Physical Activity in Severe Dementia Is Associated With Agitation Rather Than Cognitive Function

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Abstract
Background: The authors examined associations between physical activity, cognitive function, activities of daily living, and behavioral and psychological dementia symptoms (BPSD) in severe and moderate dementia.

Methods: A cross-sectional study was conducted to assess severe and moderate dementia groups according to the Clinical Dementia Rating. An actigraphy measured physical activity. Other measures included Mini-Mental State Examination, Cognitive Test for Severe Dementia, Hyogo Activities of Daily Living Scale, and Neuropsychiatric Inventory-Nursing Home.

Results: Sixty-three participants were assessed (mean age = 89.3 ± 6.4). Physical activity was not associated with cognitive function among participants with severe dementia, although there was a trend-level association with cognitive function among those with moderate dementia. Physical activity was significantly associated with BPSD, specifically agitation/aggression symptoms, for participants with severe dementia, and there was a trend-level association with anxiety for participants with moderate dementia.

Conclusions: Physical activity appears to be associated with BPSD among individuals in the advanced stages of dementia.

Keywords
behavioral and psychological symptoms of dementia, cognitive function, physical activity, sedentary, severe dementia

Physical activity has gained increasing focus as a nonpharmaceutical approach for managing symptoms of dementia.1 Many studies have reported that more physically active older adults have diminished rates of cognitive decline and a lower incidence of dementia.2,3 Hence, maintaining physical fitness well into late life is important. However, maintaining physical activity is difficult for the elderly patients, once they develop dementia. Patients with severe dementia, in particular, demonstrate progressive decline in motor functioning,4 comorbidities,5 cognitive impairment, limited activities of daily living (ADL),6 and several additional behavioral and psychological symptoms of dementia (BPSD).7 Therefore, most patients with severe dementia are quite sedentary. One study observed that among nursing home residents with dementia, individuals with severe dementia slept for an average of 14 hours daily.8 Additionally, ability to engage in ordinary activities generally declines among individuals with dementia because of cognitive impairments9 or lack of spontaneity.10

However, since most previous studies on physical activity have mainly focused on individuals undergoing healthy aging or with only mild cognitive impairment, little is known about the effects of a sedentary lifestyle on dementia symptomology.11 Research on physical activity in the context of severe dementia is particularly lacking, apart from a few intervention studies using observational rating methods.12 Additionally, most of these limited previous studies examined severe dementia mixed with moderate dementia.11,12 Another previous study suggested that people with dementia should be evaluated separately in each stage, since their clinical features vary according to the severity of dementia.13

Thus, the present study quantitatively measured physical activity patterns using an actigraph and examined the associations between physical activity and cognitive function, ADL,
and BPSD in patients with severe dementia, using patients with moderate dementia as a comparison group.

**Materials and Methods**

**Participants**

The current study was conducted at a 270-bed hospital for recuperation in Hyogo prefecture, Japan, from October 2015 to March 2018. Participants were evaluated with a standard clinical interview, completed a physical and neurological examination, and underwent a computerized tomography scan. The inclusion criteria were (1) diagnosis of dementia according to the Diagnostic and Statistical Manual of Mental Disorders-5 and (2) a Clinical Dementia Rating (CDR) score of 2 (moderate dementia) or 3 (severe dementia). We excluded patients who had any of the following conditions: (1) additional diseases or comorbidities such as neuropsychiatric disorders or orthopedic disease that impair consciousness and/or physical activity; (2) a judgment made by the attending doctor that study participation would negatively influence the patient’s condition; and/or (3) use of prescribed antipsychotics, antidepressants, or hypnotics in the week prior to test administration.

A family member or caregiver provided written informed consent prior to participation. The ethics committee at Osaka Prefecture University approved the study protocol (2017-204).

**Procedure**

This study used a cross-sectional and observational design. All participants were assessed on physical activity, cognitive function, ADL, BPSD, and comorbidities. They were divided into severe and moderate dementia groups based on their CDRs. All examinations were conducted within 1 month to reflect conditions during the same period of time.

**Clinical Assessments**

Amount of physical activity was recorded using an actigraph device (Micro Motionlogger Watchware, version 1.94 in Ambulatory Monitoring, Inc.). Actigraphy has been clinically useful for investigating physical activity in patients with dementia and provides objective quantitative information regarding sleep-related variables. Prior studies have reported that 3 days of actigraphy data are needed to accurately estimate physical activity levels among older adults. Thus, participants wore the actigraph on consecutive days for 1 week. It could be removed when bathing or undergoing examinations or medical treatments. Any data from participants who wore the actigraph for fewer than 3 days were excluded. The actigraph was worn on the nondominant wrist; however, if paresis was present on the nondominant limb, the dominant hand was used.

The amount of daytime physical activity (9:00 to 16:59) and the total amount of daily physical activity were obtained from actigraphy data. Hourly mean physical activity was also calculated for each 24-hour period. Cognitive function was assessed using the Mini-Mental State Examination (MMSE) and the Cognitive Test for Severe Dementia (CTSD). The MMSE is a widely used screening tool. The total score ranges from 0 to 30; lower scores indicate greater cognitive impairment. The CTSD is a reliable and valid test for severe and profound dementia. The total score ranges from 0 to 30; lower scores indicate greater cognitive impairment.

Activities of Daily Living was assessed using the Hyogo Activities of Daily Living Scale (HADLS). The HADLS assesses the level of independence with basic and instrumental ADL (IADL). It consists of 18 items, including toileting, eating, dressing, grooming, personal hygiene, brushing, bathing, mobility, telephoning, shopping, preparing meals, cleaning, making one’s bed, cleaning up after meals, doing laundry, managing fire, handling switches, and managing finances. Since participants do not perform IADL while residing at a recuperation hospital, the IADL items were excluded from the present analyses. Thus, we assessed 8 basic ADL items that included toileting (1-7 points), eating (1-5 points), dressing (1-6 points), grooming (1-6 points), personal hygiene (1-6 points), brushing (1-6 points), bathing (1-7 points), and mobility (1-7 points). Total scores range from 8 to 50; higher scores indicate lower independence.

Behavioral and psychological dementia symptoms was assessed using the Neuropsychiatric Inventory-Nursing Home (NPI-NH) scale that assesses 12 domains: delusions, hallucinations, agitation/aggression, depression, anxiety, euphoria, apathy, disinhibition, irritability, aberrant motor behavior, night-time behavior, and eating behavior. A composite score from each domain is calculated by multiplying the frequency and severity within each domain as follows: 1-4 (4 = most frequent) and 1-3 (3 = most severe). Total scores range from 0 to 144; higher scores indicate increased neuropsychiatric symptomology.

Comorbidities were assessed using the Charlson Comorbidity Index (CCI) that was employed for the assessment of severity. Charlson Comorbidity Index is a scale for predicting mortality by classifying or weighting comorbid conditions which has been widely utilized by health researchers to measure the burden of disease. Charlson Comorbidity Index has 19 items, and a higher score indicates severe comorbidities.

**Statistical Analyses**

The Mann-Whitney U test or χ² test was employed to compare the severe and moderate dementia groups. Spearman rank correlation coefficients were employed to examine relationships among daytime physical activity (9:00 to 16:59), daily physical activity, and other variables (ie, age and MMSE, CTSD, HADLS, and NPI-NH scores) within each patient group. All analyses were conducted using IBM SPSS Statistics version 24. P values <.05 were considered statistically significant.
However, physical activity significantly differed from 7:00 to 1:00 and most sedentary from 1:00 to 1:59 (46.3 ± 34.6 counts/minute, respectively). For both groups, physical activity was most robust from 18:00 to 18:59 (106.7 ± 62.8 counts/minute and 154.3 ± 53.5 counts/minute, in the severe and moderate groups, respectively) and most sedentary from 1:00 to 1:59 (46.3 ± 34.6 counts/minute, 37.8 ± 40.8 counts/minute, respectively). However, physical activity significantly differed from 7:00 to 13:59 and 16:00 to 18:59. That is, participants with severe dementia were significantly less active than those with moderate dementia during most daytime periods, although they showed similar patterns of change in physical activity.

### Correlations of Physical Activity With Other Variables

#### Severe dementia group.
Neither the amount of daytime physical activity nor of daily physical activity was correlated with age (\( \rho = -.072, P = .645; \rho = -.022, P = .889 \), respectively), the MMSE (\( \rho = .017, P = .914; \rho = .057, P = .716 \), respectively), the CTSD (\( \rho = -.001, P = .997; \rho = .075, P = .633 \), respectively), or the HADLS ( \( \rho = -.155, P = .321; \rho = -.128, P = .365 \), respectively; Table 2).

By contrast, there were significant correlations between physical activity and BPSD. Specifically, the amount of daytime physical activity and daily physical activity was significantly correlated with the NPI-NH (\( \rho = .355, P = .0019; \rho = .411, P = .006 \), respectively; Table 2). In terms of subscale scores, both the amount of daytime physical activity and daily physical activity were significantly correlated with agitation/aggression (\( \rho = .479, P = .001; \rho = .456, P = .002 \), respectively). Daily physical activity was also significantly correlated with night-time behavior (\( \rho = .445, P = .003 \); Table 3).

#### Moderate dementia group.
Neither the amount of daytime physical activity nor of daily physical activity was correlated with age (\( \rho = -.225, P = .339; \rho = -.103, P = .665 \), respectively), the MMSE (\( \rho = -.132, P = .608; \rho = -.298, P = .202 \), respectively), or the HADLS (\( \rho = .084, P = .725; \rho = .287, P = .219 \), respectively). Regarding the relationships between physical activity and cognitive function, similar to the group with severe dementia, the amount of daytime physical activity was not correlated with the CTSD (\( \rho = -.188, P = .94 \)). However, amount of daily physical activity had a negative trend-level correlation with the CTSD (\( \rho = -.411, P = .072 \); Table 2).

For the association between physical activity and BPSD, the daily amount of physical activity had a trend-level correlation with the NPI-NH, while amount of daytime physical activity did not (\( \rho = .421, P = .065; \rho = .319, P = .17 \), respectively; Table 2). In terms of subscale scores, amount of daily physical activity had a trend-level correlation with anxiety (\( \rho = .413, P = .071 \)).

Overall, physical activity was not associated with cognitive function for severe dementia, while it had a trend-level association with cognitive function for moderate dementia. Physical activity was not associated with ADL independence in either group. Finally, physical activity was significantly associated with symptom severity within the agitation/aggression domain for the severe dementia group but only had a trend-level association with the anxiety domain for the moderate dementia group.

### Discussion

The present study assessed physical activity among patients with moderate and severe dementia, examining associations...
between amount of physical activity and cognitive function, ADL, and BPSD. Two major findings emerged. First, physical activity was not associated with cognitive function for severe dementia. Second, physical activity was significantly associated with agitation/aggression symptoms among patients with severe dementia. Additionally, hourly activity values via actigraphy for most participants in the severe dementia group were lower than 100 counts/minute, which is considered sedentary,

Table 2. Correlations Among Study Variables.

| Variables       | CDR3 | CDR2 | CDR3 | CDR2 |
|-----------------|------|------|------|------|
| MMSE            | .017 | -.132| .057 | -.298|
| CTSD            | -.001| -.188| .075 | -.411|
| HADLS           | -.155| .084 | -.128 | .287 |
| NPI-NH          | .355*| .319 | .411*| .421 |

Abbreviations: CDR, Clinical Dementia Rating; CTSD, Cognitive Test for Severe Dementia; HADLS, Hyogo Activities of Daily Living Scale; MMSE, Mini-Mental State Examination; NPI-NH, Neuropsychiatric Inventory-Nursing Home.

Table 3. Correlations Between Amount of Physical Activity and NPI-NH Subscore.

| Variables          | Amount of Daytime Physical Activity | Daily Amount of Physical Activity |
|--------------------|-------------------------------------|-----------------------------------|
| Delusions          | -.075                              | -.112                             |
| Hallucinations     | -.199                              | -.199                             |
| Agitation/aggression| .479*                             | .456*                             |
| Depression         | -.044                              | -.036                             |
| Anxiety            | -.195                              | -.099                             |
| Euphoria           | .284                               | .216                              |
| Apathy             | -.172                              | -.071                             |
| Disinhibition      | .173                               | .09                               |
| Irritability       | .126                               | .115                              |
| Aberrant motor     | .182                               | .205                              |
| Euphoria behavior  |                                    |                                   |
| Night-time behavior| .267                               | .445*                             |
| Eating behavior    | .075                               | .012                              |

Abbreviation: NPI-NH, Neuropsychiatric Inventory-Nursing Home.

Previous studies have reported a significant relationship between physical activity and cognitive function in healthy aging. However, this study did not show such a relationship in the context of severe dementia. Patients with dementia exhibit decreased physical function and significant cognitive decline and tend to develop several comorbidities during the disease course. The World Health Organization recommends that people aged 65 years and older should engage in at least 150 minutes of moderately intense (or 75 minutes of vigorously intense) aerobic physical activity throughout the week. However, patients with severe dementia cannot achieve these
physical activity levels. There are several studies reporting similar findings to ours. A longitudinal study on AD samples and a cross-sectional study on nursing home residents with moderate dementia observed no association between physical activity level and cognitive function. These studies suggested that physical activity levels engaged in close to or after AD onset may not further affect the disease course in the face of accumulated AD pathology. It is also possible that low physical activity levels provide no substantive benefit to cognitive function. Therefore, any existing association between physical activity and cognitive function holds true only in healthy aging or mild dementia and not necessarily in severe dementia. Another interpretation of our findings is that some participants may have already exhibited a lower amount of physical activity, regardless of their dementia severity. This could be supported by a concept regarding frailty. In the older population, frailty is a prevalent clinical condition that includes unintentional weight loss, self-reported exhaustion, weakness, slow walking speed, and low physical activity. Indeed, AD patients in even mild to moderate stages have also been reported to show clinical features of frail syndrome at a certain rate. Concerning moderate dementia, the amount of physical activity had a negative trend-level association with cognitive function. Future studies should examine the relationship in detail, including the influence of BPSD.

Second, physical activity was not significantly associated with ADL in either group. One possible explanation for this finding is that patients who are past the moderate stage of dementia may not engage in higher levels of physical activity to engage more effectively in ADL, as they require much assistance with ADL. In people with moderate and severe dementia, better ADL performances are largely dependent on the skills of caregivers, which induce positive attitudes from the patients toward the activities. These attitudes may not lead to physical activity. Concerning the relationship between physical activity and BPSD, physical activity had a significant association with agitation/aggression symptoms in severe dementia and a trend-level association with anxiety symptoms in moderate dementia. These findings could be explained as follows. Selbaek and colleagues reported that agitation symptoms worsen as dementia progresses. Relatedly, Moyle and colleagues measured physical activity among residents with dementia living in long-term care facilities and observed increased physical activity during the afternoon and early evening, suggesting that this increase in activity could reflect heightened agitation symptoms. Similarly, physical activity in our samples was highest during the evening (18:00-18:59). Thus, activity among those with moderate and severe dementia is low; this includes few practical activities, owing to their limited functional capacity but many abnormal behaviors such as agitation/aggression. However, unexpectedly, there was no relationship found between the amount of physical activity and aberrant motor behavior in this study, which is one of the most common behavioral symptoms exhibited in severe dementia. This result could be supported by the characteristics of aberrant motor behavior. In our study, almost no participants presented any disruptive behaviors such as wandering, which could substantially affect the amount of their physical activity. This lower development of disruptive behavior symptoms might be in part due to the hospital environment, where inpatients could not independently exit the hospital or ward.

This is the first study, to our knowledge, that quantitatively examined physical activity within the context of severe dementia. The present results suggest that potential relationships between physical activity and cognitive function, which previous studies have reported, may be irrelevant at severe stages of dementia. This result suggests that it may not be worthwhile to push patients to increase their physical activity once dementia symptoms have already reached a severe stage. It is necessary to consider other factors such as rest–activity rhythm, and whether such activities are meaningful for the person in examining physical activity in patients with severe dementia.

This study had several limitations. First, the patient sample was fairly small, making it difficult to adequately describe the associations of physical activity with cognitive function and BPSD in the group with moderate dementia. Additionally, we could not analyze the association between physical activity and types of dementia. Future studies with larger patient populations are warranted. Second, the HADLS may not have been sensitive enough to detect variability in ADL within the patient groups. Many HADLS items have exhibited floor effects among patients with severe dementia. However, no currently available scale precisely measures the ADL of patients with severe dementia. Finally, the cross-sectional and correlational design precludes causal inferences. Therefore, longitudinal methods should be employed to further address temporal changes in these relationships and throughout disease progression.

In conclusion, physical activity was not associated with cognitive function but was related to agitation/aggression behaviors in patients with severe dementia. Thus interventions to improve the daily lives of such patients should focus not only on the amount but the quality of physical activity.

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