syndrome (VS) due to a chronic exposure of vibration hazard to the body have often insomnia as a chief complaint

(10, 23). In this study, the present DBS method was preliminarily applied to determine whether it serves to alleviate insomnia in patients with VS.

Subjects were seven male inpatients (age: 45.4 ± 12.8 years) in Tokushima Kensei Hospital who were diagnosed to have VS and received insurance benefit under the Industrial Injuries Act. They had not taken any medications for several days before each night of polygraphic recording. All-night polygraphic recordings were made three nights weekly on each subject in the sleep laboratory. For electrode placements and electroencephalogram (EEG) and electro-oculogram recording techniques, the conventional method (18) was adopted. The monitorings were continuously made on a 13-channel EEG apparatus (NEC San-ei Instruments, Ltd.: 1A 52A) at a paper speed of 15 mm/s with simultaneous recording of skin temperature and respiration, as well as heart rate and electromyogram of the mental muscle. After spontaneous awakening in the morning, all subjects reported their self-ratings of the quality of actual sleep on a scale from 1 to 10, 1 being very poor and 10 being excellent.

A weak DBS was delivered from an electrical stimulator, which was newly devised by this research laboratory in cooperation with Homer Ion Laboratory of Tokyo, Japan. Using this stimulator, animal and healthy human experiments showed both effectiveness and safety for inducing sleep as reported in detail elsewhere (4, 14, 16, 17, 20, 21). The stimuli consisted of rectangular pulses (1-3 V, 0.5 ms), its frequency gradually decreasing from 14 to 0 Hz for 187 s (16, 17).

The subjects received the stimuli once or twice before sleep in the bed and a few also in the awakening during sleep on the third night. The pseudo-stimulation based on a single blind method was adopted for use as a control experiment of the present study, in which the pseudo-DBS was identical with the active one except for the output lead from the stimulator being disconnected. The actual situation for the pseudo-DBS to the patients was quite same as for the DBS-treated patients.

The sleep records were scored minute by minute according to the classification of sleep stages by Rechtschaffen and Kales (18). The results obtained from the DBS-treated night in each subject were compared with those from the pseudo DBS-treated one. The first night recordings were excluded from this analysis because of the first night effect (1). The statistical significance of difference was evaluated for matched pairs by the Student's *t* test or Wilcoxon Test.

The results are presented on Tables I and II. In comparison with normal data of the same age group by Williams et al. (25), the patients M.N., H.U., M.D., T.O. and E.O. seemed to be insomniacs of having difficulties

in getting sleep, because of showing a long latency to sleep spindles; while patients K.N. and M.Y. seemed to be normal sleepers, because of their normal occurrence rate of each sleep stage, a normal latency to sleep spindles and also fairly high subjective ratings of sleep evaluation (Table I). In the case of patient M.Y., he slept very well in the sleep laboratory, and gave a subjective rating of sleep of 10; whereas he had been chronically complaining of insomnia at the hospital.

In the sleep parameters from the DBS-treated night (Table II), the occurrence rate of awakening during sleep was decreased in six out of seven cases. Patient T.O., the only exception, reported sleep interruption by the DBS when the stimuli were administered upon awakening during sleep on the DBS-treated night. The occurrence rate of stage 1 sleep tended to decrease on the DBS-treated night. Furthermore, in the above-mentioned five insomniac patients, the latency of sleep spindles on the DBS-treated night shortened prominently in comparison with that on the pseudo DBS-treated one ($P < 0.05$, Wilcoxon Matched Pairs Test). Also, subjective self-ratings were increased significantly ($t(5) = 3.102$, $P < 0.05$, paired t -test). Patient M. D. reported the same excellent ratings on both nights, but he indicated that he felt better on the DBS-treated night as though he took a sleeping pill. And rapid-eye-movement (REM) sleep latency shortened on the DBS-treated night in the same patient. In

TABLE I

Sleep parameters in pseudo DBS-treated patients with vibration syndrome. 1, sleep period time, the time from the onset of sleep to final morning awakening. 2, total sleep time, the time from sleep onset to morning awakening, after the time awake during the night is subtracted. 3, latency from the beginning of dimness. 4, self-rating of the quality of actual sleep on a scale from 1 (very poor) to 10 (excellent)

Subject	M.N.	H.U.	M.D.	T.O.	E.O.	K.N.	M.Y.
1. SPT (min)	383	320	289	568	500	514	428
2. TST (min)	309	289	255	451	325	466	367
% of SPT							
Wake	19.32	9.69	11.76	20.60	36.00	9.34	14.25
Stage 1	36.29	16.88	13.84	17.08	18.40	10.70	12.38
Stage REM	16.45	19.69	17.99	15.49	11.60	26.07	25.47
Stage 2	15.93	52.80	32.19	45.07	26.00	41.05	47.67
Stage 3	4.44	0.94	19.38	1.76	6.60	10.70	0.23
Stage 4	7.57	0	4.84	0	2.40	2.14	0
3. Latency (min)							
Spindle	25	121	38	33	20	6	12
Stage REM	163	180	86	156	207	114	83
4. Rating of sleep	3	2	10	2	3	8	10

TABLE II

Sleep parameters in DBS-treated patients with vibration syndrome. Abbreviations: same as in Table I

Subject	M.N.	H.U.	M.D.	T.O.	E.O.	K.N.	M.Y.
SPT (min)	434	332	310	429	469	520	392
TST (min)	401	295	302	273	414	498	371
% of SPT							
Wake	7.60	8.39	2.58	36.36	11.73	4.23	5.36
Stage 1	21.20	19.25	11.61	12.59	15.57	16.92	11.99
Stage REM	21.20	17.39	25.16	9.09	28.14	22.31	25.26
Stage 2	39.17	45.03	32.91	41.73	41.36	43.85	57.39
Stage 3	4.15	9.94	23.55	0.23	2.99	7.69	0
Stage 4	6.68	0	4.19	0	0.21	5.00	0
Latency (min)							
Spindle	8	31	27	27	14	28	12
Stage REM	82	91	108	177	179	170	74
Rating							
of sleep	6	7	10	6	5	7	10

the case of patient K.N., an experimenter entered the bedroom when the patient voiced something during DBS before sleep on the third night. This disturbance affected the patient to prolong the latencies to sleep spindles and stage REM. No side effects of the present DBS were observed in any subject.

In the early period, VS had been mainly thought to be a disorder of peripheral motor function. Thereafter, several investigators reported some disfunctions of the central nervous system in VS. Recently, Matsumoto et al. (13) and Morita et al. (15) noted that patients with a severe case of VS frequently had insomnia and biogenic impotence, which are considered to be troubles of the central nervous system. Matsumoto (11) also indicated the appearance of the spindle-formed fast waves during REM sleep, which Takamatsu and Matoba (22) had already found to be around 25 Hz EEG waves during Non-REM sleep. As clinical symptoms, VS shows overall a sympathicotony with the increase in sweating of the palm, Raynaud's phenomenon resulting from the contraction of the peripheral blood vessels, etc. According to the pharmacological examinations of autonomic functions, patients with VS showed an increase of sympathetic or parasympathetic tone (6). Matsumoto et al. (13) and Morita et al. (15) found no flexible changes in the hand skin temperature during sleep of patients with VS and pointed out that VS showed the loss of a supple response in sympathetic activity.

From the study of the hand skin temperature at the sleep-onset period in healthy humans, Matsumoto et al. (12) concluded that Non-REM sleep occurred from a relatively parasympathicotonic state as the result

of a decrease in sympathetic tone. Animal experiments by the same research group had led to an understanding that the sleep inducement of the present DBS is due to decrease sympathetic tone caused by inhibiting the sympathetic systems in the brain (14, 20). The reesearch group also verified that the mild DBS through the cat skull produced slowing of the EEG frequency in the hypothalamus and hippocampus, and also verified that sleep occurred after the DBS even faster than in case of the stimulation to the ventro-medial hypothalamic nucleus (14, 20). Recently, the other researchers also showed that the low frequency and low voltage DBS caused EEG slowing in humans (9). Actually in human beings, this DBS method was effective in improving insomnia and essential hypertension (16, 17), as well as in facilitating daytime sleep in normal healthy adults, especially in shortening the sleep latency (4, 21). In these experiments, the researchers also confirmed that the effect of the DBS method was not due to the placebo effect by adopting a single or double blind cross-over design. In the present study, the DBS method also improved the initiation and/or maintaining of sleep, and a subjective rating of sleep. Considering all the results and findings, this DBS treatment for insomniacs with VS can be said to work effectively for improving the reactivity in sympathetic activity.

In conclusion, the present DBS assists artificially to decrease the sympathetic tone, especially in those whose body system has difficulty in doing this automatically, and which is needed to initiate sleep at the sleep-onset period.

The authors would like to thank Ms. Mae F. Sakamoto for her revision of the English text.

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