人間発達科学部紀要　第４巻第１号：77－82（２００９）

RELATIONSHIP BETWEEN RAPID EYE-MOVEMENT ACTIVITY DURING NOCTURNAL SLEEP AND DEVELOPMENTAL QUOTIENT IN INFANTS WITH DEVELOPMENTAL DISABILITIES

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Summary

－Rapid eye-movement (REM) activity during nocturnal sleep was investigated in 27 infants with developmental disabilities. A relationship was found between REM sleep degree of REM and developmental psychomotor function. Developmental psychomotor scores were correlated with percentage of REM20, the percentage of sleep stages with REM. Age was not a factor in this relationship. Present findings are similar to earlier measures for adult patients with similar cognitive deficits.

keywords：REM, nocturnal sleep, children with developmental disabilities

1. Footnote

The author thanks Drs. S. Kiyono, K. Watanabe, T. Takeuchi, S. Hakamada and T. Kumagai for providing relevant clinical information, and M. Kobayashi for statistics. Send correspondence to Masamitsu Shibagaki, Ph.D., 488-8711, Nagoya Industry University, Owari-Asahi City, Aichi Prefecture, Japan.

Since the discovery of rapid eye-movement (REM) sleep, analyzing this state of sleep has interested many researchers. There is, however, a paucity of studies on polysomnography in people with mental retardation. Sleep studies on infants with developmental disabilities are lacking. Most studies have included adults with mental retardation (Espie & Tweedie, 1991; Espie, Paul, McFie, Amos, Hamilton, McColl, Tarassenko, & Pardey, 1998; Gunning & Espie, 2003). From these studies, it may be concluded that person with mental retardation show several distinct polysomnographic features. Disordered sleep may have several adverse consequences for the individual involved (e.g., problem behavior, fatigue, depressed learning) as well as for his or her caretaker. However, still little is known about the relationship between mental retardation and sleep parameters (including REM activity).

Some authors reported results from studies that show there is a association between performance on various sleep parameters and developmental level. Espie and his colleague (1991, 1998) have published a number of subjects on polysomnography in people with mental retardation. Other studies have been published this area during the last 5 years (Diomedi, Curatolo, Scalise, Placidi, Caretto, & Gigli, 1999; Elia, Ferri, Musumeci, Gracco, Bottitta, Scuderi, Miano, Panerai, Bertrand, & Grubar, 2000).

It has been reported that mentally retarded Down's syndrome subject presented a reduction of REM sleep percentage and R index (number of high frequency REMs against number of low frequency REMs) and this was positively correlated to a low IQ (Diomedi, et al., 1999). In individuals who are developing typically, REM sleep occurs cyclically throughout the night and is thought to be associated with cognitive processing (Espie, et al., 1998).

In the present report we studied the relationship between the amount of REM during REM sleep and estimated developmental level in a group of infants with developmental disabilities. We hypothesized that a positive relationship exists between the amount of REM during REM

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sleep and the estimated developmental level of an infant. The aim of the present study was the studies of sleep-cognitive hypothesis and the frequency of REM directly reflecting brain maturation.

2. METHOD

Twenty-seven infants with developmental disabilities (11 girls and 16 boys) ranging in age from 4 months to 1 year were the subjects of this study. All subjects were selected for the study according to the followings. They were inpatients of the Central Hospital, Aichi Prefectural Colony. Table 1 shows subject data including sex, and Developmental Quotient (DQ) [obtained by the Tsumori Inage questionnaire for infants and children (1979)]. In Japan, this questionnaire is one of the most widely used assessments of DQs. It is based principally on a questionnaire of Knobloch and Pasamanick (1955). This questionnaire has known validity and reliability. The numbers of profoundly (DQ less than 25), moderately (DQ = 25 - 49), and mildly (DQ greater than 50) retarded subjects were 2, 10, and 15, respectively. All of the subjects were the products of uncomplicated pregnancies with uneventful labors and deliveries. They had no seizure history and no behavioral disabilities with the exception of psychomotor disabilities. They had been free of medication, which would affect a sleep EEG, for at least 1 month before the recording. No sedatives were used. They experienced clinical electroencephalogram (EEG) recordings of two or three times during the daytime before the nocturnal sleep EEG recordings of this study. So, measures were apparently taken to prevent novelty effects of apparatus.

Polygraph recordings (EEG, electrooculogram, electrocardiogram, respiration, and electromyogram) were carried out in the subject's room (temperature, 25-27℃; relative humidity, 50-70%) after a conventional meal until spontaneous awakening the next morning. The experimenter and polygraph machine were located in the room next to the subject's bed. The paper speed was 15 mm/sec. Vertical ocular movements were recorded by the difference in potential between the upper and lower orbital electrodes. Horizontal ocular movements were recorded by the difference in potential between the electrodes situated on the two external epicanthi. Those who scored the sleep tracings had no knowledge of a subject's developmental psychomotor status. The Tsumori Inages' questionnaire was administered to the parents of the subjects by consultant psychologists who were unaware of the records taken during sleep.

Sleep stages (each 20 sec.) were classified according to instructions in Rechtschaffen and K ales' manual (1968). The following parameters were measured as suggested by Williams, Karacan, and Hursch (1974): sleep period time (the time from the onset of sleep to the final morning awakening); total sleep time (the time from sleep onset to morning awakening, after the time awake during the night is subtracted); number of REM periods; average REM period length (the time between REM period); average REM period cycle length (the time between the beginning of one REM period and the beginning of the next); and percentage of time in stages of wakefulness (W), 1, 2, 3, 4, and REM calculated against the sleep period time.

All horizontal and vertical REMs with an amplitude>100 μV, in the sleep recordings, were detected visually for each REM period. Brief definitions of the REM measures used in this report are as follows: (1) REM activity (REM20) is defined as the number of 20 sec. epochs showing evidence of REMs during REM period. (2) REM density is defined as the percentage of 20 sec. epochs showing evidence of REMs during REM period calculated against the whole REM period. (3) Percent REM20 is defined as the percentage of 20 sec. epochs showing evidence of REMs during REM period calculated against the whole sleep (total sleep time).

3. RESULTS

Table 1 shows subject data including all REM activity

Inter-correlation of sleep variables, age, and developmental psychomotor scores

1. Relation of sleep variables to age

As may be observed in the correlation matrix of Table 2, correlation coefficients for the average REM period length, percent stage of wakefulness, 1, 2, 3, and 4, stages 3 and 4, REM, percent REM20, REM density, and DQ were not statistically significantly correlated with age. Sleep period time, total sleep time, number of REM period, average REM period cycle length and REM20 were, however, significantly correlated with age.

2. Relation of sleep variables to DQ scores

Developmental psychomotor scores showed statistically significant association with a number of sleep variables. Developmental quotient scores were correlated at the 5% level with percent REM20 (r = 0.39). The correlation coefficient between DQ scores and age was

Statistically non-significant (r=-0.21). Developmental quotient scores were correlated with percent stage of wakefulness (r=-0.53) [p<.01], and with average REM period length (0.46) [p<.05].

TABLE 1 AGES, DEVELOPMENTAL QUOTIENT, ALL REM ACTIVITY MEASURES BY SUBJECT

Sub.	Sex	Age	DQ	REM20	%REM20	REM density
H.K.	M	4mo.	36	174	12.46	56.49
R.S.	M	6mo.	74	617	27.97	73.28
H.M.	M	6mo.	88	253	19.04	72.91
T.K.	M	6mo.	75	428	24.83	64.65
K.H.	M	6mo.	48	318	19.97	83.25
Y.T.	M	7mo.	48	278	15.10	39.83
K.S.	F	8mo.	79	279	16.79	58.86
R.T.	F	8mo.	42	363	21.76	61.53
Y.Y.	M	9mo.	42	400	24.48	76.34
Y.S.	F	10mo.	46	310	19.34	77.69
K.K.	M	10mo.	68	179	11.00	51.29
Ke.K.	F	11mo.	86	303	18.48	73.01
K.I.	M	11mo.	56	190	12.23	54.13
Y.I.	F	11mo.	16	119	8.57	69.19
K.Y.	M	11mo.	57	377	19.50	67.68
Y.H.	M	11mo.	60	309	17.50	68.36
S.E.	F	1yr.	62	228	15.00	64.96
S.U.	F	1yr.	36	375	25.17	76.06
Y.T.	M	1yr. 1mo.	35	231	17.00	62.60
K.T.	M	1yr. 2mo.	42	137	9.24	58.30
K.Y.	F	1yr. 3mo.	60	104	12.52	63.41
M.K.	F	1yr. 4mo.	67	170	17.97	34.98
T.A.	M	1yr. 4mo.	67	264	18.97	70.78
Y.Y.	F	1yr. 6mo.	57	245	17.14	72.70
M.T.	M	1yr. 6mo.	79	220	26.10	80.30
T.I.	M	1yr. 7mo.	30	260	19.82	62.50
M.H.	F	1yr. 9mo.	23	65	6.62	28.26

Note.—The developmental quotient was obtained by the Tsumori Inage questionnaire for infants and children (1979). The mean and SD were 54.8 and 19.1, respectively.

TABLE 2 INTER-CORRELATION FOR AGE, SLEEP PARAMETERS AND DQ SCORES

	(N)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 Age	(27)																
2 Sleep period time	(27)	-0.64**															
3 Total sleep time	(27)	-0.58**	0.84**														
4 No. REM period	(27)	-0.70**	0.85**	0.78**													
5 Average REM period length	(27)	0.23	-0.35	-0.24	-0.39*												
6 Average REM period cycle length	(27)	0.43*	-0.59**	-0.29	-0.71**	0.34											
7 % Stage W	(27)	-0.16	0.40*	-0.14	0.24	-0.26	-0.61**										
8 % Stage 1	(27)	-0.02	-0.07	-0.28	-0.15	-0.20	0.00	0.35									
9 % Stage 2	(27)	0.25	-0.17	-0.02	-0.26	-0.06	0.27	-0.26	-0.41*								
10 % Stage 3	(27)	-0.07	-0.02	0.09	-0.02	-0.16	0.13	-0.20	-0.42*	0.00							
11 % Stage 4	(27)	0.16	-0.17	-0.05	-0.13	0.09	0.14	-0.25	-0.28	-0.42*	0.24						
12 % Stage 3 and 4	(27)	0.04	-0.09	0.06	-0.07	-0.08	0.16	-0.28	-0.42*	-0.30	0.73**	0.84**					
13 % Stage REM	(27)	-0.31	0.41*	0.38	0.60**	0.37	-0.46*	0.11	-0.45*	-0.22	-0.21	-0.03	-0.15				
14 REM20	(27)	-0.50**	0.65**	0.70**	0.80**	-0.10	-0.41*	-0.01	-0.32	-0.20	-0.09	-0.02	-0.05	0.72**			
15 %REM20	(27)	-0.23	0.27	0.32	0.48*	0.25	-0.18	-0.09	-0.40*	-0.17	-0.09	0.04	-0.05	0.76**	0.84**		
16 REM density	(27)	-0.23	0.01	0.04	0.20	-0.23	0.06	-0.09	0.08	-0.14	0.14	-0.10	-0.01	0.04	0.49**	0.59**	
17 DQ	(27)	-0.21	-0.10	0.20	-0.03	0.46*	0.26	-0.53**	-0.38	0.36	-0.08	-0.11	-0.14	0.25	0.30	0.39*	0.21

* $p < 0.05$
** $p<0.01$

For this problem, we could have strengthened the design of our study by including a control group populated with infants without developmental disability.

In the present study, although correlations were statistically significant, the number of the subjects were might not enough to be meaningful in any theoretical or practical sense. How do we address the fact that we only account for $(0.39)^2$ or about 16% of total variance in developmental quotient? This is noteworthy, as it leaves the vast majority of the variability in this variables unaccounted for.

In the present study, DQ was significantly correlated with % stage W (r=-0.53) and with the average REM period length (r=0.46). The short sleep time in our subjects were related to the long awaking periods during the night. The subjects with long awaking during the night were unable to sustain sleep for protracted periods. This relative insomnia does not seem to be due to anxiety because of their ages (0-1 year). A significantly low DQ was found in these subjects with short sleep and long waking time as compared with those with long sleep and short waking time. It can be expected that the developmental disabilities were greater in the former than in the latter. Moreover, it is suggested that in the finding between DQ and the average REM period length, this length showed the degree of an approximately development of a sleep pattern in infants with developmental disabilities.

In the present study, there were several significant correlations between age and other variables affecting eye movements and REM sleep. A significant correlation between age and total sleep time might be the by-product of shortening sleep length as a function of age. The significant correlations between age and REM sleep variables are caused by the developmental change of sleep length.

These results further support the view that the brain carries out certain active processes of adequate function during sleep [the sleep-cognition hypothesis, advanced by Espie, et al. (1998)]. Moreover, these results support the view that measurements of electrophysiological concomitants of these processes provide an index of the developmental psychomotor level, at least for individuals with varying degree of developmental psychomotor impairment. The polysomnographic features as REM frequency in this study were used as a tool in the diagnostic of developmental disability. They explained developmental characteristics in infants with developmental disability. The outcomes of this study may be used as an additional assessment for diagnosis of early infancy with developmental disabilities.

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（2009年５月13日受付）
（2009年７月15日受理）