Scientific Research Publishing

Health, 2023, 15, 895-907
https://www.scirp.org/journal/health
ISSN Online: 1949-5005
ISSN Print: 1949-4998

Sleeping Conditions of Older Adults with Delirium Receiving Home Care

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How to cite this paper: Higo, M. and Morimoto, K. (2023) Sleeping Conditions of Older Adults with Delirium Receiving Home Care. *Health*, **15**, 895-907.
https://doi.org/10.4236/health.2023.158059

Received: May 16, 2023
Accepted: August 27, 2023
Published: August 30, 2023

Abstract

We aimed to clarify the sleep status before delirium onset among older adults receiving home care. The sleep status of 21 participants aged ≥65 years was monitored while they slept with a sensor placed under their bedding, after ruling out insomnia and dementia. The incidence of delirium was 28.6%; delirium onset occurred within an average of 2.7 (SD = 12) days after the start of home care among those whose care environment was changed due to hospital discharge or moving. Increased interrupted sleep and activity during sleep indicated that sleep fragmentation occurred before delirium onset. In conclusion, individuals aged ≥65 years and those whose care environment has changed should be screened for delirium because the time to delirium onset is short. Further, interventions to monitor the sleep status and prevent delirium onset should be implemented from the day home care begins.

Keywords

Patients in Home Care, Elderly, Delirium, Sleep

1. Introduction

Delirium is known to be more likely to occur during hospitalization; however, in Japan, the incidence of delirium at home is likely to increase in the future due to the trend of shifting from hospital- to home-based care. Up to 50% of hospitalized delirium patients are discharged before their symptoms resolve [1], and thus, the incidence of delirium at home increases after hospital discharge, preventing conversion to home care.

Screening patients at a high risk of delirium development and preventing the onset of delirium are crucial as delirium can be reversed if identified early and

managed aggressively. However, this condition is missed in approximately 75% of cases [2] when an evidence-based delirium screening tool is not used. Delirium is often misdiagnosed as depression due to a subjective assessment and followed up incorrectly. Furthermore, hypoactive delirium has been reported to cause as much distress to the patients and their families as hyperactive delirium, with a longer duration and a higher mortality rate reported in cases of hypoactive delirium among patients with dementia [3]. Thus, delirium care at home is important because prevention of the onset of delirium and reduction of the duration of delirium can improve the quality of life of the patients and their families, which is the main objective of home care.

Delirium may be prevented through non-pharmacological preventive interventions; hence, preventive care can reduce delirium incidence [4]. In addition to identifying risk factors to predict the onset of delirium and subsequent care, care providers who understand the pathology of delirium development may be able to reduce the risk and duration of delirium through timely preventive interventions.

The use of non-pharmacological strategies, including routine screening, environmental modifications, and avoidance of deliriogenic medications, effectively prevents delirium. Several of these interventions target sleep disturbance, a significant risk factor for delirium. Burton et al. found that good sleep hygiene was associated with a reduced risk of incident delirium [5]. However, it is challenging for caregivers or medical personnel to assess the sleep/wake patterns of their care recipients at home; thus, sensors are necessary for this purpose. Sleep disturbances influence the development of delirium. Accordingly, this study aimed to clarify the sleep/wake patterns before the onset of delirium in older adults receiving home care after hospital discharge.

2. Method

2.1. Study Design and Participants

This study was conducted as an exploratory analysis to determine the actual sleep status of older adults receiving home care before the onset of delirium. Data were collected from March 2022 to November 2022.

Older adults aged ≥65 years receiving home care from one of three home healthcare facilities; those who, along with their primary caregivers, agreed to participate in the study; and those who had obtained permission from their doctor were eligible for participation. The exclusion criteria were as follows: 1) obvious disturbance of consciousness; 2) serious physical illness; 3) diagnosis with hearing loss or visual impairment; 4) treatment with benzodiazepines; 5) treatment with anticholinergic drugs; 6) disturbance of consciousness; 7) serious physical conditions, and 8) an Athens Insomnia Scale (AIS) score of ≥6 and an MMSE score of ≤23. Those who developed delirium during the monitoring period were categorized into the delirium-onset group, and those who did not develop delirium were categorized into the non-delirium-onset group.

2.2. Methods

First, we visited the participants at their homes and explained the study to them. A 20-minute interview was conducted, and an actigraphy device was placed under the mattress of the participant's bed. The device comprised a highly sensitive pressure sensor that continuously recorded the activity of the person lying on the mattress and could identify the "in bed" and "out of bed" states from the change in mattress pressure. The initial interview comprised assessments using the Mini-Mental State Examination (MMSE) and the AIS, along with a 3-minute diagnostic interview for delirium using the confusion assessment method (3D-CAM). All of those interviews were conducted by the researcher.

From the start of sleep monitoring with the seat-type non-wearing actigraphic device, each participant's condition was assessed by telephone or video communication at the same time each day using the 3D-CAM questionnaire, and any change was considered an occurrence of delirium, and the procedure was discontinued. The participant's involvement in the study was terminated when the home-care nurse and the home physician determined that the patient had delirium. Participants who showed no particular change were continued to be monitored for 2 weeks. The maximum period was 2 weeks from the date of actigraphy device installation.

2.2.1. MMSE

The MMSE [6] is a 30-point cognitive function test consisting of 11 items, namely, time disorientation, place disorientation, immediate playback of three words and delayed playback, calculation, object calling, sentence recitation, three levels of verbal commands, written commands, written text, and graphic imitation. A score of ≤23 indicates suspicion for cognitive impairment.

2.2.2. AIS

The AIS [7] [8] [9] is an 8-question universal tool for determining insomnia; it has a sensitivity of 91% and a specificity of 87% [6]. The AIS was developed by the Global Project on Sleep and Health, led by the World Health Organization. It enables the measurement of the degree of insomnia by quantifying the answers to the 8 questions on a 24-point scale. In the current study, participants with a score of ≥6 at the initial interview were deemed to have insomnia [10] and were excluded.

2.2.3. 3D-CAM

The 3D-CAM is used to assess the following: 1) sudden change in the mental state, 2) lack of attention; 3) confusion of thought, and 4) change in the level of consciousness. A person who screens positive for features 1, 2, and 3 or 1, 2, and 4 is considered to have delirium. This tool has a sensitivity and specificity of 95% and 94%, respectively, in reliability evaluations of older American adults and a sensitivity and specificity of 96% and 86%, respectively, in patients with dementia [11]. Information on age, sex, cognitive impairment, hearing and visual im-

pairment, cohabiting family members and main caregivers, current and past medical history, care environment (including bedroom), alcohol consumption habits, drug usage, and history of infectious diseases was collected through medical record reviews and interviews with participants and other informants (physician, home care nurse, and family members).

2.3. Sleep Sensor

A newly developed non-wearable actigraphy device (NEMURI SCAN NN-1100, PARAMOUNT BED CO., LTD., Tokyo, Japan) [8] was used to monitor the sleep/wake pattern. The actigraphy device was used to determine the heart rate, respiratory rate, period of sleeping in bed, waking time, sleeping time, sleep latency, sleep efficiency, interrupted sleep time, number of times the participant got out of bed, and activity level (frequency and intensity of body movements greater than respiration and heartbeat, using a total of 7 minutes of activity from 4 minutes before to 2 minutes after to determine sleep/wake per minute). The average activity level was the average value of body movements counted per minute, and the interrupted sleep time was the total time the patient was awake but not yet ready to leave the bed.

2.4. Statistical Analysis

Descriptive results are expressed as the means and standard deviations. A Mann-Whitney U test was used to examine the differences in each sleep item between the delirium-onset and non-delirium-onset groups. P values of ≤0.05 indicated a significant difference. All statistical analyses were performed using IBM SPSS version 26 (IBM Japan Ltd., Tokyo, Japan).

2.5. Ethical Considerations

This study was approved by the appropriate Research Ethics Committee and was conducted in compliance with the Declaration of Helsinki. Participants and their primary caregivers were informed of their rights as research subjects verbally and in writing, and consent to study participation was obtained. It was explained that participation could be discontinued at any time after the start of the study at the request of the family members and the participants themselves. The trial was immediately terminated if it became difficult to continue during the daily phone conversations. The results of the study appeared in the study findings only when it was possible to carry out the study, with the participants' and their family members' consent. The data are available from the corresponding author upon reasonable request.

3. Results

3.1. Participant Characteristics

In total, 21 participants were included; among them, 9 were receiving home nursing care unrelated to hospitalization or relocation, 10 were receiving home

care after hospital discharge, and 2 were receiving home care after relocating from another residence. There were six patients (three men and three women) who developed delirium, yielding a delirium incidence rate of 28.6%. The mean age was 81 years (SD = 4.0 years, and all six patients had experienced a change in the recuperation place. Meanwhile, the remaining 15 participants (4 men and 11 women) did not experience delirium (mean age, 73 years (SD = 4.0)) and were able to continue with sleep monitoring without any problems. The delirium-onset group was significantly older than the non-delirium-onset group ($p = 0.01$). Based on the mean age of the delirium-onset group (*i.e.*, 81 years (SD = 4.0)), most participants could have been older adults aged between 75 years and 84 years, and their advanced age may be an indicator of delirium development (Table 1).

3.2. Results of Sleep Monitoring

3.2.1. Delirium-Onset Group

The average number of days of sleep monitoring was 2.7 days (SD = 1.2). The average heart rate and respiratory rate were 61 beats/min (SD = 7) and 16 breaths/min (SD = 4.0), respectively. The average amount of sleep, duration of sleeping in bed, sleep latency, and sleep efficiency were 412.6 minutes (SD = 114.2), 495.2 minutes (SD = 110.2), 13.0 minutes (SD = 3.2), and 80.5% (SD = 10.9), respectively. The average interrupted sleep time, activity level, and number of times the participant got out of bed were 64.1 minutes (SD = 25.1), 78.9 counts/minute (SD = 26.6), and 2.1 times (SD = 1.3), respectively. The mean MMSE score was 29.7 (SD = 0.5), and the mean AIS score was 3.8 (SD = 1.5). The monitoring results of two representative participants in the delirium-onset group are shown in Figure 1. The first participant was in bed during the day and had difficulty getting a good night's sleep. The second participant who had a good night's sleep on the first day had intermittent sleep on the second and third days. The first participant clearly had a pattern that a medical professional would be alerted to if the patient were to develop delirium. However, the second participant could be overlooked because of the relatively good night's sleep on the first day (Table 2).

3.2.2. Non-Delirium-Onset Group

The average heart rate and respiratory rate were 62 beats/min (SD = 7) and 15 breaths/min (SD = 2), respectively. The average number of days of sleep monitoring, amount of sleep, duration of sleeping in bed, sleep latency, and sleep efficiency were 14 days, 435.7 minutes (SD = 75.3), 489.4 minutes (SD = 80.7), 16.4 minutes (SD = 5.0), and 89.0% (SD = 3.6), respectively. The average interrupted sleep time, activity level, and number of times the participant got out of bed were 30.2 minutes (SD = 15.9), 45.5 counts/minute (SD = 16.4), and 0.9 times (SD = 0.6), respectively. The average MMSE score was 30, and the average AIS score was 3.3 (SD = 1.8). An example of sleep monitoring findings in the non-delirium-onset group is shown in Figure 2. As shown, the patients had

Table 1. Participant characteristics.

	Sex	Age (y)	Average Heartbeat (beats/min)	Average Respiratory rate (min)	Average Sleep Duration (min)	Average Period of Sleeping in Bed (min)	Average Sleep Latency (min)	Average Sleep Efficiency (%)	Average Interrupted Sleep Time (min)	Average Activity during Sleep (count/min)	Average Number of Times of Getting Out of Bed	MMSE Score	AIS Score	Monitoring Period (days)	Delirium Onset	Residential Environment
1	M	83	69.9	13.1	405.0	462.0	9.9	87.3	44.2	87.6	3.0	29	5	1	Yes	After discharge
2	F	84	65.7	16.4	634.0	718.0	16.6	88.4	63.3	118.0	2.6	30	2	2	Yes	Moving
3	M	79	59.1	15.7	414.0	461.0	9.5	89.7	32.3	83.9	0.2	29	2	4	Yes	After discharge
4	F	78	52.7	23.2	331.4	425.4	15.0	62.8	96.2	43.4	2.0	30	5	3	Yes	Moving
5	F	76	53.2	14.4	328.4	464.0	16.0	71.3	90.2	86.08	1.0	30	5	2	Yes	After discharge
6	M	86	65.6	12.3	363	441	11.2	83.3	58.3	54.46	3.6	30	4	4	Yes	After discharge
7	F	78	57.0	15.6	558.9	613.2	14.4	91.2	34.4	30.0	1.6	30	5	14	No	After discharge
8	M	73	77.0	15.7	498.7	559.4	17.9	87.8	35.1	44.6	0.8	30	2	14	No	After discharge
9	F	69	67.8	16.0	534.2	586.6	14.7	91.1	37.1	31.3	1.2	30	4	14	No	After discharge
10	F	71	63.8	13.5	439.0	509.0	14.8	86.3	52.6	56.8	0.5	30	0	14	No	
11	F	71	67.1	14.8	583.0	641.0	10.3	91.3	44.6	31.6	0.7	30	2	14	No	
12	F	74	58.5	15.8	385.0	440.0	27.8	87.2	23.7	63.8	1.5	30	5	14	No	After discharge
13	M	74	60	14.6	366	385	13.6	95.2	4.5	23.8	0	30	5	14	No	
14	F	67	60.7	17.6	362	408	24.5	88.6	6.9	38.6	0.1	30	2	14	No	
15	F	74	64.5	14	374	430	22.7	86.9	30.9	78.6	1	30	4	14	No	After discharge
16	M	72	61.4	13	429	482	13.7	89	31.5	42.6	0.4	30	2	14	No	
17	F	74	64.3	14.8	400	473	15	84.7	50.9	54	1.8	30	1	14	No	
18	F	78	48.1	18.5	437	467	9.4	93.6	16.4	73	2.1	30	5	14	No	
19	M	83	56.6	14.6	368	449	15.6	82.4	43.3	32.6	0.5	30	5	14	No	After discharge
20	F	66	63.9	16.5	444	516	16	86.4	37.2	38	0.5	30	5	14	No	
21	F	69	56.6	13.1	357	382	16.2	93.7	4.3	43.2	1.2	30	2	14	No	

M: male; F: female; y: years; MMSE: Mini-Mental State Examination; AIS: Athens Insomnia Scale.

Table 2. Participant summary, sleep condition monitoring results, and scale scores.

		Delirium-onset Group	Non-delirium-onset Group	U-test
	Factor	n = 6	n = 15	Significance probability
Basic characteristics	Sex			
	Male (persons)	3.00	4.00	
	Female (persons)	3.00	11.00	
	Age (years)	81 ± 4	73 ± 4	0.01
	With environmental change	6.00	6.00	
	Without environmental change	0.00	9.00	
Sleep monitoring days		2.7 ± 1.2	14	
Sleep-related data	Heart rate (beats/min)	61 ± 7	62 ± 7	1.00
	Respiratory rate (breaths/min)	16 ± 4	15 ± 2	0.79
	Sleep duration (min)	412.6 ± 114.2	435.7 ± 75.3	0.30
	Period of sleeping in bed (min)	495.2 ± 110.2	489.4 ± 80.7	0.79
	Sleep latency (min)	13.0 ± 3.2	16.4 ± 5.0	0.34
	Sleep efficiency (%)	80.5 ± 10.9	89.0 ± 3.6	0.10
	Interrupted sleep time (min)	64.1 ± 25.1	30.2 ± 15.9	0.01
	Average activity during sleep (counts/min)	78.9 ± 26.6	45.5 ± 16.4	0.01
	Number of times the participant got out of bed (times)	2.1 ± 1.3	0.9 ± 0.6	0.06
Scale scores	MMSE score	29.7 ± 0.5	30.00	0.27
	AIS score	3.8 ± 1.5	3.3 ± 1.8	0.57

Data are presented as numbers or as the mean ± standard deviation. MMSE: Mini-Mental State Examination; AIS: Athens Insomnia Scale.

coherent sleep from the time of sleep onset until awakening.

4. Discussion

4.1. Incidence of Delirium

This study found that delirium occurred in 28.6% of older adults in home care. Sandberg *et al.* [12] reported a delirium incidence of 34% in home healthcare groups in a Swedish study of patients aged ≥75 years. Kelly *et al.* [13] reported also delirium incidence of 14.2% in nursing homes in Sweden, and Evelyn *et al.* [14] reported a higher incidence of 40.4% in nursing homes in Canada. Meanwhile, Meagher *et al.* and Li *et al.* reported delirium incidence rates of 16.7% and 18.4%, respectively, in the hospital population [15] [16] These studies show that

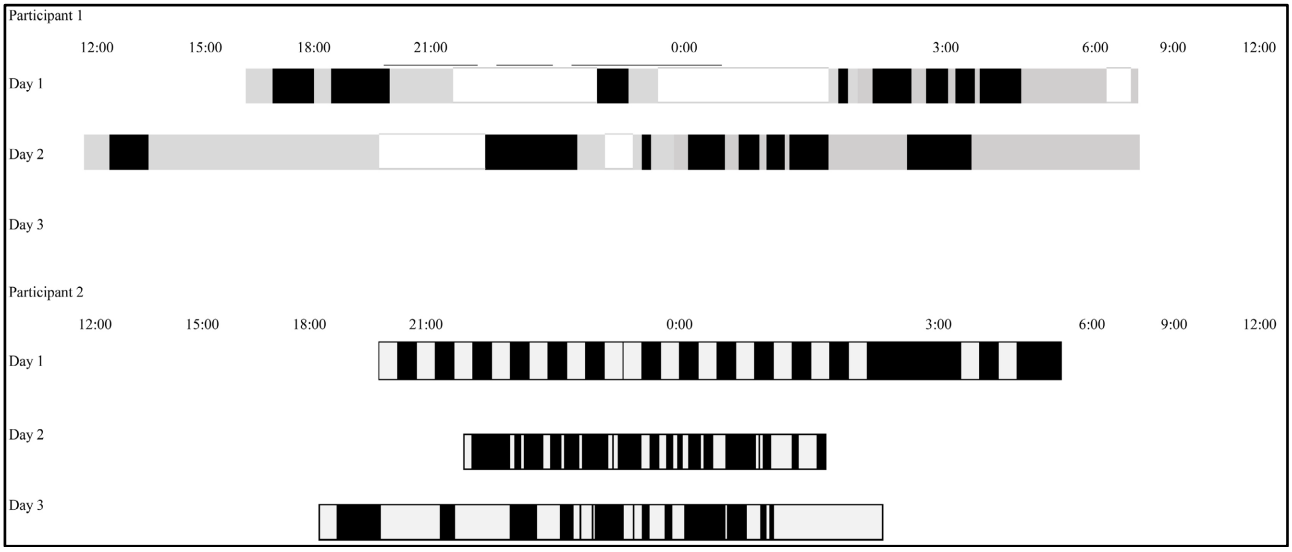

Figure 1. Sleep monitoring results of two representative participants in the delirium-onset group.

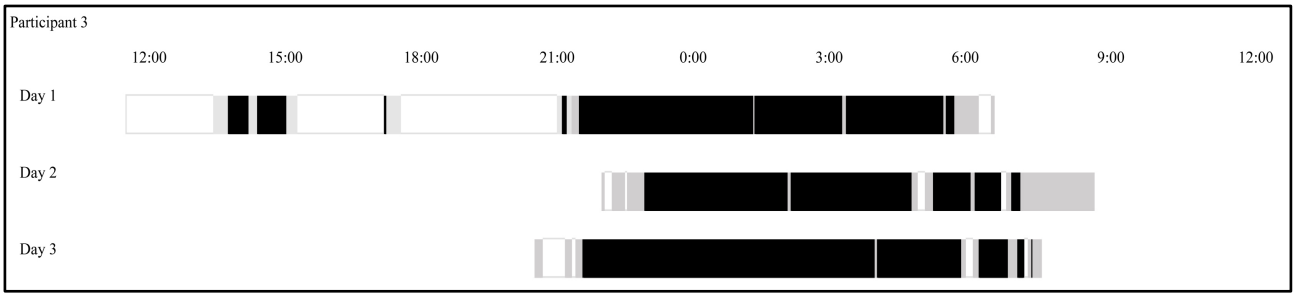

Figure 2. Sleep monitoring result of one participant in the non-delirium-onset group.

the incidence of delirium is higher in older adults living outside the hospital than in those admitted to critical and acute care units

In addition, in this study, 6 of the 13 patients who experienced a change in the care environment due to discharge or moving developed delirium, while all 8 patients who experienced no environmental change did not develop delirium. Management systems, diseases, and other factors; however, it is necessary to note that changes in the care environment are a strong risk factor for the development of delirium (regardless of whether the patient is in a hospital, facility, or home-care setting). It is essential to intervene to prevent the onset of delirium even before the care environment changes.

4.2. Relationship between Delirium and Sleep

Delirium has been suggested to be highly associated with sleep. Acetylcholine and dopamine are important neurotransmitters in the regulation of sleep and wakefulness, and their dysregulation has been implicated in the development of delirium [17]. The present study also observed significant differences in the average sleep activity and interrupted sleep time between the delirium-onset and non-delirium-onset groups. Particularly, intermittent sleep due to increased

wakefulness during nocturnal sleep was observed prior to the onset of delirium, confirming the results of previous studies.

Regarding sleep-related items, the sleep duration, duration of sleeping in bed, and number of times the participant got out of bed did not differ significantly between the delirium-onset and non-delirium-onset groups. However, daily monitoring of sleep and wakefulness yielded graphs that clearly differed between the two. Caregivers can sense abnormalities by noises, such as those made when the patient gets up in the middle of the night and fidgets; however, they cannot sense whether the sleep is becoming shallow while the patient is in bed. We still believe that understanding the sleep status using sleep sensors is crucial for the early detection of delirium onset.

4.3. Delirium Onset Date

Delirium onset occurred within an average of 2.7 days (SD = 1.2) after the initiation of home care, indicating that a change in the care environment from hospital to home had a significant impact on the onset of delirium. These results support that it may be possible to predict the onset of delirium as evidenced by the change in the sleep/wake patterns from the first or second day after the care environment changed before the onset of delirium in the delirium-onset group. Particularly, it may be possible to screen for the presence of delirium by investigating the sleep/wake patterns at the same time as the occurrence of changes in the care environment.

4.4. Age at Delirium Onset

The delirium-onset group was significantly older than the non-delirium-onset group (average age: 81 years (SD = 4) vs. 73 years (SD = 4), p = 0.01). Kukreja *et al.* reported a low overall incidence of delirium in community-based older adults (1% - 2%), but the incidence increased with age, increasing to 14% in individuals aged >85 years. [18]. Sharma *et al.* [19] compared the incidence and outcome of delirium in patients in the intensive care unit with those in younger patients and found a significantly higher incidence of delirium in older adult patients. This finding supports that the incidence of delirium is higher in older adults and that older age is one of the most important risk factors for delirium. Folstein *et al.* [20] reported that the association between delirium and increasing chronological age in adulthood is present in both community-dwelling and hospitalized patients, with the very elderly being at the greatest risk.

Thus, interventions that consider older adults at a particularly higher risk of developing delirium are needed. However, it is debatable whether age alone is a risk factor. There are individual differences in the degree of age-related changes in the physiological functions and drug-processing ability among older adults. Rather than considering an association between age and the development of delirium, we may need to consider whether there is an association between frailty and the development of delirium.

4.5. Comparison between the Delirium-Onset and Non-Delirium-Onset Groups

Monitoring revealed that the non-delirium-onset group had a regular sleep/wake pattern (**Figure 2**), similar to the findings of Otsuka *et al.* [21] Conversely, the delirium-onset group showed a disturbed sleep/wake pattern or sleep fragmentation, which worsened with each passing day (**Figure 1**). In the second case shown in **Figure 1**, the sleep latency (*i.e.*, the time between sleeping in bed and actually falling asleep) was longer on the first day but shorter on the second and third days. This suggests that in the future, it may be possible to detect sleep patterns by comparing actual monitoring graphs and to follow up on areas that are often overlooked based on numerical values alone.

Furthermore, interrupted sleep time ($p = 0.01$) and average activity level ($p = 0.01$) were significantly different between the two groups. The interrupted sleep time and the average amount of activity during sleep were significantly higher in the delirium-onset group. Furthermore, delirium onset occurred within an average of 2.7 days (SD = 1.2) after home care initiation in the present study. Mineko [22] similarly reported that the onset of delirium in older adult patients with stroke occurred within an average of 3.79 days (SD = 4.21) after admission, and the most frequent onset day was the second day of admission. Jaiswal *et al.* [23] also found that increased sleep fragmentation was associated with the development of delirium in hospitalized older adult patients. Although it is difficult for caregivers to grasp the state of a patient's sleep, the increase in the number of body movements during the night and during the awake time in patients who develop delirium suggest that the use of sensors to assess sleep/wake patterns may be useful in predicting the onset of delirium without placing a burden on the caregivers. Thus, monitoring sleep/wake patterns is useful.

4.6. Study Limitations and Future Directions

This study examined differences in the sleep/wake patterns between participants who did and did not develop delirium at home and found significant intergroup differences in the age, mean interrupted sleep time, and mean activity level during sleep between these participants. Insomnia symptoms in older adults commonly occur due to age-related changes in sleep regulation. The participants in this study were limited to those who were not taking any sleep medications, and individuals with insomnia were excluded based on the AIS scores. However, because the sleep state before the care environment changed was not monitored, no comparison was made between before and after the care environment changed. Thus, the possibility that the underlying sleep may be shallow cannot be ruled out. In addition, older adults are multimorbid and take many medications; the effects of these medications could not be completely eliminated. However, despite the small number of participants in this study, we believe that we have obtained unprecedented and valuable data on the actual sleep/wake patterns of older adults before the onset of delirium, based on the distinction between patients

with dementia and those with delirium. In the future, we would like to investigate the sleep patterns of patients with delirium by starting the sleep-state monitoring even before there is a change in the care environment and collecting similar data to increase the number of cases.

5. Conclusion

Age ≥75 years is a risk factor for delirium onset. In addition, sleep is interrupted and activity during sleep is increased from the first day of monitoring, indicating that sleep fragmentation appears before the onset of delirium. Given the short interval between the onset of changes in the care environment and the onset of delirium, sleep/wake patterns should be monitored immediately after the start of home care in patients aged >75 years and in those who have experienced changes in the care environment. Further, early interventions are needed to prevent the onset of delirium.

Acknowledgements

This study was supported by the Yuumi Memorial Foundation for Home Health Care Grant for Problem-Solving Demonstration Research (2021). The funder had no role in study design; in the collection, analysis, and interpretation of data; in the writing of the report; and in the decision to submit the article for publication. We would like to thank the families of the participants who agreed to participate in this study as well as those who cooperated with us.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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