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Volitional Lifestyle and Nocturnal Sleep in the Healthy Elderly

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The role of lifestyle in nocturnal sleep was examined in the healthy elderly. The Philadelphia Geriatric Center morale scale and the self-confidence scale were used to select high- and low-volitional elderly individuals (n=10 each, mean age=73.2 years). Their activity levels were monitored by a wrist actigraph for 10 consecutive days. On the fourth and eighth nights, polysomnograms were recorded at their homes using an ambulatory monitoring system. Although the daytime activity level did not differ between the groups, high-volitional individuals had better nocturnal sleep than low-volitional individuals: nocturnal awakening was shorter, slow wave sleep was longer, EEG delta power in the first sleep cycle was higher, and the feeling after rising was better. Daily logs revealed that high-volitional individuals spent more time in mental activities during the daytime than low-volitional individuals. These results suggest that a high-volitional lifestyle may contribute to maintaining good nocturnal sleep in the elderly.

CURRENT CLAIM: Elderly people with a volitional lifestyle have a subjectively and objectively good nocturnal sleep.

Sleep problems are a common health concern among the elderly. More than 25% of the people over 60 years old report difficulties in sleep initiation or maintenance (Millinger et al., 1985). They often complain of longer sleep latency, frequent awakenings at night, insufficient sleeping time, and excessive daytime sleepiness (Campbell and Dawson, 1992; Evans and Rogers, 1994). Polysomnographic studies have shown that nocturnal sleep of aged persons is fragmented, and that sleep Stages 3 and 4 are reduced or completely eliminated (Feinberg, 1974; Hayashi and Endo, 1982).

Czeisler et al. (1992) suggested that sleep disturbance in the elderly is linked tightly with the deterioration of the circadian timing system. The circadian system or biological clock tends to make a less clear distinction between day and night in the elderly than in the young (Monk, 1989). Such dysfunction may result from three possible mechanisms (Monk et al., 1992): 1) weakened ability to generate an endogenous 24-hour circadian signal; 2) weakened ability to use external circadian time cues (zeitgebers) to keep the circadian system appropriately aligned; and 3) fewer and/or less potent zeitgebers impinging on the individual (e.g., less exercise, less daylight exposure, and fewer social contacts). Another line of research suggests that such dysfunction is not an inevitable consequence of aging. For example, adequate physical exercise has a therapeutic effect on sleep disturbance in the elderly (Vitiello et al., 1994; King et al., 1997).

In previous studies using actigrams and daily logs, we suggested that "volitional" lifestyle is a key to maintaining good nocturnal sleep and a regular sleep-wake cycle in the elderly (Shirota et al., 1997, 1998). The volitional level of elderly people (over 65 years old) was assessed by the Philadelphia Geriatric Center (PGC) morale scale (Lawton, 1975) and the self-confidence scale for the aged (Yaguchi et al., 1982). The PGC morale scale consists of three factors: Agitation (six items; e.g., "Little things bother me more this year"); Toward Own Aging (five items; e.g., "Things keep getting worse as I get older"); and Lonely Dissatisfaction (six items; e.g., "I sometimes feel that life isn't worth living"). The self-confidence scale focuses on the resources of confidence in one's ability (ten items; e.g., "I can achieve something well when I have a strong will to do so"). We defined high-volitional individuals as those who had higher scores than the average in both scales, and low-volitional individuals as those who had lower scores than the average in both scales. High-volitional elderly individuals were shown to have less sleep complaints than low-volitional individuals (Shirota et al., 1998). Moreover, the acrophases of the circadian (τ=24 hr) and circasemidian (τ=12 hr) rest-activity cycles were less advanced for high-volitional than for low-volitional individuals, suggesting that high-volitional individuals were more resistant to aging (Shirota et al., 1997).

In the present study, the nocturnal polysomnogram was recorded from high- and low-volitional elderly individuals, in addition to actigrams and daily logs. We hypothesized that high-volitional elderly individuals would have, not only subjectively but also objectively, better nocturnal sleep (e.g., fewer nocturnal awakenings and longer slow wave sleep, along with better feelings after rising) than low-volitional

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individuals. Moreover, it was predicted that the activity level and/or activity contents during the daytime would also differ between high- and low-volitional individuals.

METHODS

Participants

Ten high-volitional and 10 low-volitional individuals were selected from 821 elderly, a large sample population because this study was done as a part of a large-scale survey using questionnaires. Mean score of the PGC morale scale was 9.9±3.98 (range: 0-17) and mean score of self-confidence scale was 6.7±2.37 (range: 0-10). PGC morale and self-confidence scales seemed to reflect a similar psychological aspect that we would call "volitional lifestyle." However, they only moderately correlated with each other (r=0.44). Thus, this study used the combined measures to screen high- and low-volitional individuals. Table 1 summarizes the characteristics of the high- and low-volitional groups. Each group consisted of five men and five women. The participants also completed Okawa's sleep-health questionnaire (Okawa, 1994), which showed that they had no history of sleep or psychiatric disorders and were not using sedative drugs. All participants were living in their own home. Although four participants of the high-volitional group and five of the low-volitional group were bereaved of their spouse, all of them were living with or near their children's families. They signed informed consent forms and were paid for their participation.

Table 1
Characteristics of the
High- and Low-volitional Groups (n=10 each)

	High		Low		
	Mean	SD	Mean	SD	*t*-value
Age	73.8	3.05	72.6	4.84	0.66
PGC Morale Scale	15.8	0.79	7.0	2.11	12.36 **
Self-confidence Scale	9.6	0.52	5.6	1.17	9.86 **

**p<0.01

Measurement of Activity

Participants were asked to wear an actigraph (Ambulatory Monitoring Inc., Ardsley, NY) on their non-dominant wrist for 10 consecutive days. They were instructed to lead their life as normally as possible. Activity counts were recorded by zero crossing mode and stored at 1-min intervals (Cole et al., 1992). The mean activity levels in the daytime (from one's rising time to bedtime) and in the nighttime (the time one spent in bed) were calculated. During the experimental period, participants were asked to keep a daily log of rising time, bedtime, meals, and other daytime activities. The total hours spent for physical activities (e.g., taking a walk or doing housework) and for mental activities (e.g., reading or chattering) were calculated separately from the log.

Polysomnography

On the fourth and eighth nights of the experimental period, the polysomnogram was recorded at each participant's home using an ambulatory monitoring system (SYNA ACT MT11, NEC Medical Systems, Tokyo). The electroencephalogram (EEG) was recorded from Cz and Pz referenced to A1 or A2 (band pass filter: 0.3-100 Hz). The horizontal electrooculogram and chin electromyogram were also recorded. Electrode impedance did not exceed 10 kΩ. The sampling rate was 200 Hz. To avoid a possible first-night effect (Wauquier et al., 1991), the data of the eighth night were used for analysis. The polysomnogram data were manually scored every 30 s according to the criteria of Rechtschaffen and Kales (1968). Moreover, Fast Fourier Transform was performed on consecutive 5.12-s epochs of the EEG data (5 ms x 1024 points, smoothed with a cosine-tapered window; fr=0.195 Hz). To reduce error variance, EEG power spectra were calculated for every 30.72 s by averaging six consecutive 5.12-s epochs and the integrated amplitude (root power) for the delta band (0.5-2.0 Hz) was computed. For each participant, the amplitude data were converted to z scores using the data of the first six hours after sleep onset (z-transform).

Subjective Sleep Estimation

Post-sleep inventory (Oguri et al., 1981, 1985) was administered the morning after the polysomnographic recording. This inventory was highly reliable (confidence coefficient=0.93 [Oguri et al., 1985]). Five scale scores were calculated: less sleepiness (e.g., Can you answer this questionnaire briskly?); without interrupting arousal (e.g., Did you awake many times last night?); no worries (e.g., Are you feeling easy this morning?); quality of sleep (e.g., Did you sleep well last night?); and ease of falling asleep (e.g., Did you find it easy to go to sleep last night?).

Statistical Analysis

The data of activity level and EEG delta amplitude were submitted to a mixed-type analysis of variance (ANOVA) with a between-subjects factor of volitional level and a within-subjects factor of time (using SAS/STAT software, SAS Institute Inc., Cary, NC). Whenever appropriate, the Greenhouse-Geisser ε correction for violation of sphericity was applied. The degrees of freedom after correction were shown in the results. *Post hoc* comparison was made by Tukey's HSD test. Group differences on the other measures were assessed by two-tailed t-tests.

RESULTS

Daytime Activity

Table 2 shows the mean activity levels measured by actigram and the mean hours of daytime activity estimated from the logs. Although the daytime activity level and the time of physical activity did not differ between the groups, the time of mental activity and total activity were longer for high-volitional than for low-volitional participants. Figure 1 illustrates the actigram data from a high-volitional participant (male, 70 years old). Although his daytime activity level was lower than the average of all the participants in this study, he

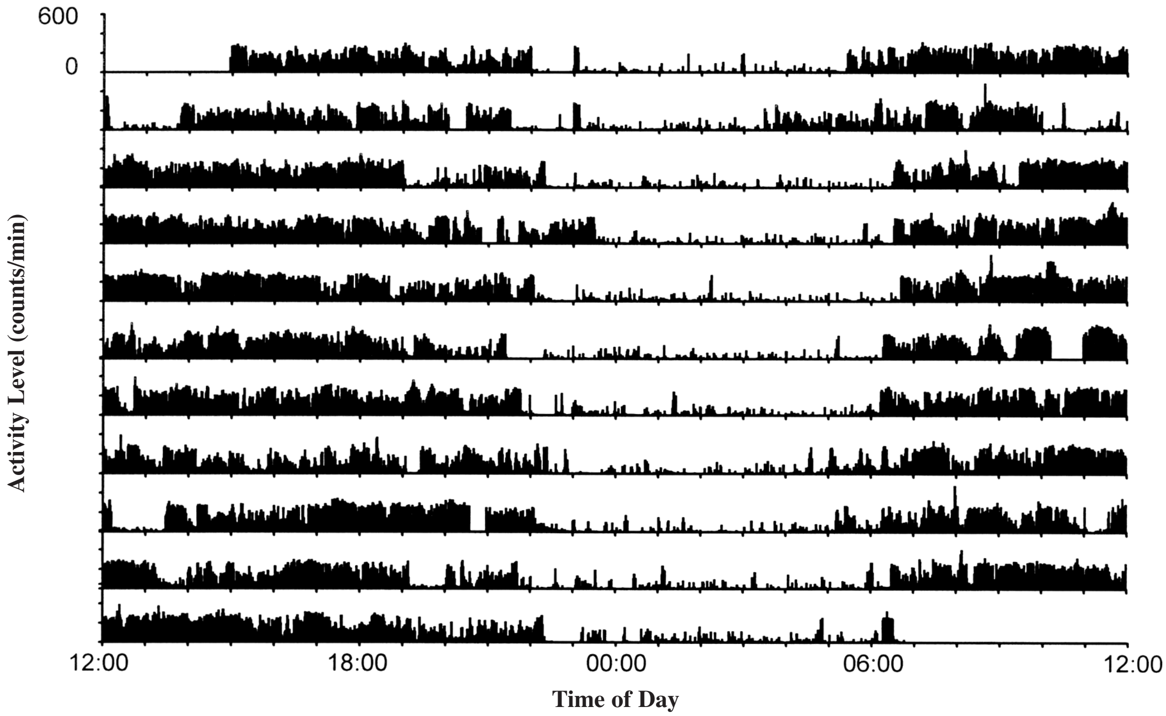

Figure 1. Actigram data from a high-volitional participant (male, 70 years old).

had good nocturnal sleep (sleep efficiency: 93.1%; percentage of SWS: 12.5%). Daily logs showed that he often played shogi (Japanese chess) during the daytime.

Nighttime Activity Level

As shown in Table 2, the activity level during the nighttime was significantly lower for high-volitional than for low-volitional participants. Figure 2 shows the mean activity levels of the first five hours in bed for the high- and low-volitional groups. A Volitional Level x Time ANOVA showed significant main effects of volitional level and time, $F(1,18)=6.25$, $p<0.05$; $F(4,57)=6.50$, $p<0.01$, $\varepsilon=0.79$, respectively, along with an interaction between them, $F(4,57)=2.68$, $p<0.05$, $\varepsilon=0.79$. *Post hoc* comparison showed that the activity level in the first hour of sleep was lower for the high-volitional than for the low-volitional group.

Table 2
Mean Activity Levels (± standard errors) Measured by Actigram and Mean Hours (± standard errors) of Daytime Activities Estimated from the Logs for the High- and Low-volitional Groups

	High	Low	*t*-value
Activity Level (counts/min)			
Daytime	197.5±8.39	194.8±4.48	0.29
Nighttime	21.6±2.01	27.8±2.14	2.12*
Daytime Activity (hours)			
Physical	5.7±0.59	6.1±0.41	0.45
Mental	4.2±0.55	1.8±0.48	3.35*
Total	9.9±0.55	7.8±1.57	2.25*

*$p<0.05$

Nocturnal Sleep

The parameters of nocturnal sleep are summarized in Table 3. Although the total time in bed, total sleep time, and sleep latency did not differ between the groups, the total time of nocturnal awakening was shorter and the sleep efficiency was higher for high-volitional than for low-volitional participants. The lengths and percentages of Stage REM, Stage 1, and Stage 2 did not differ between the groups, whereas those of Stage 3 and Stage 4 were significantly longer for high-volitional participants.

Figure 3 shows the time course of delta band amplitude after sleep onset. In the high-volitional group, delta band amplitude was higher in the first sleep cycle than in the following cycles. The mean amplitude data of four consecutive 90-min epochs after sleep onset were submitted to a Volitional Level x Epoch ANOVA. The main effect of epoch was significant, F

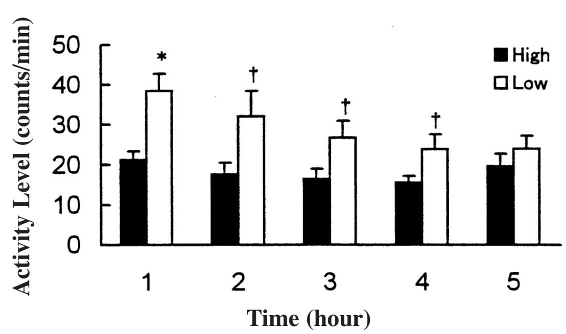

Figure 2. Mean activity levels (± standard errors) of the first 5 hours in bed for the high- and low-volitional groups. †$p<0.10$, *$p<0.05$

Table 3
Sleep Variables (means ± standard errors) for the High- and Low-volitional Groups

	High	Low	t-value
Time in Bed (min)	434.6±20.18	457.8±12.52	0.98
Total Sleep Time (min)	387.6±17.01	386.8±16.34	0.03
Sleep Latency (min)	14.7±3.60	12.9±3.13	0.38
REM (min)	62.2±5.73	63.5±8.72	0.12
Stage 1 (min)	103.1±16.23	100.6±15.95	0.11
Stage 2 (min)	188.2±21.48	212.8±14.66	0.95
Stage 3 (min)	28.5±6.94	7.3±2.73	2.84*
Stage 4 (min)	5.6±1.98	0.1±0.10	2.77*
SWS (Stage3 + Stage4) (min)	34.1±8.47	7.4±2.81	2.72*
Nocturnal Awakening (min)	32.3±3.91	58.1±10.09	2.39*
Sleep Efficiency (%)	92.4±0.76	86.3±2.32	2.51*
REM (%)	14.9±1.32	14.3±1.87	1.62
Stage 1 (%)	24.4±3.81	22.5±3.50	0.27
Stage 2 (%)	44.8±5.07	47.8±3.19	0.36
Stage 3 (%)	6.9±1.67	1.7±0.63	2.91**
Stage 4 (%)	1.4±0.51	0.5±0.02	2.73*
SWS (Stage3 + Stage4) (%)	8.3±2.10	2.2±0.61	2.76*
Nocturnal Awakening (%)	7.6±0.76	13.2±2.38	2.25*

*p<0.05, **p<0.01

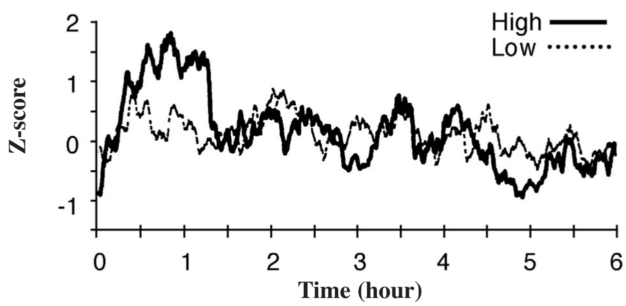

Figure 3. The time courses of EEG delta band amplitude after sleep onset for the high- and low-volitional groups (after *z*-transform).

(2,31)=6.63, p<0.01, ε=0.569, and the interaction was marginally significant, F (2,31)=2.64, p=0.09, ε=0.569. A *post hoc* comparison showed that the delta band amplitude was higher in the first 90-min epoch than in the following epochs. This tendency was significant only for the high-volitional group, F (1,10)=5.74, p<0.05, ε=0.385.

Table 4
Mean Scale Scores (± standard errors) of Subjective Sleep Quality for the High- and Low-volitional Groups

	High	Low	t-value
Less Sleepiness (0-49)	33.9±1.37	29.0±1.66	2.28*
Without Interrupting Arousal (0-42)	26.6±1.90	25.8±1.67	0.31
No Worries (0-47)	31.6±1.85	29.0±1.56	1.09
Quality of Sleep (0-48)	28.7±1.54	24.5±2.09	1.63
Ease of Falling Asleep (0-45)	28.9±1.43	24.2±1.51	2.26*

Note: Values in parentheses are the range of the scores; *p<0.05.

Subjective Sleep Quality

Table 4 shows the scale scores of the post-sleep inventory. In general, the feeling after rising was better for high-volitional than for low-volitional participants. The differences were significant for "less sleepiness" and "ease of falling asleep." These results show that the feeling upon rising in the morning was better for high-volitional participants than for low-volitional participants.

DISCUSSION

The present study showed that high-volitional elderly participants had, subjectively and objectively, better nocturnal sleep than low-volitional participants. The high-volitional group had a longer slow wave sleep and a higher EEG delta band power in the first sleep cycle, as well as better post-sleep feelings. It has been established that aging lowers the nocturnal sleep efficiency, collapses the sleep structure, and decreases slow wave sleep (Feinberg, 1974; Hayashi and Endo, 1982; Evans and Rogers, 1994). Moreover, aging causes changes in circadian rhythms, such as alterations in the period, phase, amplitude, and precision of both behavioral and physiological rhythms (Liberman et al., 1989; Czeisler et al., 1992). However, chronological aging is not the only cause of sleep disturbance in the elderly. Together with our previous report showing that high-volitional elderly individuals had a "younger" rest-activity cycle than age-matched low-volitional individuals (Shirota et al., 1997), the present study supports the view that psychological factors, such as volitional lifestyle, are key to maintaining good nocturnal sleep and a regular rest-activity cycle in the elderly.

It is well-known that physical activity during the daytime increases slow wave sleep in the young (Trinder et al., 1985; Campbell et al., 1986) and in the healthy elderly (Vitiello et al., 1994). King et al. (1997) stated that older adults reported subjective improvement of sleep quality after participating in moderate-intensity exercise over a 16-week period. Naylor et al. (2000) also demonstrated that a short-term, relatively low level of physical activity combined with social interaction can increase slow wave sleep and improve daytime functioning in elderly persons. In the present study, however, there were no significant differences between the groups in daytime activity level measured by actigram or in the total time of physical activity recorded in the daily log. Instead, high-volitional elderly individuals spent more time for mental activities during the daytime than low-volitional individuals. Only a few studies have dealt with the effect of mental activity on nocturnal sleep quality. Reyback et al. (1971) examined the effect of mental activity on the sleep EEG of young volunteers participating in an isolated 5-week bed-rest condition. The participants were allowed to watch television or read. Interestingly, the amount of nocturnal slow wave sleep did not decrease compared to the baseline even when the participants did not get physical exercise. In the present study, a high-volitional participant who often played Japanese chess and had a lower-than-average level of physical activity during the daytime was shown to have long slow wave sleep at night (see Figure 1). According to these results, physical activity does not seem to be an indispensable condition for inducing slow wave sleep. Even without muscular activity, sensory or cognitive tasks can increase slow wave sleep. Mental activity may also be effective in maintaining slow wave sleep in the elderly.

Sleep disturbance in the elderly can be linked with depression. Reynolds et al. (1992) suggested that bereaved elderly with major depression had significantly lower sleep efficiency than those without depression. Although none of the participants in the present study had a history of depression, low-volitional individuals may have some traits in common with depression, or low-volitional elderly people may be in a state of apathy. Yamashita et al. (1999) suggested that the apathy of elderly people exerted a marked effect on their ability to perform routine activities of daily living. In this study, although four participants of the high-volitional group and five participants of the low-volitional group were bereaved elders, all of them were living with or near their children's families, so they may have received mental or physical support from family members.

Good sleep is an important precondition for maintaining the quality of life in the elderly. The present study indicated that psychological factors such as volitional lifestyle may modulate the adverse effect of aging on sleep. It is widely believed that sleep problems of the elderly are caused by chronological aging. In this study, however, high self-confidence and psychological well-being positively affected sleep in the elderly. Moreover, it is suggested that not only physical activity but also mental activity may improve the quality of nocturnal sleep in the elderly. Future research using an intervention procedure will be required to elucidate the causality of the relationship between volitional lifestyle and the quality of nocturnal sleep.

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