Original Research Article

DIGITAL HEALTH

DIGITAL HEALTH
Volume 11: 1–12

DOI: 10.1177/20552076251330808
journals.sagepub.com/home/dhj

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The relationship between age and physical activity as objectively measured by accelerometers in older adults with and without dementia

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Abstract

Objective: This study sought to investigate differences in physical activity and activity fragmentation between older adults with and without dementia and between older adults with dementia with Lewy bodies (DLB) and older adults with Alzheimer's disease (AD). The study also sought to investigate how these differences vary in magnitude at different ages.

Methods: Accelerometry data were analyzed from individuals with dementia ($n = 94$) and individuals without dementia ($n = 613$) who participated in the National Health and Aging Trends Study (NHATS), as well as from individuals with DLB ($n = 12$) and AD ($n = 10$) who participated in a pilot study.

Results: In the NHATS cohort, individuals without dementia had more activity counts (0.325 million [95% CI 0.162 million, 0.487 million]) and a longer active bout length (0.631 minutes [95% CI 0.311, 0.952]) at the mean age of 79 than individuals with dementia at the same age. There was also suggestive evidence that individuals without dementia had a shorter resting bout length (−2.196 minutes [95% CI −4.996, 0.605]) than individuals with dementia. Differences in data collection and processing prevented direct comparisons between the cohorts, and the parallel analyses in the smaller cohort were underpowered to detect statistically significant differences between DLB and AD.

Conclusion: This work shows that objectively measured accelerometry data differ between individuals with and without dementia; future studies with larger samples should investigate whether accelerometry data can be used to aid in the early identification of dementia and differentiation of dementia subtypes.

Keywords

Actigraphy, Alzheimer's disease, dementia with Lewy bodies

Received: 15 July 2024; accepted: 12 March 2025

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Introduction

Physical activity (PA) is an important modifiable risk factor for dementia.[1–3] Engaging in regular PA can significantly enhance brain health by promoting neurogenesis, reducing inflammation, and improving vascular health,[2,3] and meta-analyses suggest that high levels of PA can decrease the risk of developing Alzheimer's disease (AD) by up to 45%.[4] A number of large, cohort-based studies have explored associations between self-reported PA and dementia,[5–7] but these studies have been limited by the fact that *self-reported* PA is a subjective measure that is prone to recall bias.[8] Obtaining accurate measurements of PA intensity, duration, and timing can be difficult, but accelerometry-based activity monitors can capture more reliable assessments of PA than self-report measures.[8–11]

Accelerometry-based studies have established that individuals with dementia are less active than age- and sex-matched controls[1,12–15] and that individuals with dementia experience a variety of symptoms that affect their daily PA patterns, including sleep disturbances at night and sleepiness during the day.[16] Other accelerometry studies have shown that lower levels of daily activity, greater prolonged sedentary time, and less stable 24-h activity patterns are associated with lower levels of cognition in older adults.[17–21] Similar findings have been observed in studies investigating an association between daily activity or sedentary bout length and incident dementia[22–24] or in studies of fewer than 50 individuals with prevalent dementia.[25,26] These findings suggest that accelerometry devices could serve as biometric markers of activity-related symptoms and cognitive decline and/or dementia in older adults, but no large, nationally representative US studies have tackled the relationship between prevalent dementia and objectively measured PA.

Likewise, only a few studies have attempted to use accelerometers to differentiate between different dementia subtypes. Given that motor disturbances are more common in individuals with dementia with Lewy bodies (DLB) than in individuals with AD,[27] accelerometers that objectively measure the motor domain between clinic visits could help identify differences in PA between these two groups. Because differentiating DLB from AD is challenging,[28,29] future developments in this field could improve the identification of early dementia and dementia subtype.

One large-scale effort to make accelerometry data available to researchers is the National Health and Aging Trends Study (NHATS), which collects a range of accelerometer-derived measures and demographic, behavioral, and health-related covariates in older adults.[30] We seek to use the NHATS accelerometry data to better understand differences in PA and activity fragmentation between individuals with and without dementia and to examine whether these differences vary in magnitude at different ages. In addition, we will make similar comparisons in a smaller sample of older adults with DLB and AD from the Technology for Early Dementia Diagnosis (TEDD) study as an exploratory analysis to characterize PA-related differences across the two groups.

Methods

This study analyzes accelerometry data collected from individuals who participated in the NHATS consortium or in the VA Puget Sound TEDD study, but NHATS investigators did not participate in these analyses.

NHATS study population

Data were obtained from NHATS, a large consortium that conducts in-person interviews and performance-based assessments on a nationally representative sample of US Medicare beneficiaries aged 65 and older to gather information on the physical, cognitive, and sensory capacity of participants.[31] Oversampling by age and race was part of the NHATS design, so older individuals and Black individuals were sampled at higher rates than other groups. Otherwise, to be included in the initial NHATS sample, participants had to be age 65 or older and enrolled as Medicare beneficiaries as of 30 September 2010. In 2015, the sample was replenished using the same design, with eligibility extended to individuals aged 65 or older and enrolled as Medicare beneficiaries as of 30 September 2014. NHATS participants provided informed consent and were enrolled in a protocol approved by the Johns Hopkins Bloomberg School of Public Health institutional review board (IRB). NHATS participants are classified as having probable, possible, or no dementia according to one of the following three methods: (1) the report of a doctor, (2) a score on the AD8 Dementia Screening Interview,[32,33] or (3) a score on a cognitive test battery that evaluated memory, orientation, and executive function.[34] Furthermore, in the current analysis, participants with probable or possible dementia are both labeled as having dementia.

This analysis includes data from Round 11 of the NHATS (June 2021–November 2021), when NHATS began collecting PA data from a subsample of the NHATS cohort ($n = 872$). After an interview with a study team member, participants were instructed to wear the ActiGraph CentrePoint Insight Watch (a triaxial accelerometer) on their nondominant wrist for 7 days after the interview day (i.e., 8 days in total). The participants were to wear the devices at all times, except when swimming or bathing for more than 30 minutes. The devices were set to a sampling rate of 64 Hz.

Non-wear time was estimated as any interval of 90 minutes or longer, and a valid day was defined as wear time greater than 90% or 1296 minutes per day.[35] Of the 872 participants who were eligible to wear the activity watch, 747 (86%) returned an activity watch with at least 1 day of valid

data. We excluded participants who had ≤3 days of valid data ($n = 9$) given that these individuals exhibited activity outcomes that were highly variable. Finally, 31 participants who were missing demographic or health-related variables involved in our statistical analyses were excluded ($n = 16$ missing education level, $n = 9$ missing body mass index [BMI], $n = 6$ missing chronic comorbidity information). This resulted in an analytic sample size of 707 NHATS participants, of which 94 had dementia and 613 did not.

Raw accelerometer data files were unavailable for NHATS participants.

TEDD study population

Participants with DLB ($n = 12$) and AD ($n = 10$) were recruited from VA Puget Sound Health Care System (VA Puget Sound) and the Puget Sound community as part of a larger NIH-funded study to explore how novel measurements of activity, sleep, cognition, and behavior could be used to differentiate individuals with DLB from individuals with AD. The sample size for this study was not determined through formal sample size calculations; instead, we enrolled as many participants as feasible to enable exploratory analyses of associations between the novel measurements and dementia subtype. All participants provided informed consent and were enrolled in a protocol approved by the VA Puget Sound IRB; baseline data were collected from 2020 to 2024. All participants either met criteria for probable DLB according to the Fourth Consensus Report[36] or for probable AD dementia according to the National Institute on Aging–Alzheimer's Association Workgroup criteria.[37] To be eligible for the TEDD study, participants also had to have 8+ years of education, be age 22+, have a score of 12 + on the Montreal Cognitive Assessment (MoCA; or an equivalent score on the remote MoCA or telephone assessment battery), be sufficiently ambulatory to take part in the study, and have a study companion who was willing to serve as an informant; individuals were excluded if their cognitive dysfunction could be explained by the presence of a non-neurodegenerative disorder, if they had a diagnosis of Parkinson's disease, or if they had an unstable psychiatric condition.

Detailed covariate data on TEDD participants were gathered through VA electronic health records data and in-person assessments. After receiving a brief tutorial from a study coordinator (either remotely or in person), participants were instructed to wear ActiGraph's triaxial wGT3X-BT accelerometry device on their nondominant wrist. A wrist-worn device was selected (rather than a hip-worn device) and then taped in place to maximize tolerability and compliance.[38–40] The device was to be worn for 14 consecutive full days and nights, and participants were asked to wear the device at all times, including when bathing or swimming. The device was set to a sampling rate of 30 Hz.

At the beginning of the study, some participants began wearing the device shortly after the recording had started, and on the final day of recording, some participants removed the device early. These partial non-wear days were identified using the data quality visualization feature of the GGIR package (version 2.8.2) and were subsequently removed from the analysis; no other non-wear times were identified in any participants. Across all participants, 10 days of partially recorded data were identified and removed. Each participant ultimately had at least 12 days of accelerometer data with complete wear time.

Raw accelerometer data files for each participant were processed in R (version 4.1.1).

Generation of activity outcomes

Accelerometer data from both data sources are presented as the number of vector magnitude activity counts occurring in each second of wear time. We generated three primary outcome measures for each data source: mean daily activity counts, mean active bout length, and mean resting bout length. To calculate average daily counts, we summed the number of counts occurring over the 24 h of each day and then averaged the number of daily counts over all valid days of wear time for each person individually. The fragmentation outcomes (mean active bout length and mean resting bout length) were provided by NHATS based on the work of Koster et al.[41] and are defined as the average duration (in minutes) of both active bouts (≥1853 activity counts per minute) and resting bouts (<1853 activity counts per minute). We created these outcomes manually in the TEDD sample by classifying every minute of wear time of each 24-h day as active or resting using the same cutoff that NHATS uses (i.e., 1853 activity counts per minute) and calculating the average duration of each activity class for each participant.

Statistical analyses

For our analyses of NHATS data, survey-weighted linear regression models were run using the svyglm function of the survey package (version 4.2-1) in R. The models were weighted using the survey weights provided by NHATS. Three models were created: one with daily activity counts as the outcome, one with active bout length as the outcome, and one with resting bout length as the outcome. The predictor variables in these models included race (binary; white vs. non-white), sex (binary; male vs. female), age (continuous), dementia status (binary; dementia vs. no dementia), education level (binary; college degree vs. less than college degree), marital status (binary; married vs. not married), residence type (binary; community vs. care facility), BMI (continuous), total number of chronic comorbidities (continuous; includes heart attack, heart disease, high blood pressure, arthritis, osteoporosis, diabetes, lung disease,

stroke, and cancer), and an interaction term between age and dementia status.

For our analyses of TEDD data, multiple linear regression models were run with the same outcomes as the NHATS models. Predictors in these models included age (continuous) and dementia subtype (binary; DLB vs. AD). The other predictors included in the NHATS models were dropped from these models given that the sample had limited variability in race and sex and that the sample size was likely too small to support more complex modeling.

We compared the association between age and all three outcomes across the two dementia-related subgroups of each sample. Additionally, we compared the predicted value of all three outcomes at the mean age of each sample (i.e., 79 for NHATS and 74 for TEDD).

As described above, NHATS and TEDD used different ActiGraph triaxial accelerometer models that were set to record at different sampling rates and for different amounts of time; they applied different standards regarding non-wear time; and they likely used different processing methods to convert raw accelerometry data into the outcome measures in this study. These differences prevented us from directly comparing measures of daily activity, active bout length, and resting bout length between the two cohorts.

Results

In the NHATS sample, participants with dementia were slightly older, more likely to be female, and more likely to be non-white than participants without dementia (see Table 1). In the TEDD sample, participants with DLB were slightly younger than participants with AD, but the two groups were similar in sex and race (see Table 2). The TEDD participants were also much more likely to be male (91%) than the NHATS participants (46%), but this finding was not surprising given that the TEDD study recruited primarily from a population of Veterans.

Although the NHATS collects cognitive data, specific scores on cognitive assessments were not available for this analysis. In the TEDD sample, participants with DLB performed slightly worse on the MoCA than TEDD participants with AD (see Table 2) despite being slightly younger.

Mean daily activity counts in the NHATS sample ranged from 0.29 million activity counts to 4.29 million activity counts. For the NHATS participants with and without dementia, the mean (SD) daily activity counts were 1.33 (0.57) million counts and 1.72 (0.61) million counts, the mean (SD) active bout durations were 3.20 minutes (1.15) and 3.92 minutes (1.17), and the mean (SD) resting bout durations were 16.4 minutes (9.19) and 13.3 minutes (6.34), respectively (Figure 1).

Mean daily activity counts in the TEDD sample ranged from 0.41 million counts to 3.03 million counts. For the TEDD participants with DLB and with AD, the mean (SD) daily activity counts were 1.39 (0.69) million counts and 1.61 (0.21) million counts, the mean (SD) active bout durations were 6.42 minutes (2.58) and 7.55 minutes (1.76), and the mean (SD) resting bout durations were 18.5 minutes (10.3) and 12.4 minutes (2.86), respectively (Figure 2).

In our NHATS models (adjusted for race, sex, age, dementia status, education level, marital status, residence type, BMI, total number of chronic comorbidities, and an interaction term between age and dementia status), we estimate that for each 1-year difference in age, older participants with dementia have, on average, 0.022 million fewer (95% CI 0.006–0.037 million fewer) activity counts and older participants without dementia have, on average, 0.026 million fewer (95% CI 0.018–0.034 million fewer) activity counts. We also estimate that for each 1-year difference in age, older participants with dementia have, on average, 0.037 minutes shorter (95% CI 0.020–0.054 minutes shorter) active bout lengths and older participants without dementia have, on average, 0.022 minutes shorter (95% CI 0.054 minutes shorter to 0.010 minutes longer) active bout lengths. Finally, we estimate that for each 1-year difference in age, older participants with dementia have, on average, 0.206 minutes longer (95% CI 0.014 minutes shorter to 0.427 minutes longer) resting bout lengths and older participants without dementia have, on average, 0.142 minutes longer (95% CI 0.006–0.277 minutes longer) resting bout lengths. These point estimates, 95% CIs, and corresponding p-values for testing whether these age slopes differ from 0 (as well as the point estimates and 95% CIs for the interaction terms) are displayed in Table 3. We did not have sufficient evidence of differences in the age slopes for those with dementia versus those without dementia. Participants without dementia exhibited 0.325 million more (95% CI 0.162–0.487 million more, $p < 0.001$) activity counts, and a 0.631 minutes longer (95% CI 0.311–0.952 minutes longer, $p < 0.001$) active bout length than individuals with dementia at the mean sample age of 79 (Figure 3(a) and (b)). Participants without dementia also exhibited a 2.196 minutes shorter (95% CI 4.996 minutes shorter to 0.605 minutes longer, $p = 0.121$) resting bout length than individuals with dementia at the mean sample age of 79, though this finding was not statistically significant (Figure 3(c)).

The difference column was obtained from the interaction term of each model where the dementia group was the reference.

In our TEDD models (adjusted for dementia subtype, age, and an interaction term between the two), we estimate that for each 1-year difference in age, participants with DLB have, on average, 0.004 million fewer (95% CI 0.047 million fewer to 0.038 million more) activity counts and participants with AD have, on average, 0.006 million fewer (95% CI 0.097 million fewer to 0.084 million more) activity counts. We also estimate that for each 1-year difference in age, participants with DLB have, on average, 0.014 minutes longer (95% CI 0.166 minutes shorter to 0.193 minutes longer) active bout lengths and participants with AD have, on average, 0.074 minutes shorter (95% CI 0.459

Table 1. Unweighted demographic summary of NHATS participants with and without dementia.

Variable	Dementia ($n = 94$)	No dementia ($n = 613$)	Overall ($n = 707$)
Age			
Mean (SD)	82 (6)	79 (6)	79 (6)
Median (min, max)	81 (72, 100)	77 (71, 100)	78 (71, 100)
Sex			
Male	38 (40%)	288 (47%)	326 (46%)
Race			
White	62 (66%)	518 (85%)	580 (82%)
Education			
College degree	22 (23%)	226 (37%)	248 (35%)
Less than college	72 (77%)	387 (63%)	459 (65%)
Residence			
Community	84 (89%)	583 (95%)	667 (94%)
Care facility	10 (11%)	30 (5%)	40 (6%)
Marital status			
Married	31 (33%)	304 (50%)	335 (47%)
Not married	63 (67%)	309 (50%)	372 (53%)
BMI			
Mean (SD)	28 (12)	28 (6)	28 (7)
Median (min, max)	26 (15, 125)	27 (18, 60)	27 (15, 125)
Total comorbidities			
Mean (SD)	3.4 (1.4)	2.7 (1.3)	2.8 (1.4)
Median (min, max)	3 (0, 7)	3 (0, 7)	3 (0, 7)

minutes shorter to 0.311 minutes longer) active bout lengths. Finally, we estimate that for each 1-year difference in age, participants with DLB have, on average, 0.263 minutes longer (95% CI 0.356 minutes shorter to 0.881 minutes longer) resting bout lengths and participants with AD have, on average, 0.195 minutes shorter (95% CI 1.521 minutes shorter to 1.132 minutes longer) resting bout lengths. These point estimates, 95% CIs, and corresponding p-values for testing whether these age slopes differ from 0 (as well as the point estimates and 95% CIs for the interaction terms) are displayed in Table 4. We did not have sufficient evidence of differences in the age slopes for those with DLB versus those with AD.

Participants with DLB exhibited 0.27 million fewer (95% CI 0.93 million fewer to 0.38 million more, $p = 0.791$) activity counts, a 1.368 minutes shorter (95% CI 4.152 minutes shorter to 1.415 minutes longer, $p = 0.315$) active bout length, and a 6.241 minutes longer (95% CI 3.346 minutes shorter to 15.83 minutes longer, $p = 0.188$) resting bout length than individuals with AD at the mean sample age of 74, though none of these differences were statistically significant (Figure 4(a) to (c)).

Table 2. Demographic and cognitive summary of TEDD participants with AD and DLB.

Variable	DLB ($n = 12$)	AD ($n = 10$)	Overall ($n = 22$)
Age			
Mean (SD)	70 (8)	78 (4)	74 (7)
Median (min, max)	73 (55, 80)	79 (71, 85)	75 (55, 85)
Sex			
Male	11 (92%)	9 (90%)	20 (91%)
Race			
White	12 (100%)	10 (100%)	22 (100%)
MoCA score			
Mean (SD)	18 (5)	17 (4)	17 (5)
Median (min, max)	18 (8, 25)	15 (12, 23)	18 (8, 25)

As noted in the Methods section, differences in data collection and processing prevented us from directly comparing the NHATS and TEDD participants on daily activity, active bout length, and resting bout length.

Discussion

Our analysis of age, dementia, and PA is unique in that we were able to compare objectively measured accelerometry measures in a large, nationally representative sample of older individuals in the United States with and without prevalent dementia. Although others have used NHATS accelerometry data to investigate sedentary behavior or fragmented PA,[42,43] this is the first study to use the NHATS dataset to compare activity and sedentary behavior in individuals with and without dementia.

The study closest to ours in design was that of Lu et al.,[44] who investigated how patterns of PA and sedentary behavior differed across AD, mild cognitive impairment, and normal cognition in cohort samples from Hong Kong that were comparable in size to NHATS. Like us, these authors found that individuals with dementia exhibited significantly lower activity counts than individuals without dementia; they also found that active and resting bouts differed between groups, which parallels our finding of shorter active bout lengths and longer resting bout lengths for individuals with dementia. These findings are consistent with most (but not all[45]) of the findings from other, smaller studies of those with and without dementia,[26,46–48] as well as studies of incident dementia.[22–24] But whereas Lu et al. were more concerned with sedentary behavior and characterizing the daily PA patterns of participants (i.e., the time of day when individuals first became active and when their activity peaked), we focused more on how age is associated with dementia status and PA.

That is, given that both age and dementia status likely contribute to differences in activity, we were particularly interested in evaluating how age is associated with the relationship between our accelerometry measures and dementia status. We found evidence of a negative association between age and both daily activity counts and active bout length for participants without dementia and evidence of a negative association between age and daily activity counts for participants with dementia. This indicates, as one might expect, that older NHATS participants were less active than younger NHATS participants. Although there was a suggestive association between age and both active bout length and resting bout length for the NHATS dementia group, these findings were not statistically significant. We believe that this is due in part to the smaller sample size of the dementia group ($n = 94$) and to potential selection bias caused by older adults with dementia dropping out from the study. Future studies with a larger dementia sample adjusted for selection bias may be necessary to better understand these associations.

We also found that these negative associations between age, daily activity counts, and active bout length were slightly smaller in magnitude for NHATS participants with dementia than NHATS participants without dementia (see Figure 3(a) and (b), Table 3), though this was not statistically significant. The data from NHATS participants without dementia may suggest a normal age-related decline in total activity and active bout length, whereas the data from NHATS participants with dementia may suggest that activity levels and active bout length might decline precipitously sometime prior to the diagnosis of dementia and then remain consistently lower at all ages following dementia onset. To the best of our knowledge, no studies have used accelerometry data to delineate this particular activity pattern in individuals with dementia, and longitudinal studies are thus needed in healthy individuals and individuals with mild cognitive impairment to observe activity differences during the early disease processes.

We did not observe a similar pattern for resting bout length, as NHATS participants with and without dementia exhibited similar age-related associations for resting bout length (see Figure 3(c), Table 3). Our findings suggest that the association between age and resting bout length may be more prominent than the association between dementia status and resting bout length. Although some accelerometry studies have identified sedentary activity as an outcome associated with prevalent dementia[26] or incident dementia,[23] other studies have had less convincing results. For example, investigators found no association between sedentary behaviors as measured by accelerometry and incident dementia in a sample of older women,[49] or in a

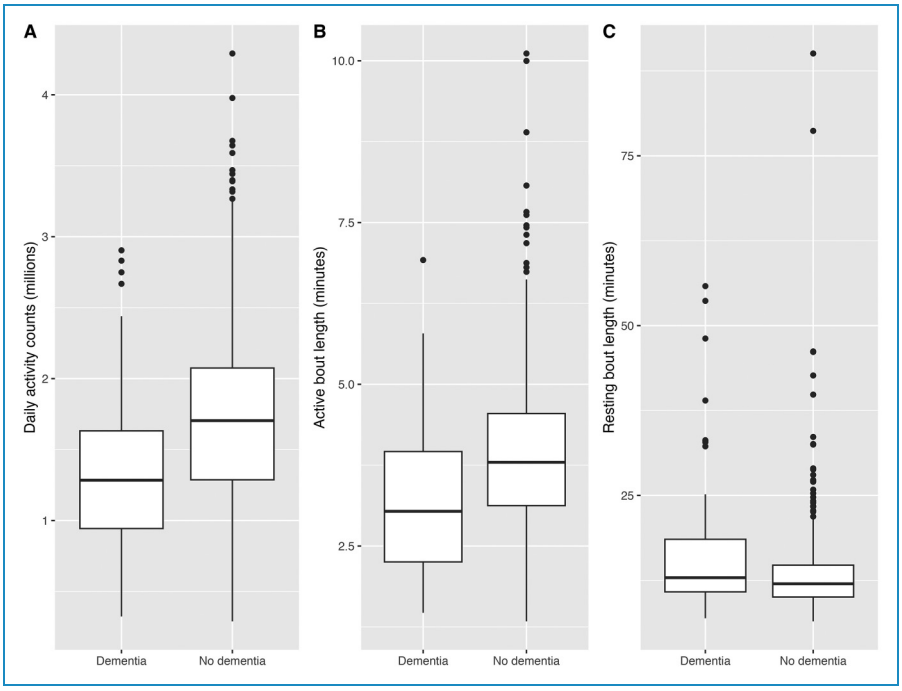

Figure 1. Unweighted boxplots of daily activity counts, active bout length, and resting bout length for NHATS participants with and without dementia.

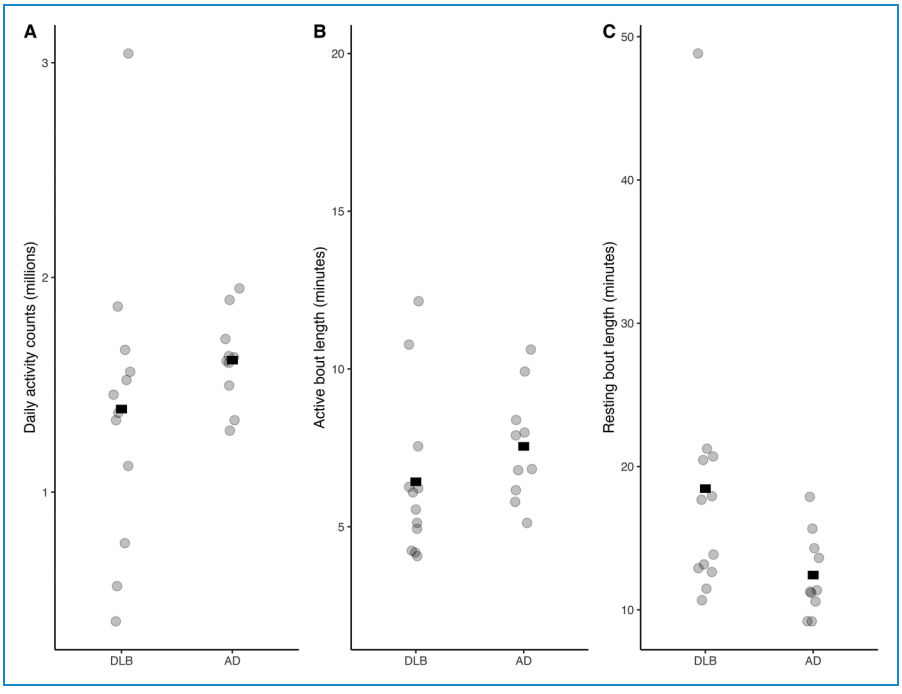

Figure 2. Scatterplots with bars indicating the mean daily activity counts, active bout length, and resting bout length for TEDD participants with DLB and AD.

study of self-reported leisure time, investigators found that spending more sedentary time watching television was associated with an increased risk of incident dementia, but spending more sedentary time on the computer was associated with a decreased risk of incident dementia.[50] The latter study suggests an important caveat: accelerometry data

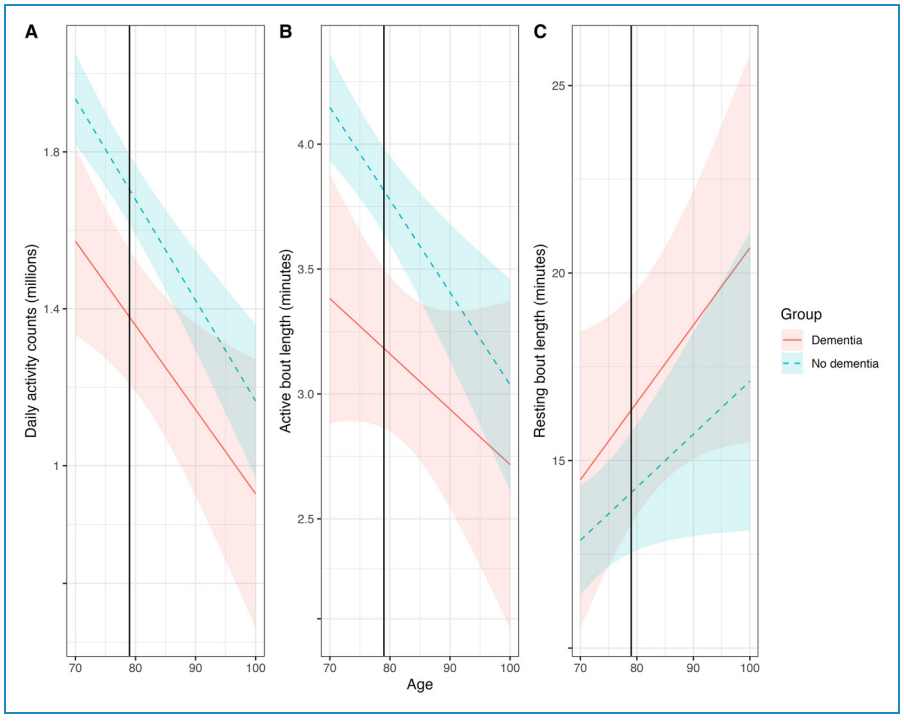

Figure 3. Predicted values of daily activity counts, active bout length, and resting bout length for NHATS participants with and without dementia by age. Vertical lines denote the mean age of the sample, 79. There are $n = 18$ and $n = 38$ participants aged 90 and older with and without dementia, respectively.

Table 3. Estimates of differences in mean daily activity counts, active bout length, and resting bout length corresponding to a 1-year difference in age for NHATS participants with and without dementia.

Outcome	Overall		Dementia		No dementia		Difference	
	Age β (95% CI)	*p*-value	Age β (95% CI)	*p*-value	Age β (95% CI)	*p*-value	Interaction β (95% CI)	*p*-value
Daily activity (counts)	−0.025 (−0.032, −0.018)	<0.001	−0.022 (−0.037, −0.006)	0.008	−0.026 (−0.034, −0.018)	<0.001	−0.004 (−0.023, 0.014)	0.657
Active bout length (minutes)	−0.035 (−0.049, −0.020)	<0.001	−0.022 (−0.053, 0.010)	0.178	−0.037 (−0.054, −0.020)	<0.001	−0.015 (−0.053, 0.023)	0.446
Resting bout length (minutes)	0.153 (0.036, 0.269)	0.014	0.206 (−0.014, 0.427)	0.074	0.142 (0.006, 0.277)	0.047	−0.065 (−0.329, 0.200)	0.634

Note. Models were adjusted for age, dementia group, sex, race, residence type, marital status, education, BMI, total comorbidities, and an interaction term between age and dementia group.

cannot account for activities during rest time, like working on a computer or reading, that may have neutral or positive effects on cognition. Additional studies are needed to better understand how sedentary behaviors are related to dementia and how accelerometry may or may not be able to account for those relationships.

In addition to clarifying the role between dementia status, age, and accelerometry metrics, we also sought to identify specific differences between a small sample of TEDD participants with DLB and with AD in an exploratory analysis. Given that motor disturbances are more common in DLB than in AD,[27] we hypothesized that individuals with DLB would exhibit

Table 4. Estimates of differences in mean daily activity counts, active bout length, and resting bout length corresponding to a 1-year difference in age for TEDD participants with DLB and AD.

Outcome	Overall		DLB		AD		Difference	
	Age β (95% CI)	*p*-value	Age β (95% CI)	*p*-value	Age β (95% CI)	*p*-value	Interaction β (95% CI)	*p*-value
Daily activity (counts)	−0.005 (−0.042, 0.032)	0.802	−0.004 (−0.047, 0.038)	0.837	−0.006 (−0.097, 0.084)	0.891	−0.002 (−0.102, 0.098)	0.970
Active bout length (minutes)	−0.002 (−0.161, 0.157)	0.980	0.014 (−0.166, 0.193)	0.883	−0.074 (−0.459, 0.311)	0.710	−0.088 (−0.513, 0.337)	0.690
Resting bout length (minutes)	0.181 (−0.370, 0.732)	0.528	0.263 (−0.356, 0.881)	0.416	−0.195 (−1.521, 1.132)	0.777	−0.457 (−1.921, 1.006)	0.548

Note. Models were adjusted for age, dementia subtype, and an interaction term between age and dementia subtype. The difference column was obtained from the interaction term of each model where the DLB group was the reference.

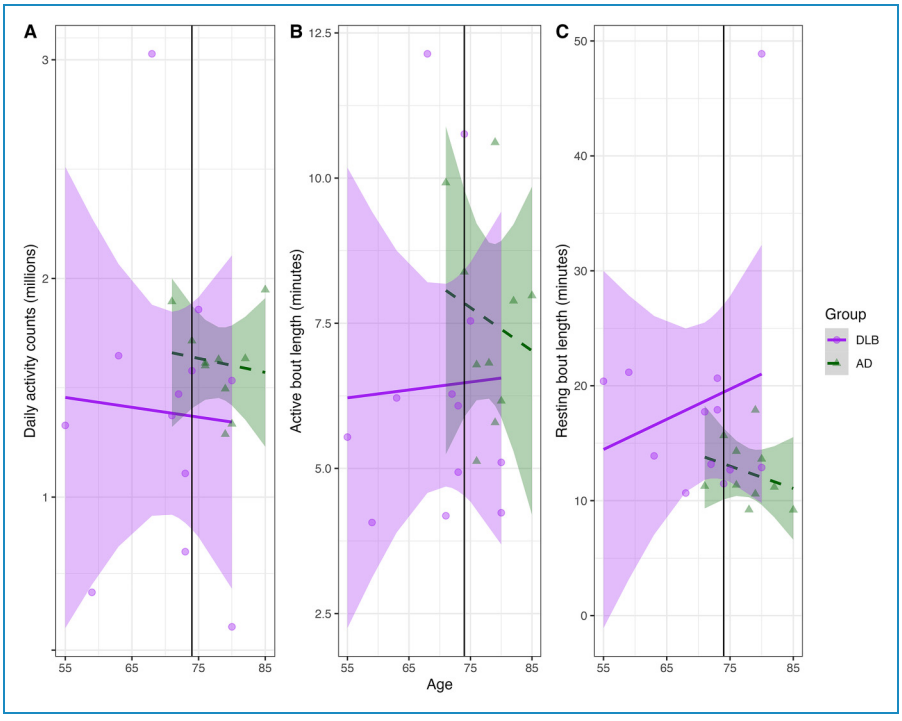

Figure 4. Predicted values of daily activity counts, active bout length, and resting bout length for TEDD participants with DLB and AD by age. Vertical lines denote the mean age of the sample, 74.

fewer total activity counts, shorter active bout lengths, and longer resting bout lengths than individuals with AD. The mean values for these three outcomes in our TEDD cohort were consistent with this hypothesis, but we found no statistically significant differences between the two groups. This suggests that studies with larger sample sizes, in which age can be better matched between the groups, may be able to establish more meaningful findings. We also observed no statistically significant differences in how the association between each outcome and age differed between the two groups (Table 4 and Figure 4).

To the best of our knowledge, McArdle et al.[46] conducted the only other study to examine differences in accelerometer-derived outcomes across individuals with DLB ($n = 30$) and AD ($n = 36$). They found no statistically significant differences in the activity volume or patterns across groups while also

observing a similar pattern such that the daily average values for minutes spent walking, step counts, and the number of active bouts were less in individuals with DLB than in individuals with AD. This serves as further evidence of a potential difference in activity levels across dementia subtypes while also highlighting the fact that existing studies lack sufficient power to detect clinically meaningful differences.

Perhaps the most striking difference in the accelerometry measures between our participants with DLB and AD, then, was that participants with DLB exhibited much greater variability in each outcome than participants with AD. For the DLB group, the standard deviation of daily activity counts was approximately 3 times greater than that of the AD group, and likewise, the standard deviation of resting bout length was almost 4 times greater for the DLB group than that of the AD group (Figure 2). Future accelerometry research that focuses specifically on individuals with DLB should investigate whether this variability is the result of randomness or something inherent to DLB.

An important limitation of this study is that differences in accelerometers, sampling rates, and processing prevented us from directly comparing the performance of NHATS and TEDD participants with dementia. Likewise, because the NHATS does not require participants to complete a robust diagnostic process that might identify dementia subtypes, it is also not possible to characterize differences between DLB and AD using this sample. This meant that to understand potential differences between dementia subtypes, we had to rely on the much smaller TEDD sample. There, a limitation is the sample size and age range. Given that the DLB group was on average younger than the AD group and that age has an established association with activity-based outcomes, future studies should concentrate on having participants with DLB and AD who are better matched on age. Additionally, the number of NHATS participants with dementia was limited at the lower and upper ends of the age range assessed in this analysis ($n = 15$ with dementia and $\leq$75 years old, $n = 18$ with dementia and $\geq$90 years old), and the results related to the association between age and PA are less robust at these extremes, as suggested by the CIs in Figure 3(a) to (c). A likely reason for the smaller sample size of the dementia group at older ages is study dropout, which may induce selection bias. Future analyses should adjust for this bias. Lastly, both the NHATS and TEDD accelerometer data were collected during the COVID-19 pandemic, and we do not have a full understanding of how that context may have affected activity levels and sedentary behavior.

Conclusions

We used a large, survey-based sample of individuals with and without dementia to identify significant differences in daily activity and active bout length, as well as a suggestive difference in resting bout length. These findings contribute to our current understanding of the association between PA and dementia and demonstrate the utility of accelerometers in deepening this understanding. A potential future use for accelerometers may be to aid in the identification and detection of dementia. The use of daily activity and active bout length measures may be especially useful in this regard, given that the association between these outcomes and dementia status was prominent, notably at the sample's younger ages. We also extended these analyses to a smaller, exploratory sample of dementia subtypes, and although we did not have a sufficient sample size to identify statistically significant differences between individuals with DLB and AD, our findings help characterize PA among people with these diseases and may contribute to future efforts to utilize accelerometers in differentiating between them.

Acknowledgments

We thank all of the research participants who volunteered their time to make this work possible.

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Statements and declarations

Ethical considerations

All participants were enrolled in a protocol that was approved by the VA Puget Sound Health Care System institutional review board (IRB00007064) on 16 September 2019.

Consent to participate

All participants provided written informed consent prior to enrolling in the study.

Consent for publication

Not applicable.

Author contributions/CRediT

Conceptualization: ASD and DWT; data curation: AJ, KB, and SP; formal analysis: KB and KW; funding acquisition: ASD and DWT; investigation: AJ and SP; methodology: DWT, ES, KB, and KW; project administration: AJ, DWT, and SP; supervision: DWT and KW; writing—original draft: ASD and KB; writing—review and editing: AJ, ASD, DWT, ES, KB, KW, and SP.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The work was supported by the National Institute on Aging (R21/R33 AG064271) and supported in part by the U.S. Department of Veterans Affairs Office of Research and Development. NHATS was supported by the National Institute on Aging (U01 AG032947).

Conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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