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Pacing and Lapping Movements Among Institutionalized Patients With Dementia

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Abstract

Wandering is a complex behavior, and defining wandering has been challenging. The current study used the integrated circuit (IC) tag monitoring system to describe the distance moved per day and the spatial movements of patients with dementia. The study was conducted in a 60-bed semiacute dementia care unit in a general hospital in Japan over a 3-month period in 2006. The distance moved per day, the numbers of pacing and lapping movements, and the proportions of the distance moved that was paced or lapped were tabulated in 23 patients diagnosed with dementia. The distance moved per day and the numbers of pacing and lapping movements varied greatly within and among study participants. The median distance moved per day was inversely correlated with participants' age and Mini-Mental State Examination (MMSE) scores (adjusted $r^2 = .34$, $P = .01$). Consecutive lapping and pacing movements were rare patients with in Alzheimer's disease (AD), while 2 patients with frontotemporal dementia paced or lapped repeatedly.

Keywords

wandering, spatial movements, pacing, dementia

Introduction

Wandering is reported to be one of the most challenging care burden issues[1-3] and is also a safety issue because it is associated with increased risk of falls.[4] The definition of wandering is mostly subjective description of ambulation in people with dementia (PWD), often characterized by "aimless"[5] or "purposeless"[6] ambulation. To date, no consensus on the definition of wandering has been attained.

Algase et al[7] summarized wandering in dimensions of frequency, pattern (lapping, random, or pacing), boundary transgressions, and deficits in navigation or wayfinding. Frequency or degree of locomotion in wandering were described as "excessive,"[8,9] "endless,"[10] "persistent,"[11] or continuous.[12] Spatial movements were described as "without a fixed course"[10,13] or "persistent and circuitous."[7] In terms of movement pattern, pacing itself is considered wandering in some studies,[10,13,14] while it was excluded in another.[15] Some definitions of wandering are mostly limited to boundary transgressions.[16,17]

Wandering develops as cognitive function deteriorates. Therefore, an objective description and classification of wandering may shed light on the underlying mechanisms.[18] The following methods for quantification of wandering have been reported: (1) scales administered by caregivers; (2) personal observations; and (3) mechanical devices. Two scales to measure wandering are available. One measures wandering as a part of the Behavioral and Psychological Symptoms of Dementia (BPSD),[14,18] and the other measures wandering itself.[8] Although the problem of subjectivity exists, these scales represent outcome measurements with which to assess interventions.[1]

Spatial disorientation is one of the characteristics of wandering in PWD. Patterns of spatial movements in elderly residents with dementia[6] were explored in a pilot study, and 4 patterns of movement were identified, namely direct, lapping, pacing, and random travel events. Direct travel was defined as travel from one location to another without diversion; random travel was defined as roundabout or haphazard travel to many locations within an area without repetition; pacing was repetitive back-and-forth movement within a limited area; lapping was repetitive travel characterized by circling large areas. Random

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travel events were considered "inefficient" and were more common among residents with severe cognitive impairment than among those with no or only mild cognitive impairment.[6,11] This pattern of travel events was confirmed by direct observation of elderly residents in a nursing home setting.[7]

Feasibility studies were conducted to test the abilities of mechanical devices to measure the number of steps or activity levels in PWD.[19,20] The major obstacle to using these devices appears to be a lack of cooperation from demented participants to wear the devices,[20] and none of these devices have been widely used in studies of wandering.

Technology to measure the temporal and spatial movements of institutionalized persons with dementia has recently become available and has since been used to monitor activities in institutionalized elderly residents with dementia.[21-23]

The purpose of the study was to quantify ambulation in terms of the distance moved and frequency of various spatial movements among patients with dementia.

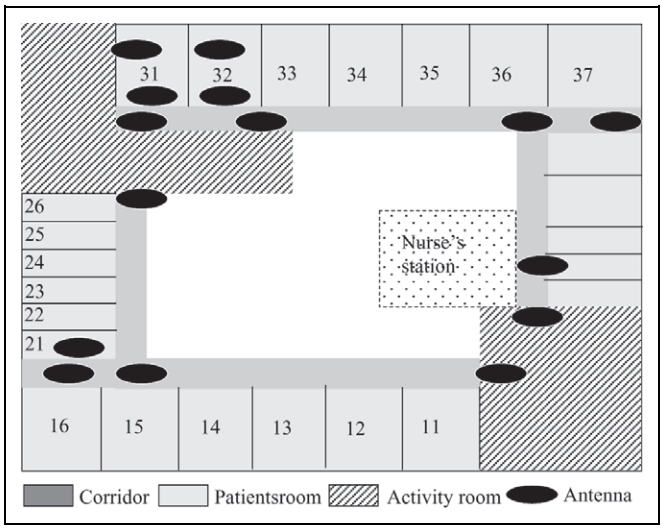

Figure 1. Layout of the unit.

Methods

Setting and Participants

Monitoring was conducted at a 60-bed dementia care unit in a general hospital in Osaka, Japan, between November 2006 and March 2007. The layout of the unit is displayed in Figure 1. The unit was a closed system and consisted of 13 four-bed rooms and 8 private rooms. The unit admitted demented patients with various PBSD and or care burden problems, and the majority of patients were discharged to long-term care facilities once the patient stabilized. There were 2 common spaces, 1 for dining and 1 for occupational and recreational therapies (hereafter called the activity room).

Monitoring Study

Eligibility criteria included (1) participants who could ambulate independently; and (2) participants who could be monitored for a minimum of 21 days. Twenty-one days were considered necessary to examine temporal variations in spatial movements.

Spatial Movement Study

Eligibility criterion included participants in the monitoring study with a median distance walked per day exceeding 500 m. The distance of 500 m was considered necessary for measuring repeated pacing or lapping movements in the unit.

Integrated Circuit Tag Monitoring System

The IC Tag monitoring system with Powertags was used for monitoring (Matrix Int, Osaka, Japan). Fifteen antennae were placed over the ceiling to receive signals from the IC tag (Figure 1). The IC tag was attached to a patient's shirt using adhesive tape. When the patient with the IC tag passed under an antenna, the tag emitted a signal containing the time, place, and ID information, which was received by the antenna. The system could monitor the temporal and spatial movements of the patient over an extended period.[21,22]

Diagnosis Criteria

The diagnosis was made by the fifth author. The following criteria were used for differential diagnosis: for Alzheimer's disease (AD), McKhann et al[24]; for vascular dementia (VaD), Román et al[25]; for frontotemporal dementia (FTD), Neary et al[26]; for dementia with Lewy bodies (DLB), McKeith et al[27]; and for dementia related to alcoholism (Alc), the *Diagnostic and Statistical Manual of Mental Disorders* (Fourth revision [*DSM-IV-R*]).[28]

Data Collection

Patients' demographic information was obtained from their hospital charts. The Mini-Mental State Examination (MMSE)[29] was used for cognitive assessment and was administered by an experienced clinical psychologist on admission. The Neuropsychiatric Inventory-Nursing Home Japanese version (NPI-NH)[30] was used to assess aberrant motor behavior, a surrogate measure of wandering. All patients were assessed by a group of staff members at the unit after admission and every 3 months.

Information about medications that may have had an impact on BPSD, such as major tranquilizers, laxatives, and narcotic medication, was obtained from the medical charts.

Operational Definition of Pacing and Lapping

A pacing movement was operationally defined as a movement in which the participant moved back and forth between any 2 antennae consecutively, and a lapping movement was defined as a movement in which the participant consecutively moved

around the 4 corners of the unit, in either a clockwise or a counterclockwise direction. Frequency distributions of pacing and lapping movements were examined to determine the cutoff points for pacing and lapping movements.

Data Analysis

The monitoring software calculated the distance moved by the participant and the distance lapped or paced by the participant. Microsoft Office Access 2003 was used for database management and Statistical Package for Social Sciences software (SPSS) Ver 17 was used for statistical analyses. If the skewness fell outside of 2 standard errors, it violated the normality assumption. Then, nonparametric tests were performed. Coefficients of variation were calculated by dividing the standard deviation by the mean to compare the variation in distance moved per day among participants. Spearman correlation coefficients were obtained to examine the relationships between distance moved and relevant variables, such as cognitive function and age. P values less than 5% were considered statistically significant. Multiple linear regression analysis was conducted to predict the distance moved per day with P value less than .1 were entered into the model.

The median numbers of consecutive pacing movements were tabulated using cutoff points of $\geq$1, $\geq$2, and $\geq$3 pacing movements. Pacing movements $\geq$2 means that the participant completed at least 2 pacing movements. The proportion of the distance moved per day that was paced was also tabulated to examine pacing movement relative to the distance moved per day. The same analysis was done for lapping movements.

Ethical Considerations

This study was approved by the Ethics Committees of Osaka University and the study hospital. Written informed consent was obtained from the eligible participants' authorized proxies after explaining the study protocol.

Results

Patient Characteristics

Thirty-two participants met the eligibility criteria for the monitoring study, and 1 participant dropped out due to isolation. In the spatial movement study, 8 participants did not meet eligibility criteria. The results are therefore presented for the remaining 23 participants.

The study participants comprised 10 men and 13 women. The mean number of days of monitoring was 53.7 $\pm$ 27.7 days, and 8 participants were monitored from admission. The demographic characteristics of the participants are displayed in Table 1. The mean age of participants was 70.0 $\pm$ 10.6 years. The mean duration of dementia (after symptom onset) was 5.5 $\pm$ 3.7 years. The mean MMSE score was 9.5 $\pm$ 7.0. Over two thirds of the participants had AD, and the majority of the participants were prescribed psychotropic medication (Table1).

Table 1. Characteristics of the Participants

		n = 23
Variable		Mean $\pm$ SD
Age (years)		70.0 $\pm$ 10.6
Duration of dementia (years)		5.5 $\pm$ 3.7
MMSE		9.5 $\pm$ 7.0
	Percentage (%)	
Sex		
Men	43.5	
Women	56.5	
New admission	34.8	
Diagnosis		
AD	73.9	
VaD	8.7	
Alc	8.7	
FTD	8.7	
Medication		
Major tranquilizer	56.5	
Laxatives	34.8	
Narcotic medication	26.1	

Abbreviations: FTD, frontotemporal dementia; VaD, vascular dementia.

Median and Mean Distances Moved Per Day and the Median Numbers of Pacing and Lapping Movements

The means and the standard deviations of the distance moved per day were displayed to show the fluctuations in the distance moved per day (Table 2). The mean distance moved per day varied from 718 to 11 827 m, with uniformly large standard deviations. Excessive movements ($\geq$6 km a day) were observed in young patients with AD with MMSE scores of 12 or less.

The distribution of the distance moved per day in each individual was examined, and the distribution was skewed in 7 participants, skewed to either the right or the left. Thus, the median distance was used for statistical testing. Because the pattern of movement in patients with FTD was quite different from that in non-FTD patients, 2 patients with FTD were excluded from the subsequent analysis. In the univariate analysis, the median distance moved per day was significantly associated with participants' age ($r = -.392$, $P = .08$) and MMSE scores ($r = -.476$, $P = .03$). The median distance moved per day did not differ significantly between those with medication (major tranquilizers, laxatives, or narcotic medication) and those without ($P > .10$). Furthermore, the median distance moved per day did not differ significantly between those with and without aberrant motor behavior, subscale of NPI-NH ($P = .83$). For multivariate analysis, participants' age and MMSE were entered, and the standardized regression coefficient was $-.40$ for age and $-.37$ for MMSE with an adjusted r^2 of .339 ($P = .01$).

The coefficient of variation ranged from 32% to 80% and was inversely associated with the mean distance moved per day ($r = -.58$, $P = .03$). In other words, those who moved less had greater fluctuations in the distances moved per day than those who moved more.

The median number of pacing movements ($\geq$1 movements) per day ranged from 2 to 52 and was highly correlated with the

Table 2. The Mean Distance Moved Per Day, Numbers of Pacing and Lapping Movements, Distances Paced and Lapped as a Proportion of Distance Moved

Dementia Type	ID	Distance Moved Per Day		Median Number of Consecutive Pacing Movements			Median Number of Consecutive Lapping Movements			Median Proportion of the Distance Moved Per Day That Was Paced			Median Proportion of the Distance Moved Per Day That Was Lapped		
		Median	Mean ± SD	1[a]	2[a]	3[a]	1[a]	2[a]	3[a]	1[a]	2[a]	3[a]	1[a]	2[a]	3[a]
AD	R32	12 242	11 827 ± 4351	52	14	3	20	2	–	0.34	0.10	0.02	0.21	0.03	–
	R17	11 624	10 555 ± 5093	42	2	–	25	4	–	0.23	0.01	–	0.29	0.05	–
	R2	8410	8733 ± 2889	47	15	3	11	2	–	0.41	0.12	0.03	0.16	0.02	–
	R11	6322	6388 ± 2139	30	7	–	16	6	–	0.33	0.08	–	0.37	0.11	–
	R6	2695	2810 ± 896	12	2	–	6	–	–	0.27	–	–	0.27	–	–
	R30	2006	1813 ± 835	8	–	–	5	–	–	0.26	–	–	0.40	–	–
	R35	1860	2248 ± 1173	11	3	–	8	2	–	0.30	0.08	–	0.50	0.13	–
	R21	1807	1935 ± 1246	6	–	–	5	2	–	0.20	–	–	0.46	0.14	–
	R4	1726	1808 ± 1016	8	–	–	2	–	–	0.30	–	–	0.14	–	–
	R16	1708	1755 ± 839	5	–	–	7	4	–	0.13	–	–	0.50	0.19	–
	R24	1683	1960 ± 798	5	–	–	5	–	–	0.15	–	–	0.32	–	–
	R15	1634	1867 ± 1007	8	–	–	–	–	–	0.31	–	–	–	–	–
	R28	1579	1683 ± 905	7	–	–	2	–	–	0.20	–	–	0.14	–	–
	R9	1113	1078 ± 380	4	–	–	1	–	–	0.25	–	–	0.12	–	–
	R8	837	970 ± 675	2	–	–	–	–	–	0.14	–	–	–	–	–
	R12	717	718 ± 290	3	–	–	–	–	–	0.25	–	–	–	–	–
	R36	700	776 ± 463	2	–	–	1	–	–	0.12	–	–	0.25	–	–
FTD	R29	4258	4225 ± 1500	2	–	–	27	23	21	0.03	–	–	0.86	0.75	0.68
	R10	1216	1666 ± 1332	15	13	12	–	–	–	0.91	0.84	0.80	–	–	–
Others	R14	1541	1523 ± 684	3	–	–	1	–	–	0.10	–	–	0.09	–	–
	R31	959	1060 ± 571	7	3	–	1	–	–	0.45	0.15	–	0.16	–	–
	R20	848	845 ± 470	2	–	–	1	–	–	0.15	–	–	0.08	–	–
	R5	677	837 ± 577	2	–	–	2	–	–	0.16	–	–	0.37	–	–

Abbreviations: AD, Alzheimer's disease; FTD, frontotemporal dementia.
[a] The number of cutoff point for consecutive pacing or lapping movement.

median distance moved per day ($r = .94$, $P < .01$). However, consecutive pacing movements (≥ 3) were only observed in 3 participants (Table 2). The maximum number of consecutive pacing movements per day was 17, observed in R10, who habitually paced. R10 was in the advanced stage of FTD, with an MMSE score of 0. The second highest number of consecutive pacing movements was 8, followed by 7 and 6 consecutive movements.

In regard to lapping movements, the median number of lapping movements (≥ 1 movements) ranged from 0 to 27 and was highly correlated with the total distance moved per day ($r = .82$, $P < .01$). However, lapping movements were rarely consecutive and only R29 showed routinized lapping (Table 2). The maximum number of consecutive lapping movements was 29, which was observed in a FTD participant (R29) with an MMSE score of 13. The second highest number of consecutive lapping movements was 11, followed by 7 and 6 consecutive movements.

Proportion of the Distance Moved Per Day That Was Paced or Lapped

Proportion of the distance moved per day that was paced or lapped was calculated to examine the amount of repetitive movements relative to the total distance moved per day. Regardless of the distance moved per day, the median proportion of the distance moved per day that was paced or lapped (≥ 3) was mostly 0 except in 2 FTD participants (R29 and R10) who paced or lapped 70% to 80% of the distance moved per day (Table 2).

Case Presentation

Fluctuations in the distance moved per day and the distances that were paced and lapped in R11 are shown in Figure 2. R11 was selected as she equally paced and lapped in terms of distance. R11 was a 50-year-old female patient with advanced-stage AD. Her clinical dementia rating (CDR) score was 3, and MMSE could not be administered. She was monitored after 120 days of hospitalization. More fluctuations were observed in the distance moved per day and the distance that was lapped in the first half of the monitoring period than in the latter half of the study.

Discussion

The current study quantitatively describes ambulation in patients with dementia in terms of distance moved per day and

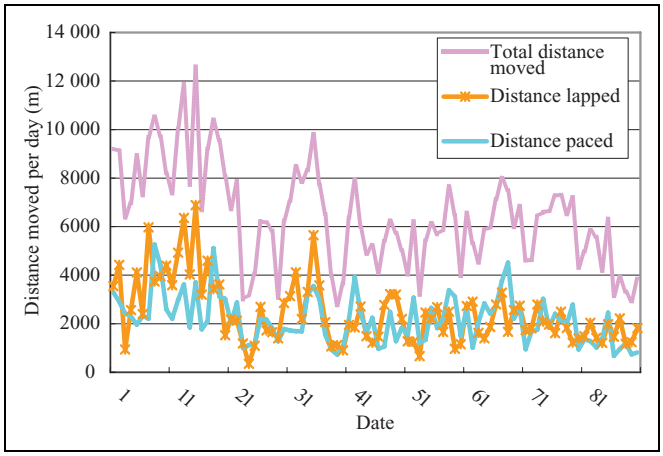

Figure 2. Total distance moved, distance paced, and distance lapped in R11 during the 90 days of monitoring.

pacing and lapping movements. Although the sample size was small, the results clearly indicate that the spatial movement patterns of patients with AD were quite different from those of patients with FTD who routinely paced or lapped most of the distance they moved.

In our study, patients with AD did not routinely pace or lap twice or more and appeared to be walking "without a fixed route." The cutoff point of $\geq$3 consecutive pacing and lapping movements in this study appears to differentiate routinized pacing movements, regardless of the distance moved per day. Identifying repetitive spatial movements may assist in differentiating patients with AD from FTD participants. In previous observational research of spatial movements, pacing was defined as "constantly (aimlessly) walking back and forth"[31] or "frequent and/or unpredictable pacing,"[13] and the number of pacing movements was not specified. However, absence of routinized pacing or lapping movements in patients with AD does not preclude occasional episodes of repetitive movements, which were observed in several participants including the case presented (R11). Further research is necessary to examine the factors associated with greater fluctuations in the distance moved and pacing and lapping movements.

Routinized pacing is one of the strong predictors of FTD[32] and is characterized by participants rhythmically pacing a fixed route. R10 was in the advanced stage of FTD, and his spatial movement pattern was fixed. The current study also suggests that walking a fixed route by patients with FTD could manifest in lapping seen in R29. Exercise is recommended for patients with FTD for health maintenance and preventative care.[33] However, increasing exercise may interrupt their routinized lifestyle because they walked 70% to 80% of the distance moved per day by repeatedly following the same route. Assessing current activity level and their routinized lifestyle is important for person-centered care in patients with FTD.

Wandering is often characterized as "excessive"[9,18] or "endless."[5] In this study, no clear cutoff point for "excessive ambulation" was found in terms of distribution of the distance moved. Those who moved around 10 km a day would appear to show excessive ambulation, and this was limited to patients with early onset AD with low MMSE scores in our study. Pathological changes in the brain could account for excessive ambulation. Accurate descriptions of the changes in ambulation may assist in identifying regions related to excess ambulation in conjunction with new imaging technologies to measure brain functions, such as near-infrared spectroscopy.

Recent review articles have reported the lack of efficacy of various nonpharmacological interventions to reduce wandering in people with dementia, such as environmental modifications, activity sessions, and music therapies.[1] The substantial fluctuations in participants' movements in the absence of intervention in this study reveal the difficulty in measuring such intervention effects, setting aside the problem of measuring wandering. Although the current study was conducted in a semiacute dementia care unit, fluctuations in the distances moved were observed in studies in long-term dementia care units in Korea[22] and Japan.[23] Therefore, the use of objective measurement instrument is desirable to evaluate interventions for wandering.

The major limitation of this study is the difficulty in measuring random movements, which was associated with cognitive decline.[34] Increasing the number of antennae would solve this problem in future research. Boundary transgressions, one of the dimensions of wandering[7] could also be measured by placing antennae in appropriate places. Quantification of various dimensions of wandering could assist in typology of wandering, which may be related to dementia type and trajectory of dementia.

The current study suggests that quantification of movement patterns in people with dementia has potential for describing the spectrum of wandering, making differential diagnoses, and elucidating the mechanisms underlying wandering.

In summary, repetitive pacing and lapping movements were observed in participants with FTD but were rarely observed in patients with AD. Quantitative descriptions of ambulation corresponded with subjective descriptions of the pattern of ambulation in patients with AD and FTD.

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Declaration of Conflicting Interest

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