Sleep-Wake Rhythm and Physical Fitness in Relation to Activities of Daily Living in Stroke Survivors Residing At Home

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Abstract

To clarify the relationship between sleep-wake rhythm, physical fitness, and competence level of elderly stroke survivors living at home, thirty-seven stroke survivors living at home (65.4 ± 7.3 years) voluntarily participated in a cross-sectional study with an interview survey and measurement of physical fitness. All subjects lived in a community and received community home health care services. Sleep-wake rhythm and competence were evaluated by the questionnaire method. Physical fitness in relation to daily living activities was measured by both the time needed to walk 10 meters and that needed to stand up from bed rest position. There was a significant positive correlation between rising time and the 10 meter walking time. Regarding rising time and the competence score, there was a significant negative correlation. Stroke survivors who actively participated in community activities arose earlier than those who had a negative attitude toward participation in community activities. The sleep-wake rhythm, especially rising time, and the participation in community activities were related to the high competence level of stroke survivors living at home. Strengthening the synchronization of the sleep-wake rhythm and increasing the social network may serve as useful procedures to improve the competence of stroke survivors living at home.

Key words: sleep-wake rhythm, physical fitness, competence, stroke survivor, synchronization

Introduction

The sleep-wake rhythm of stroke survivors living at home occasionally changes due to their disabilities. Sleep behavior disturbances such as awakening during sleep, which may affect stroke survivors, are considered to be important home health care problems for both care-receivers and care-givers.^{1,2,3)} The interruption of nocturnal sleep decreases the daytime activity level of the elderly as well as the quality of nocturnal sleep,²⁾ and thereby impairs synchronization of the biological rhythm.^{4,5)} Thus, sleep-related problems of stroke survivors living at home appear to be related to functional impairment of circadian rhythms, especially a decrease in the level of circadian rhythm synchronization to external entrainment factors such as bright lights and social contact. Thus, the sleep-wake rhythm in the elderly stroke survivors merits study aimed at improving their competence, and raising the level of instrumental activities of

daily living, intellectual activities and social roles.

The other factor to be taken into consideration for the improvement of the synchronization of stroke survivors living at home is the maintenance of the physical fitness needed for daily living. The maintenance of physical fitness also seems to be related to the elevation of the competence level of the elderly^{6,7)}. An objective evaluation of physical fitness as related to daily living can reportedly be achieved by measuring the speed of walking.^{8,9)} Recently, a functional fitness test evaluating physical fitness, as it pertains to daily living, was developed by Oida et al.^{10,11)} In this test, the time needed to stand up from bed rest and that needed to walk 10 meter were measured. By using this test, the level of physical fitness for daily living was quantitatively evaluated. The 10 meter walking test is thought to reflect quickness, stability and endurance of motion in walking.¹⁰⁾ The determination of the time needed to stand up is thought to reflect leg strength and quickness of motion.¹⁰⁾ These tests allow evaluation of competence, which is required for everyday life in stroke survivors living at home. Furthermore, it is presumed that a stroke survivor who lives at home and preserves a certain level of physical fitness is able to conduct domestic chores, manage the household, engage in outdoor activities and use transportation.

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Thus, the improvement of physical fitness, as it pertains to daily living, would presumably increase the competence of stroke survivors living at home.

The purpose of this study was to investigate the relationship between sleep-wake rhythm, physical fitness and the competence level of elderly stroke survivors living at home and receiving community rehabilitation services, with special attention to a synchronization of social and biological rhythms of the disabled persons.

Methods

Thirty-seven stroke survivors living at home (29 males and 8 females) voluntarily participated in this study. All lived in the community, Natori City, located in the Tohoku Region of Japan. The mean age was 65.4 ± 7.3 (SD) years old, ranging from 56 to 83 years. The subjects were selected from a registered list of home health care service recipients in the Natori City Health Center. All subjects were informed of the purpose and protocol of the study prior to participation, and informed consent was obtained. Criteria for inclusion were as follows: (1) stroke survivors living in their own homes. (2) stroke survivors able to come to the City Health Center for an interview and assessment of physical fitness. (3) no symptoms or signs of stroke-related dementia. Stroke survivors with cerebral bleeding, cerebral infarction and subarachnoid hemorrhage were all included in this study. Participants were asked to come to the Health Center on one day in November 1995.

The questionnaire study was conducted by the interview method. The interviewer asked about subjective characteristics, life style, sleep-wake rhythm, quality of sleep, activities of daily living, social network and health complaints. The questionnaire items on life style included of regular exercise, drinking, smoking, preference for tea, coffee and salt. The questionnaire items concerning the sleep-wake rhythm included of sleep habits (bed time, awakening time, regularity of bed time and rising time), frequency of walking outdoors, behavioral pattern differences between weekdays and holidays, and preferences for outdoor activity, and an evening-type life style. The questionnaire items concerning quality of sleep included the presence of sleep disturbance, frequency of awakening during nocturnal sleep, and frequency of daytime naps. The reliability and validity of bedtime and rising time by the questionnaire method was confirmed by our previous study^{7,12}, in which the bedtime and rising time by the questionnaire method were strongly correlated to those estimated by the ambulatory motion logger apparatus.

The competence level of stroke survivors living at home was evaluated by using a questionnaire of thirteen-items of Index of Competence developed by Koyano et al., which measures the competence of the community-dwelling elderly.^{13,14} This questionnaire measures three factors of higher-level competence: instrumental self-maintenance, intellectual activity and social role. The competence score, ranging from 0 to 13, was calculated from the questionnaire. The higher the score, the higher the level of competence. The questionnaires on social network included of living arrangement (number of living family members), the frequency of interaction with neighbors (neighbors with whom the subject has friendly discussions), feeling of integration into the community, presence of persons who encourage the subject when the subject feels depressed, and the frequency of participation in community activities.

Regarding health complaints, subjects were asked to answer "always", "sometimes", or "never" to questions about fatigue, digestive troubles, and depressive mood, which appeared in the setting of circadian rhythm desynchronization. A question on perceived general health status (healthy, moderately healthy, not healthy) was also asked.

An evaluation of physical fitness related to daily living was conducted by measuring both the time needed to stand up from recumbent bed rest and that needed to walk 10 meters. The original methods of measuring these physical fitness were standardized by Oida et al.^{9,10} In this study, we slightly modified Oida's method because the original method dealt with the healthy independent elderly. Regarding the test for the time needed to walk 10 meters, the subject walked in a straight line for 10 meters as quickly as possible. Then, the time needed to walk 10 meters was measured with a chronometer. As the subjects in this study had a variety of hemiplegic disabilities caused by their strokes, they were allowed to use canes when they walked during the test. Each measurement was conducted twice, and the shorter time was adopted as the official result. Regarding the test for the time needed to stand up from bed rest, the subject stood up from the bed rest position as he/she normally would like to do as quickly as possible. Then, the time needed to stand up from bed rest was measured with a chronometer. The subjects were allowed to use canes when they stood up from bed rest for the same reason as in the 10 meter walking test. Each measurement was conducted twice, and the shorter time was adopted as the official result. The reliability and validity of these two tests for the disabled elderly were confirmed in our series of studies.^{7,15}

Student's t-test was used to validate differences in means. Pearson's correlation coefficient was calculated in order to measure association between the competence score, physical fitness as it pertains to daily living, and other variables. Multiple logistic regression analysis was conducted in order to evaluate the effects of various factors on the competence score. Independent variables to be incorporated in the regression analysis were selected from the results of the correlation analysis between the given variables and the competence score. Thus, the model incorporated the following variables as independent variables: age, regularity of bed time, frequency of awakening during nocturnal sleep, frequency of daytime naps, preference for outdoor activities, perceived general health status, and frequency of participation of community activities. The SPSS for Windows Release 7.5.1J was used for statistical analysis. A difference was considered statistically significant when the p-value was less than 5 percent.

Results

1. Sleep-wake rhythm, physical fitness pertaining to daily living, and the competence score

The mean bedtime (hour:minute) of the stroke survivors living at home was $20:54 \pm 0:54$ (SD), and the mean rising time was $6:43 \pm 0:55$ (SD). Bedtimes ranged from 18:00 to 0:30, where rising times varied from 3:30 to 10:00. There was no significant difference in either bedtime or rising time among the three types of stroke survivors.

Fig. 1 shows the relationship between rising time and the time needed to walk 10 meters. The earlier the rising time, the shorter the 10 meter walking time ($r=0.33$, $p<0.05$). On the

other hand, there was no significant relationship between bedtime and the 10 meter walking time, although a tendency was noted in that the earlier the bedtime, the shorter the 10 meter walking time.

Regarding rising time and the time needed to stand up, there was no significant correlation ($r=0.21$, $p<0.25$).

Figure 1: The relationship between the rising time and the 10 meter walking time of stroke survivors living at home and receiving community health services in the Tohoku Region of Japan. The correlation was significant at $r=0.33$ ($p<0.05$).

2. Sleep-wake rhythm and daily social activities

Fig. 2 shows the relationship between rising time and the competence score of stroke survivors living at home. The competence score showed a significant negative correlation with rising time at $r=-0.41$ ($p<0.05$). The earlier the rising time, the higher the competence score.

Figure 2: The relationship between the rising time and the competence score. The competence score showed a significant negative correlation with the rising time at $r=-0.41$ ($p<0.05$).

Fig. 3 shows the relationship between rising time and participation in community activities. Subjects who frequently participated in community activities arose earlier than those who had a negative attitude toward participation in community activities. On the other hand, there was no statistically significant difference in bedtime according to the frequency of participation in community activities. It was also found that survivors who had different behavior patterns in terms of the daily activity rhythm, between weekdays and holidays, tended to wake up early in the morning, to participate enthusiastically in community activities, and to be greatly satisfied with their lives.

Figure 3: The mean rising time and the frequency of participation in community activities. A bar represents a standard deviation. A significant difference was observed between the "frequently participated" group and the "seldom participated" group by Student's t-test. (*, $p<0.05$)

3. Results of multiple logistic regression analysis

Table 1 shows the results of multiple logistic regression analysis. The competence score was significantly related to younger age, regularity of bedtime, and participation in community activities ($p<0.05$).

Table 1 Multiple logistic regression analysis of eight selected variables affecting the competence score (dependent variable). Statistically significant variables are shown

Independent variables	Regression coefficient	p
Age	-0.17	0.025
Regularity of bed time	2.56	0.043
Participation in community activities	1.78	0.045

Independent variables: Age (50-69 years=0, 70-89 years=1), regularity of bed time (irregular=0, moderately regular and regular=1), frequency of awakening during nocturnal sleep (more than one time=0, no awakening=1), frequency of daytime naps (more than one time=0, no nap=1), preference for outdoor activity (prefer indoor activity=0, prefer outdoor activity=1), perceived general health status (not healthy=0, moderately healthy and healthy=1), frequency of participation in community activities (seldom=0, occasionally and frequently=1)

Discussion

Stroke survivors, who lived at home, as in this study had already recovered from the acute phase of stroke and received community health care services such as rehabilitation services in

their home, visiting medical care service, and visiting nursing care service. They could go outside with or without the help of care-givers. They were able to walk 10 meters with or without a cane. They were also able to stand up from recumbent bed rest without the help of a care-giver. Measuring physical fitness in relation to daily living for such stroke survivors can provide an objective evaluation of reserve physical fitness capacity, and provide new indicators of physical fitness as regards the daily living activities of disabled persons. It has been reported that this level of physical fitness reflects comprehensive muscle strength, neuromuscular control of muscle coordination, and the physical fitness required for daily living.¹⁰⁾

This study demonstrates that the level of physical fitness as it pertains to daily living activities, is associated with sleep behavior variables, specifically rising time. The earlier the rising time, the shorter the 10-meter walking time. The explanation for this phenomenon is as follows: stroke survivors whose physical fitness levels are relatively high are better synchronized to external entrainment factors such as light and social contact, and as a consequence their sleep habits tend to be more regular than those with lower levels of physical fitness. It is well known that rising time phase-advances with aging.⁷⁾ Decreases in the quality of both subjective and objective sleep have also been reported in the elderly.¹⁶⁾ Thus, age-related changes in sleep-wake rhythm appear to affect the level of biological rhythm synchronization in our study population. Furthermore, subjects whose rising times are extremely late in the morning were those whose sleep-wake rhythm was irregular. As irregular sleep-wake rhythm is known to relate to impaired synchronization of circadian rhythms,¹⁷⁾ subjects whose rising times are extremely late in the morning are apparently poorly synchronized to external entrainment factors because of the irregularity of their sleep-wake rhythm. Thus, it can be said that rising time is an indicator of biological rhythm synchronization in the stroke survivors living at home.

The significant association between participation in community activities and rising time is of interest, because this relationship implies that community activity participation depends on the state of synchronization of biological as well as social life rhythms in the disabled persons. Thus, amelioration of the synchronization state of both biological and social life rhythms may improve the community participation of stroke survivors living in their own homes. The synchronization of the human circadian system is thought to be regulated by cerebral cortical oscillator in addition to the suprachiasmatic nucleus.^{18),19)} The present results suggest the importance of the cortical oscillator reinforced by social activities in the synchronization of disabled persons.

There are several noteworthy characteristics of stroke survivors living at home whose state of synchronization is good, and whose results of physical fitness results are good: these are subjects whose daily activity rhythm pattern differ between weekdays and holidays, who wake up early in the morning or have a morning-preference, who enthusiastically participate in community activities, and who are greatly satisfied with their lives. In other words, stroke survivors living at home who have regular social life rhythms have stronger social ties and a higher

level of satisfaction with their lives.

In this study, significant correlations were found among rising time, the 10 meter walking time, and the competence score. These three variables reflected synchronization of the sleep-wake rhythm, physical fitness as it pertains to daily living, and a higher level of activities of daily living, respectively. It was hypothesized that strengthening the synchronization of the sleep-wake rhythm by appropriate procedures is a promising means of promoting the competence of stroke survivors living at home. This hypothesis is supported by several findings that elderly individuals with dementia tend to lose the circadian time structure, resulting in clinically abnormal behavior due to circadian rhythm impairment.^{20),21)} Regular physical fitness training for daily living activities is a good and feasible means of achieving synchronization of sleep-wake rhythm. As subjects in our study willingly participated in regular programs provided by the Health Center, they were motivated to engage in regular fitness training aimed at enhancing daily living activities. Furthermore, as shown in this study, the tendency for a loss in the recognition of a weekly social rhythm as related to a low competence level implies that consciousness of social rhythms is an important reinforcing factor, maintaining of a high level of daily living activities.

Based on these considerations, we propose an effective means of improving the competence of stroke survivors living at home: that is, to strengthen the synchronization of their sleep-wake rhythm by chronobiologically rational procedures. Strengthening the synchronization of the sleep-wake rhythm is possible by employing both biological and social synchronization. Biological synchronization is achieved by a high intensity of bright light²²⁾ and pharmacological interventions such as sleeping pills.¹⁹⁾ Social synchronization is achieved by active participation in community activities and increasing the social network of stroke survivors living at home. These procedures appear to be more effective for younger subjects. Public health policies focusing on synchronization strengthening for stroke survivors living at home will be promoted in future community services.

Conclusion

The sleepwake rhythm, especially rising time, and the participation in community activities were related to the high competence level of stroke survivors living at home. Strengthening the synchronization of sleep-wake rhythm and increasing the social network may serve as useful procedures to improve the competence of stroke survivors living at home.

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