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Circadian Rhythm Disorders in Sleep–Waking and Body Temperature in Elderly Patients with Dementia and Their Treatment

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Summary: Circadian rhythms in elderly patients with severe dementia and behavioral disorders such as wandering, agitation and/or delirium were examined. The subjects consisted of 24 patients with dementia (5 with senile dementia of Alzheimer's type and 19 with multi-infarct dementia), aged 56–89 ($\bar{x}$ = 75.5 ± 8.7) and 8 control patients without dementia or with dementia of slight degree, aged 65–81 ($\bar{x}$ = 75 ± 5.4). The sleep–wake state of the patients was judged every hour by nurses over periods of 1–4 mo and recorded in the form of a sleep diary. Oral temperature was recorded for 4–7 consecutive days. For the treatment of sleep–wake rhythm disorders, social interaction with nurses was encouraged in addition to drug therapy. The patients showed various types of sleep–wake disorders such as reversed day–night rhythm or irregular sleep–wake rhythm corresponding to a decreased amplitude of the sleep–wake rhythm. Circadian rhythm of oral temperature was irregularly disturbed in 59.0% of the patients in the dementia group and in only 12.5% of the patients in the control group. The effects of treatment by enforcement of social interaction with nurses was effective in reducing behavioral problems and sleep–wake rhythm disorder in 30.0% of the patients tested. However, body temperature rhythm disorganization remained after the treatment. These observations indicate that behavioral disorders such as delirium, agitation or wandering in patients with severe dementia might be closely related to disrupted biological rhythms of sleep–waking and the autonomic system (body temperature). **Key Words:** Circadian rhythm—Sleep–Wake rhythm—Body temperature—Dementia—Social zeitgeber.

With increasing age, humans develop various types of sleep disturbances such as fragmented sleep–wake rhythm, numerous daytime naps and appreciable time spent awake at night, together with increasing numbers of awakenings from sleep. Elderly patients with dementia due to organic brain syndrome, such as senile dementia of Alzheimer's type (SDAT) or multi-infarct dementia (MID), are especially likely to show reversed night–day sleep–wake cycle in some cases. These patients also exhibit numerous behavioral disorders during time awake, such as wandering, aggressiveness, agitation, violent behaviors, purposeless behaviors and/or delirium. Such disturbances pose nursing problems in the geriatric hospital, leading to frequent use of sedative drugs as a last resort. Several factors have been implicated as causes of disturbed sleep–wake rhythms in dementia: (1) sensory deprivation during the day and absence of social stimulation, (2) lack of daytime physical and mental exercise, leading to tiredness in evening and sound sleep at night and (3) organic factors such as insufficient supply of oxygen to the brain during sleep, with ensuing emergency reactions leading to arousal.

The aims of the study were to reveal the type of sleep–wake rhythm disorder in elderly demented patients through use of prolonged behavioral observations and to relate these observations to body temperature (BT). Furthermore, as a trial for treatment of sleep–wake rhythm and behavioral disorders in patients with severe dementia, we studied the effects of social interaction with nurses and outdoor walking in the daytime.

SUBJECTS AND METHODS

The subjects consisted of 24 patients with dementia, aged 58–89 ($\bar{x}$ = 75.5 ± 8.7) and 8 patients without dementia or with dementia of a slight degree, aged 65–81 ($\bar{x}$ = 75.0 ± 5.4), as controls. The patients were admitted to a geriatric ward in Kyowa Hospital. The

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controls consisted of individuals at the same hospital who suffered from hypertension or heart disease without any sleep disorders. The patients were selected because of the irregularity of their sleep–wake rhythm in conjunction with behavioral disorders and/or delirium. Patients with sleep apnea as defined behaviorally (1) were not included in the study. Consent for participation was obtained from patients or their nearest relatives. Patients who reacted with obvious anxiety and distress at any time during the study were excluded.

The clinical diagnosis of dementia was made according to: 1) the clinical course, i.e. whether the progress of the dementia was smooth, suggesting SDAT, or whether it followed a fluctuating course, suggesting MID; 2) clinical history of hypertension or evidence of vascular brain disease, on computerized tomographic (CT) scan, indicating MID and 3) focal neurological deficits. Demented patients were classified into two groups, probable SDAT (subsequently called SDAT, n = 5) and probably MID (subsequently called MID, n = 19). The clinical features of the 24 patients in the dementia group are shown in Table 1.

The degree of dementia as measured by Hasegawa's test (2) or the Suzuki–Binet test was moderate or severe. Hasegawa's test is designed for clinical assessment of dementia in elderly people. It consists of 11 questions and is considered to be a reliable screening test for dementia. Most patients were totally dependent on nursing staff for bathing, dressing, grooming, mobility or cognition. Eighteen of 24 patients in the dementia group had incontinence problems that were controllable with scheduled bowel and bladder programs. Seventeen of 24 patients took cerebroactive drugs or cerebral vasodilators and 5 of them occasionally took sedatives, hypnotics or antidepressants. Delirium was diagnosed according to Diagnostic and Statistical Manual of Mental Disorders (DSM)-III. All subjects with delirium were free of congestive heart failure, hepatic or renal diseases, cancer, infection or any other physical illness or medication known to cause delirium.

During the observation period, patients were asked to follow a daily ward schedule; meals were provided at 0700, 1130 and 1830 hr, and light snacks were given at 1500 hr. Patients were asked to stay in bed 10 min before temperature measurements were made, and oral temperature was measured with the nurse in attendance.

The sleep–wake state and behaviors of the patients were observed hourly by nurses on consecutive days for 1–4 mo, and these observations were recorded in the form of a sleep diary. The mean and range of days of observation were 59.2 ± 14.5 days and 28–84 days, respectively. The mean and range of number of observations were 1,441 ± 338.4 and 627–2,016, respectively. Oral temperature was recorded at 0000 hr, 0400 hr, 1000 hr and 1800 hr for 4–7 consecutive days (mean 6.1 ± 1.2 days) during the period of sleep–wake observation. In order to examine the accuracy of oral temperature, simultaneous monitoring of rectal temperature for 3 days was made in three subjects in the control group and in two patients in the dementia group. For the evaluation of circadian sleep–wake rhythm, sleep was summed each hour for 24 hr during the observation period, and nocturnal sleep distribution was calculated in percent according to night-sleep hours during the scheduled lights-out period from 2100 hr to 0600 hr.

Because the number of BT measurements was not satisfactory to apply customary methods such as cosinor analysis for evaluation of circadian rhythmicity, we employed the following method. A disorganization in BT rhythm was defined in reference to the time of the BT curve peak. If the peak time of BT appeared at the same recording time less than five times for 7 consecutive days, disorganization in BT rhythm was considered to be present. Otherwise the BT rhythm was considered to be intact.

For treatment of sleep–wake rhythm and behavioral disorders, social interaction with nurses was systematically maintained for 1–2 mo. Nurses attended a patient individually, talking to him, engaging him and walking outdoors with him etc. for 3 hr from 0900 hr to 1100 hr and from 1400 hr to 1500 hr. During the treatment period, sleep–wake observation continued, and in the last week of the treatment BT was measured the same way as before treatment.

RESULTS

Sleep-wake rhythm

The patients in the dementia group showed various types of sleep–wake rhythm disorders, whereas the patients in the control group showed a regular sleep–wake rhythm. The sleep–wake rhythms of representative cases are shown in Fig. 1. Patient 30 in the control group represented consolidated night sleep with regular naps in the daytime (Fig. 1, upper left). Patient 5 in the dementia group showed a reversed day–night sleep–wake rhythm, and wandered at night, awakening other patients and shouting to the nursing staff (Fig. 1, lower left). Patient 1 showed an irregular sleep–wake rhythm, i.e. sleep onset time and waking time changed day by day, and several naps unexpectedly appeared in the daytime. The patient also showed behavioral disorders such as wandering, agitation and delirium frequently during both the day and the night (Fig. 1, right). Patient 1 slept mostly at night, although he had several sleep-

TABLE 1. *Clinical features of demented patients*

Patients				Degree of	CT findings			EEG findings		
No.	Name	Age/sex	Diagnosis	dementia	CA	DV	INF	(degree of abnormality)		Behavior disorders
1	IJ	84 M	MID	+++	+	++	+	6–7 Hz θ	(++)	Wandering at night, violent behaviors
2	MT	72 M	MID	++	+	+	+	7–8 Hz slow α	(+)	Wandering at night, aggressive
3	KT	75 M	MID	+++				6–7 Hz + 3 Hz δ	(++)	Urination into a garbage can
4	IK	82 M	MID	++	++	++	+	4–5 Hz θ	(++)	Repetitive lights-on behavior, wandering
5	SM	81 M	MID	++						Night delirium, improper sexual behavior
6	ST	78 M	MID	++				6–7 Hz diffuse	(++)	Violent behavior
7	IKi	80 F	MID	++				6–8 Hz θ, α	(++)	Incoherent speech, agitation
8	TT	71 M	SDAT	++				4–5 Hz θ 3 Hz δ burst	(+++)	Irritability, wandering, behavior of setting a fire
9	MK	82 M	MID	++	±	±	+	7–8 Hz slow α	(+)	Wandering at night, agitation
10	TK	89 M	MID	++	++	+	+	4–6 Hz diffuse θ	(++)	Maintaining standing position, wandering
11	IH	85 F	MID	++						Pica, wandering at night
12	SMi	84 F	MID	++	++	+	+	Low voltage, fast	(+)	Wandering, delirium
13	AR	64 M	SDAT	++				4–6 Hz θ	(+++)	Dressing apraxia, garbage collection
14	OS	76 F	SDAT	+++	++	+	±	4–6 Hz θ	(+++)	Wandering at night
15	KK	63 F	SDAT	+++	++	+	−	7–8 Hz θ	(++)	Purposeless behavior
16	KS	56 M	SDAT	+++	++	++	−	Slow α, θ, δ	(+++)	Wandering, mutism
17	KIy	80 F	MID	+++				7–10 Hz θ, δ	(++)	Nocturnal wandering, agitation
18	IM	80 M	MID	++	++	+	±	6–7 Hz θ	(++)	Violent behavior, stealing, delusion of injury
19	WK	71 M	MID	++				8–9 Hz θ	(+)	Agitation, urination in bedroom, night delirium
20	NM	73 F	MID, IHD	++		+	±	8–9 Hz slow α	(+)	Repeated behavior of bed making
21	TTo	80 F	MID, PK	++	++	+	−	7–8 Hz θ	(++)	Restlessness, delirium, nocturnal wandering
22	TG	80 M	MID	++				6–7 Hz θ	(++)	Nocturnal wandering, violent behavior, setting a fire
23	SI	61 M	MID	++	+	+	++	8–10 Hz slow α	(+)	Urination in bedroom, delirium, violent behavior
24	TTa	61 M	MID, DEP	++				7–9 Hz θ, α, δ	(++)	Depressive state, agitation, frequent shouting to nurse at night

MID: multiple-infarct dementia; IHD: ischemic heart disease; PK: Parkinsonism; DEP: depressive state; SDAT: senile dementia of Alzheimer's type; CA: cortical atrophy; DV: dilatation of ventricle; INF: infarction; +++: severe, ++: moderate, +: mild, ±: slight, −: none.

less nights with behavioral disorders. A summary of circadian rhythm disorders in patients in the dementia group is shown in Table 2. Two patients (patients 5 and 24) showed severe sleep–wake rhythm disorder, i.e. patient 5 with reversed day–night sleep–wake rhythm showed only 27.1% of night sleep and 72.9% of day sleep, and patient 24 with dispersed day and night sleep showed 49.8% of night sleep and 50.2% of day sleep. Other patients showed sleep–wake rhythm disorders of varying degrees.

BT rhythm

The difference between oral temperature and rectal temperature in the five patients who were simultaneously recorded was 0.5–0.8°C, and both temperatures ran parallel during the observation period. Although oral temperature is not absolutely reliable as an indicator of BT, oral temperature is thought to provide some information about the BT rhythm in elderly patients with dementia.

Daily changes in BT of two representative cases in each group are shown in Fig. 2. For the two control subjects, the nadir of BT appeared between 0000 hr and 0400 hr, and the peak appeared at 1600 hr. Daily changes in BT rhythm were smaller compared to those of the dementia group. In contrast, the peak time of BT in demented patients appeared at a different time almost every day. The extent of BT fluctuation changed day by day, and this was greater than that of the control group (Fig. 2). Such disorganized BT rhythms were seen in 13 of 22 patients (59.0%) who completed the BT examination in the dementia group, but a disorganized BT rhythm was seen in only one of eight sub-

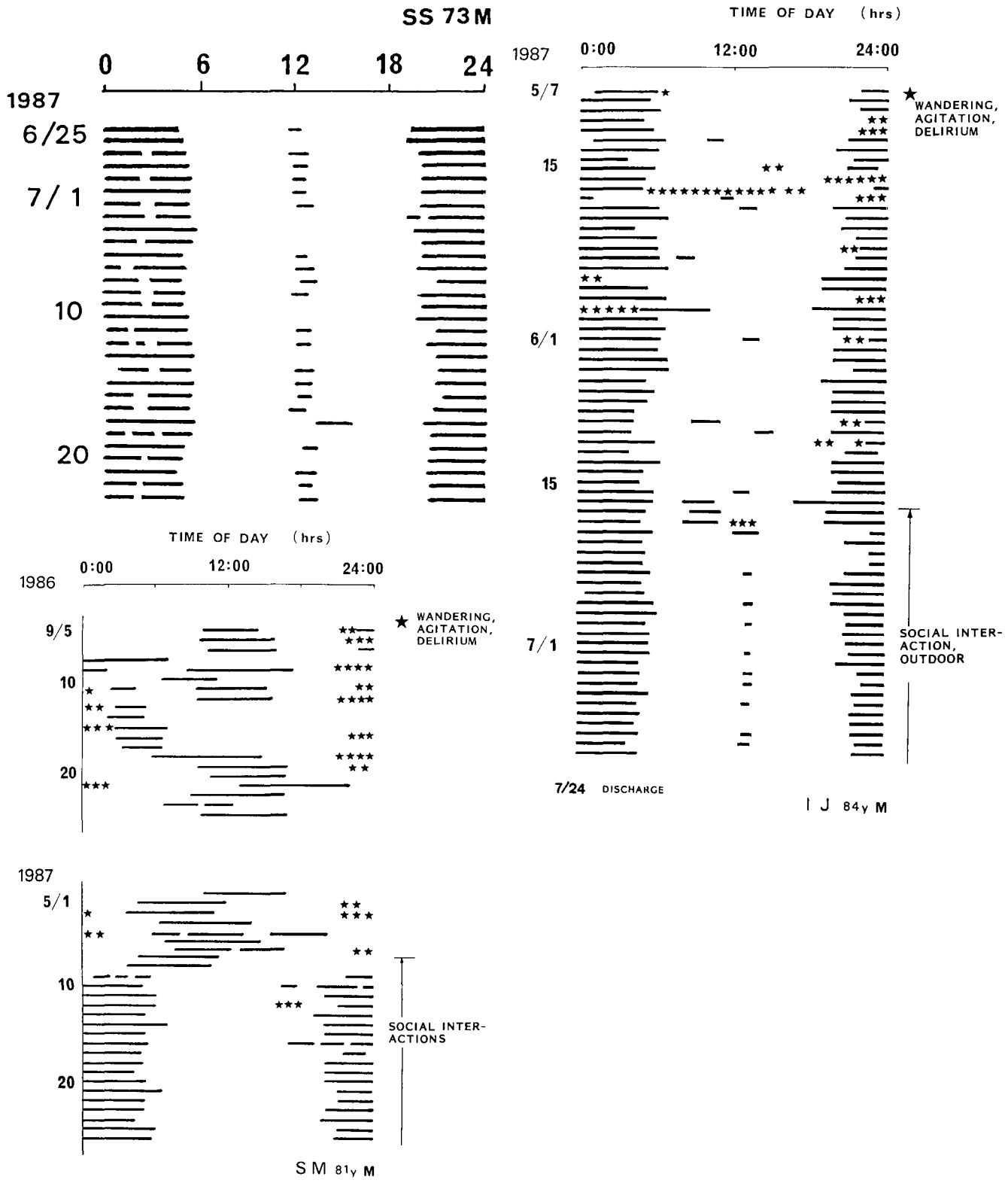

FIG. 1. Illustration of the sleep–wake rhythm and the effect of social interaction in three representative patients. The abscissa indicates time of day, and the ordinate indicates date of observations. Horizontal bars indicate sleep and asterisks indicate episodes of behavioral disorders such as wandering, agitation and/or delirium. (upper left) The sleep–wake rhythm of a 73-yr-old male patient in control group. The patient usually fell asleep at about 2000 and woke up at about 0600 with a brief period of awakening at about 0300. He usually took a short nap after lunch. His sleep–wake pattern showed a regular circadian rhythm. (lower left) Reversed day–night rhythm of sleep–waking in an 81-yr-old male patient (case 5) in the dementia group. The patient slept mainly in the daytime and stayed awake at night, showing frequent behavioral disorders. In early May 1987, shortly after the initiation of regular social interactions with nurses, the patient started

TABLE 2. *Sleep–wake and body temperature rhythms and effect of treatment*

No.	Age/sex	Diagnosis[a]	Sleep–wake rhythm: Total observation Days	Sleep–wake rhythm: Total observation Numbers	Mean total sleep time/24 hr[b]	% night sleep[b]	Disorganized BT rhythm[c]	Effect of social interaction[c]
1	84 M	MID	73	1,752	8.02 ± 2.2 (29)	84.9	(+)	◎
2	72 M	MID	56	1,344	7.2 ± 2.5 (11)	82.5	(+)	◎
3	75 M	MID	56	1,680	8.9 ± 2.6 (19)	67.8	(−)	×
4	82 M	MID	28	672	7.6 ± 2.1 (14)	83.6	(−)	×
5	81 M	MID	28	840	6.0 ± 2.1 (14)	27.1		○
6	78 M	MID	45	1,080	8.5 ± 1.6 (10)	72.4	(+)	○
7	80 F	MID	56	1,344	6.7 ± 1.8 (14)	88.0	(+)	×
8	71 M	SDAT	56	1,344	8.2 ± 2.5 (14)	64.3	(+)	×
9	82 M	MID	56	1,344	6.2 ± 2.5 (14)	72.5	(+)	×
10	89 M	MID	84	2,061	8.8 ± 1.5 (21)	86.9	(+)*	×
11	85 F	MID	84	2,016	8.4 ± 1.6 (21)	70.2	(+)	×
12	84 F	MID	84	2,016	6.0 ± 2.4 (21)	89.0	(+)	◎
13	64 M	SDAT	56	1,344	6.8 ± 2.4 (14)	75.8	(−)	◎
14	76 F	SDAT	56	1,344	5.1 ± 2.2 (19)	78.4	(−)	×
15	63 F	SDAT	56	1,344	7.9 ± 2.5 (14)	88.9	(+)	×
16	56 M	SDAT	56	1,344	6.7 ± 3.6 (14)	79.3		×
17	80 F	MID	70	1,680	8.3 ± 2.7 (21)	85.6	(+)*	×
18	83 M	MID	56	1,344	8.0 ± 2.0 (14)	86.2	(−)*	×
19	71 M	MID	56	1,344	9.2 ± 1.2 (14)	83.7	(−)*	○
20	73 F	MID	56	1,344	7.3 ± 1.2 (14)	78.7	(−)	×
21	80 F	MID	56	1,344	9.0 ± 1.6 (14)	79.9	(−)	×
22	80 M	MID	56	1,344	8.0 ± 1.8 (14)	83.8	(+)	
23	61 M	MID	56	1,344	7.8 ± 2.1 (14)	61.3	(+)	◎
24	61 M	MID	84	2,016	4.7 ± 3.4 (21)	49.8	(−)	×

[a] MID: multi-infarct dementia; SDAT: senile dementia of Alzheimer's type; BT: body temperature.
[b] Based on observation days in parentheses before the treatment.
[c] (+): present; (−): absent; ◎: very effective; ○: effective; ×: not effective; *: hypothermia < 34°C.

jects (12.5%) in the control group (Tables 2 and 3). Extremely low BT (accidental hypothermia) below 34°C appeared in four patients in the dementia group (see Fig. 2 and Table 2). This low BT was also recorded in rectal temperature recording for those subjects having both recordings. Amplitude of BT rhythm was significantly higher in the dementia group.

Effects of treatment by enforcement of social interaction

Social interaction with nurses was effective in reducing behavioral problems and sleep–wake rhythm disorder in 8 of 24 patients. Improvement of sleep–wake rhythm and behavioral disorders occurred in the two patients shown in Fig. 1 (lower left, right). In patients who responded to the treatment, disorders in sleep–wake rhythm and behavioral problems decreased or disappeared simultaneously. Disorganized BT rhythm, however, disappeared only in two of the eight patients who responded to the treatment.

DISCUSSION

Sleep in old age can best be characterized by a reduced tendency to sleep at night and difficulty in remaining awake during daytime (3–5). This observation can be taken to reflect a dampening of circadian sleep–wake rhythm. However, numerous factors, not necessarily related to the circadian rhythm itself, but merely related to other aspects of aging, may influence rhythms in the elderly. For instance, increased nocturia may result from cognitive heart failure. Similarly, sleep-related respiratory disturbances may cause insufficient nocturnal sleep, thus inducing a homeostatic sleep rebound during the subsequent day. Nonetheless, there may be some elderly people who show altered circadian rhythms apart from the effects of specific diseases, as has been shown by analogy with experimental animal data, where age-related changes have been described for hormonal, temperature, as well as behavioral rhythms in humans.

There are to date only a few systematic studies of circadian rhythms in dementia. Recent studies using

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to sleep at night and the behavioral disorders disappeared. (right) An irregular sleep–wake rhythm and frequent behavioral disorders in an 84-yr-old male patient (case 1) in the dementia group. After the beginning of social interaction, his behavioral disorders almost disappeared and his sleep–wake rhythm improved.

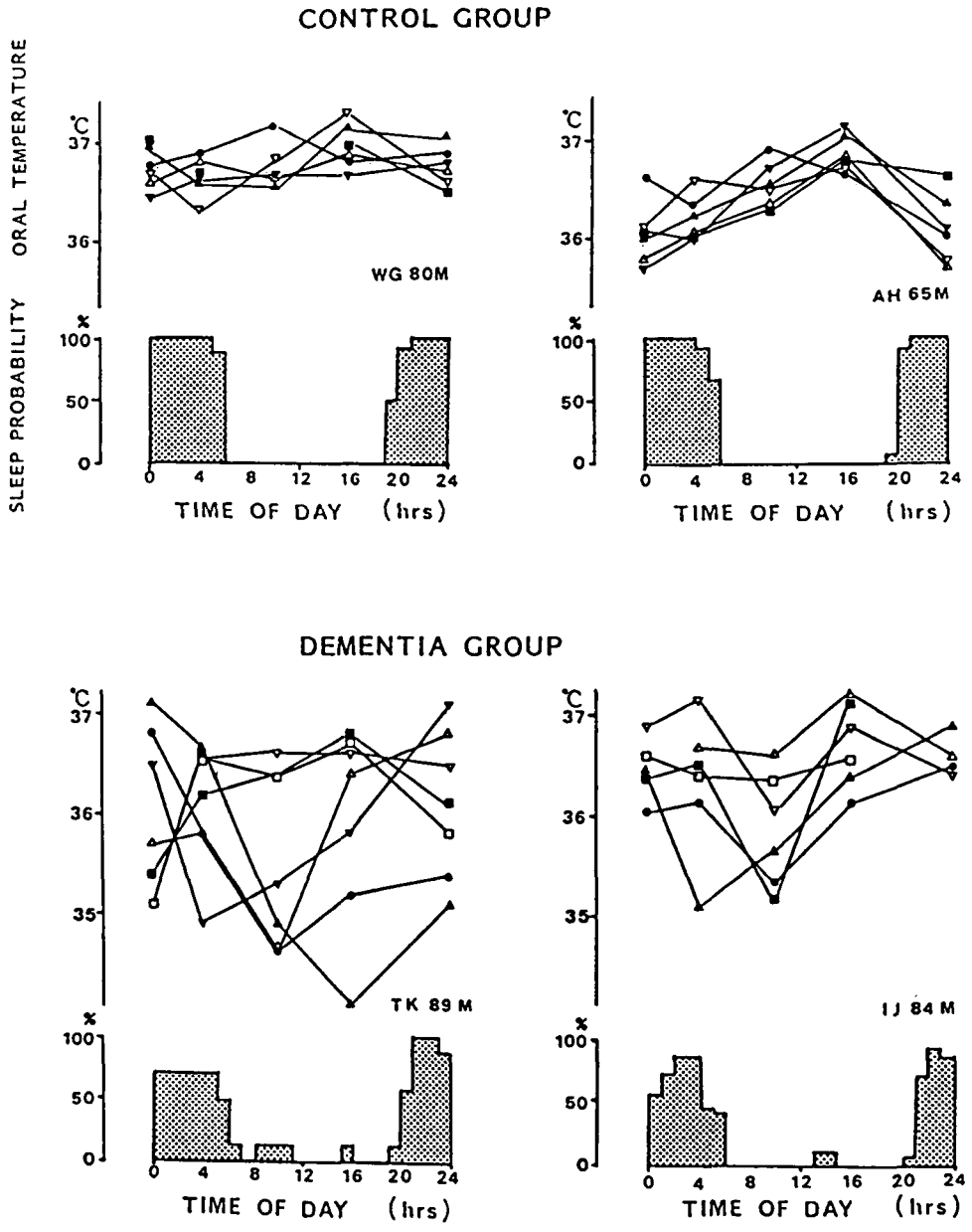

FIG. 2. The circadian temperature rhythm and sleep–wake variations in two control patients and two patients with dementia. Variations in oral temperature are present as superimposed 7-day records (upper portion). In control patients, daily variations in oral temperature were small. In contrast, those in patients with dementia were very large and sometimes an extremely low temperature was recorded. Sleep probability graphs (lower portion) indicate a propensity for sleep in each hour during 7 days. Patients with dementia showed an irregular sleep–wake rhythm compared to control patients.

reliable observations of sleep suggest that such observations are a viable approach to the study of the sleep–wake cycle in nursing home settings (1,6–8). These studies suggest considerable dispersion of sleep throughout the 24-hr day.

Of those studies using polysomnography, a marked fragmentation of the diurnal sleep–wake pattern was found in patients with SDAT, and daytime sleep showed about a 10-fold increase with severely fragmented nocturnal sleep (9). Allen et al. (10) also described numerous daytime naps in SDAT patients. Similar fragmentation of day and night sleep has been described in studies using the wrist actigraph (11,12). The present observational study also showed that sleep–wake rhythm in elderly patients with dementia was characterized by decreased amplitude, as evidenced by frequent naps in the daytime and less sleep at night. Furthermore, our patients showed behavioral disorders as well as sleep–wake rhythm disorders. Because of the frequent transition between states, it is conceivable that frequent transitions from sleep to waking or vice versa may contribute to delirium.

TABLE 3. *Body temperature rhythm in dementia and control groups*

Patients						
No.	Name	Age/sex	n	Mean BT (°C)	Range (°C)[a]	Peak time (hr)[b]
Dementia group						
1	IJ	84 M	5	36.02	1.73 ± 1.12	13.71 ± 6.71†
2	MT	72 M	7	36.66	0.85 ± 0.46	10.29 ± 6.71†
3	KT	75 M	7	36.26	1.14 ± 0.50	14.29 ± 2.71
4	IK	82 M	7	36.62	0.94 ± 0.53	16.29 ± 3.77
5	SM	81 M				
6	ST	78 M	4	36.43	1.69 ± 1.39	16.57 ± 5.31†
7	IKi	80 F	7	36.37	1.86 ± 1.26	12.00 ± 6.68†
8	TT	71 M	7	35.85	1.27 ± 0.60	13.71 ± 5.90†
9	NK	82 M	7	36.21	0.94 ± 0.53	14.57 ± 5.73†
10	TK	89 M	7	35.88	1.27 ± 0.77	14.86 ± 7.62†
11	IH	85 F	6	35.90	1.01 ± 0.62	10.29 ± 5.90†
12	SMi	84 F	7	36.62	1.18 ± 0.48	16.57 ± 6.21†
13	AR	64 M	7	36.58	1.76 ± 0.46	12.57 ± 2.97
14	OS	76 F	7	36.35	0.60 ± 0.30	15.14 ± 2.10
15	KK	63 F	6	36.88	0.48 ± 0.23	4.80 ± 4.49†
16	KS	56 M				
17	KIy	80 F	6	36.74	1.25 ± 0.73	10.29 ± 5.90†
18	IM	80 F	4	35.09	2.16 ± 1.16	17.43 ± 4.63
19	WK	71 M	7	35.38	1.99 ± 0.69	17.40 ± 2.80
20	NM	73 F	6	36.57	0.94 ± 0.39	12.57 ± 4.37
21	TTo	80 F	7	36.21	1.77 ± 0.67	12.57 ± 4.37
22	TG	80 M	4	35.99	1.39 ± 0.70	8.67 ± 7.45†
23	SI	61 M	5	36.32	1.20 ± 0.83	11.50 ± 4.98†
24	TTa	61 M	4	36.03	1.52 ± 0.25	14.67 ± 3.77
	Mean			36.23	1.32 ± 0.67*	13.22 ± 5.05
Control group						
25	KK	81 F	7	35.91	1.10 ± 0.21	16.29 ± 3.77
26	WG	80 M	7	36.59	0.46 ± 0.19	20.57 ± 3.96
27	IM	75 F	7	36.74	0.63 ± 0.21	12.57 ± 2.97
28	TM	75 F	6	36.33	1.54 ± 0.54	14.29 ± 2.71
29	YT	71 F	7	36.72	0.54 ± 0.22	13.71 ± 4.95†
30	SS	73 M	7	36.49	0.49 ± 0.25	15.43 ± 4.37
31	AH	65 M	7	36.45	0.95 ± 0.19	15.14 ± 2.10
32	HS	80 F	7	36.53	0.53 ± 0.10	10.86 ± 3.38
	Mean			36.47	0.77 ± 0.21	14.85 ± 3.46

[a] *: $p < 0.01$, t test, dementia group vs. control group.
[b] †: Disorganized BT rhythm (+) in Table 2.

The age-related reduction in the amplitude of the circadian BT rhythm has already been reported in many studies (13–15). The present study also elucidated decreased amplitude in elderly control subjects. However, patients with moderate to severe dementia showed irregular BT rhythms, which seemed arrhythmic and fluctuated widely compared to those in the control group. One of the contributing factors to this pattern was hypothermia, which may indicate dysfunction in the thermoregulation mechanism in the central nervous system. BT rhythms are usually considered to be more stable and more difficult to disturb relative to other circadian parameters such as the rest–activity rhythm or endocrine rhythms (16,17). However, there are many inconsistent reports about biological rhythms in elderly patients with dementia. Studies have shown no significant change in circadian temperature variation in SDAT (18), accidental hypothermia in aged patients with dementia (19,20), fragility to change of air temperature (21) or exaggeration of the BT fluctuations etc. (20,22). These studies raise the possibility that in some demented patients hypothalamic centers controlling BT homeostasis may deteriorate.

For treatment of the disturbed sleep–wake rhythm and behavioral disorders, increased contact with nurses was effective. This indicates that the disturbed sleep–wake rhythm and behavioral disorders such as wandering, agitation and/or delirium might be influenced at least in part by the lack of sufficient social stimulation and physical and mental exercise in the daytime waking state. These treatments may be effective by acting as social zeitgebers. However, it is noteworthy that, after improvement of sleep–wake rhythms and behavioral disorders by social interactions with nurses, changes in the disorganized BT rhythm hardly improved. This indicates that enforcement of social zeitgebers may be effective to reentrain disrupted sleep–wake rhythms but may not be effective in reentraining a disrupted BT rhythm.

In the human circadian system, two oscillators have

been proposed: a strong oscillator driving rapid eye movement sleep, core BT and cortisol secretion, and a weak oscillator responsible for rest–activity, slow–wave sleep, skin temperature, urine calcium excretion etc. (23). In our study, the disrupted sleep–wake rhythm, driven by the weak oscillator, was easily reentrained by enforcement of social interaction, but the BT rhythm driven by the strong oscillator was not influenced by such social interaction. Thus, disturbed circadian BT rhythms in elderly patients with dementia would appear to persist after the sleep–wake rhythm disorder disappeared.

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