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### Article

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***Dementia patients are more sedentary and less physically active than age- and sex-matched cognitively healthy older adults***

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**Declarations**

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**2 ABSTRACT**

3 **Aims:** To examine physical activity and sedentary behavior characteristics of ambulatory and  
4 community dwelling patients with dementia compared to cognitively healthy age-, sex- and weight-  
5 matched controls.

6 **Methods:** In this cross-sectional study we included community dwelling dementia patients (N=45,  
7 age=79.6±5.9 years, MMSE=22.8±3.2) and matched controls (N=49, age=80.0±7.7 years,  
8 MMSE=29.0±1.2). Participants wore a wrist accelerometer for seven days to assess sedentary time,  
9 sedentary bout duration and time spent in very light, light-to-moderate and moderate-to-vigorous  
10 physical activities.

11 **Results:** Relative sedentary time and sedentary bout duration was significantly higher in dementia  
12 patients compared to controls (median and interquartile range: 57% (49 - 68) vs 55% (47 - 59) and  
13 18.3 (16.4–21.1) minutes vs 16.6 (15.3–18.4) minutes, P=0.042 and P=0.008 respectively). In addition,  
14 dementia patients spent a lower percentage of their waking time in light-to-moderate and moderate-to-  
15 vigorous intensity physical activities (20% (15–23) vs 22% (18–25) and 5% (2–10) vs 10% (5–13),  
16 P=0.017 and P=0.001 respectively).

17 **Conclusion:** We revealed that dementia patients are more sedentary and perform less physical activity  
18 compared to cognitively healthy controls. This may have clinically important consequences, given the  
19 observation that sedentary behavior and little physical activity independently predicts all-cause  
20 mortality and morbidity.

21

22

23

## 24 INTRODUCTION

25 The incidence and prevalence of dementia is rising [1]. Pharmacological treatment to slow disease  
26 progression shows limited benefits on cognitive functioning [2]. Therefore, non-pharmaceutical  
27 therapies are needed to attenuate or slow cognitive decline. Engagement in moderate to vigorous  
28 physical activity (i.e. exercise) is one of the most important modifiable risk factors for dementia [3].  
29 Moreover, exercise interventions have beneficial effects on cognitive function in older adults with  
30 dementia [4]. Interestingly, recent research showed that sedentary behavior (activities requiring low  
31 levels of energy expenditure, e.g. sitting and lying), independent of performance of physical activity,  
32 is strongly related to negative health outcomes and mortality [5,6]. Moreover, sedentary behavior is  
33 associated with lower cognitive performance [7], which stresses the relevance to understand the  
34 prevalence and characteristics of sedentary behavior in the context of dementia. Therefore, we aim to  
35 objectively determine physical activity and sedentary behavior characteristics of community-dwelling  
36 dementia patients compared to cognitive healthy age-, sex- and weight-matched controls. Secondary,  
37 we will explore whether increasing age attenuates physical activity and sedentary behavior in  
38 dementia.

39

## 40 MATERIALS AND METHODS

41 *Participants and design.* In this cross-sectional study persons with a dementia diagnosis, aged >60  
42 years, that were ambulatory and community dwelling were included. Dementia diagnosis was based  
43 on comprehensive clinical assessment by a physician, typically including neuropsychological  
44 assessment and imaging. We used the mini-mental state examination (MMSE) to indicate severity of  
45 cognitive impairment [8]. Baseline measurements of a longitudinal trial examining the effects of  
46 exercise on cognitive functioning in dementia were used for the current study [9]. Cognitively healthy  
47 controls were age-, sex- and weight-matched to dementia patients and had no history of cognitive  
48 impairment (MMSE >24 [8]). All participants were ambulatory and community-dwelling. The study  
49 protocol was approved by the local Medical Ethics Committee in accordance with the latest revision of  
50 the declaration of Helsinki. Written informed consent was obtained from all participants.

51 *Physical activity monitoring.* Directly after screening, physical activity and sedentary behavior were  
52 assessed by the Philips Actiwatch 2, a wrist-worn accelerometer validated in middle-aged females  
53 [10]. The Philips Actiwatch 2 contains an acceleration-responsive piezoelectric sensor which measures  
54 wrist accelerations in three directions every 30 seconds. These wrist accelerations were translated into  
55 a number of counts that were used to estimate physical activity and sedentary behavior. The  
56 accelerometer was worn for seven days on the non-dominant wrist, to provide a reliable estimate of  
57 physical activity and sedentary behavior. the [11,12]. All participants wore the actiwatch 24 hours per  
58 day. The accelerometer was waterproof and participants did not take it off during swimming or taking  
59 a shower. Therefore, non-wear time was not expected. Sleep intervals, including daytime naps, were  
60 filled in by the participants or their caregivers in a sleep diary.

61  
62 *Data analysis.* Data was uploaded using the Philips Actiware 6 software. Data from the first day of  
63 testing were excluded from analysis to give participants the opportunity to familiarize with the device.  
64 Sleep intervals were manually set by the researcher using the Philips Actiware 6 software [13] and  
65 excluded by custom software written in MATLAB R2014b (MathWorks, USA). Hereby only the data  
66 of the waking hours remained. Participants were included if they provided at least six valid days (>10  
67 h of waking data). Data was converted from counts per epoch to counts per minute (CPM). Cut-off  
68 points of 145 counts per minute (CPM), 145-274 CPM, 274-597 CPM and >597 CPM were used for  
69 sedentary behavior, very light, light-to-moderate and moderate-to-vigorous physical activity  
70 respectively [10]. To account for individual differences in waking time, our primary analysis  
71 expressed activity levels as a percentage of total (awake) measuring time. Interruptions in sedentary  
72 behavior were defined as spending one minute  $\geq 145$  CPM after 5 minutes  $< 145$  CPM. Prolonged  
73 sedentary behavior was defined as spending 30 minutes  $< 145$  CPM without one minute above 145  
74 CPM. Duration of average sedentary bout was defined by total time spent sedentary divided by  
75 number of interruptions in sedentary behavior.

76  
77 *Statistical analysis.* Statistical analyses were performed in IBM SPSS Statistics 20.0 (IBM SPSS; IBM  
78 Corp., Armonk, New York, USA). We performed a complete case analysis, including only those

79 participants that wore the actiwatch for a minimum of 7 days. Chi<sup>2</sup>-tests for categorical variables and  
80 independent samples t-tests for continuous variables were used to compare dementia patients and  
81 controls. Non-parametric tests were used for not normally distributed data (including physical activity  
82 and sedentary behavior). To evaluate the impact of age, the same analyses were performed between  
83 participants aged <80 years and ≥80 years. All data are presented as median (interquartile range)  
84 unless stated otherwise. Level of significance was set at P<0.05.

85

## 86 RESULTS

87 45 dementia patients (mean±SD age=79.6±5.9 years, MMSE=22.8±3.2) and 49 controls (mean±SD  
88 age=80.0±7.7 years, MMSE=29.0±1.2) were included (Figure 1). Sex, BMI, walking aid use and  
89 number of comorbidities did not differ between groups (Table 1). MMSE was significantly lower in  
90 dementia patients (P<0.001), and dementia patients received significantly more home care (P<0.001).  
91 The majority of dementia patients and controls lived independently (93% and 98% respectively).

92

93 Total waking time tended to be lower in dementia patients compared to controls (mean±SD 14.9±1.3  
94 h/day vs 15.4±1.0 h/day, P=0.053, Table 2). Dementia patients had significantly lower activity counts  
95 and spent more hours in categories reflecting lower-intensity activity (Table 2). Relative sedentary  
96 time was significantly higher in dementia patients compared to controls (57% (49 - 68) vs 55% (47 -  
97 59), P=0.042, Table 2). In addition, dementia patients spent a lower percentage of their waking time in  
98 light-to-moderate and moderate-to-vigorous intensity physical activity (20% (15-23) vs 22% (18-25)  
99 and 5% (2-10) vs 10% (5-13), P=0.017 and P=0.001, respectively). Number of interruptions in  
100 sedentary behavior and prolonged sedentary bouts did not differ. Duration of sedentary bouts was  
101 significantly longer in dementia patients compared to controls (18.3 (16.4-21.1) minutes vs 16.6 (15.3-  
102 18.4) minutes, P=0.008, Table 2).

103

104 When comparing younger *versus* older subgroups, older participants showed more walking aid users.  
105 Whilst older controls showed significantly less physical activity and more sedentary behavior  
106 compared to their younger peers, no such changes were present between dementia patients aged ≥80

107 years and aged <80 years (Figure 2). More specifically, younger controls had a significantly higher  
108 activity counts, lower relative sedentary time, and spent more hours in categories reflecting light-to-  
109 moderate and moderate-to-vigorous intensity activity compared to older controls. Since no such  
110 differences were present between young and older dementia patients, differences in physical activity  
111 and sedentary behavior characteristics between populations was most prominent in the younger groups  
112 (see Figure 2).

113

## 114 **DISCUSSION**

115 The aim of our study was to objectively investigate physical activity and sedentary behavior  
116 characteristics of dementia patients compared to controls, and assess whether age affects this  
117 comparison. First, in our relatively large sample we found that dementia patients spent significantly  
118 more of their waking hours in a sedentary state and significantly less time in light-to-moderate and  
119 moderate-to-vigorous intensity activities. This may have clinically important consequences, given the  
120 observation of previous prospective studies that sedentary behavior independently predicts all-cause  
121 mortality and morbidity [5,14]. Secondly, we found that older age was associated with a decline in  
122 physical activity and increase in sedentary behavior in controls, whilst no such age-related changes  
123 were found in dementia patients. Consequently, negligible differences in physical activity and  
124 sedentary behavior characteristics were present when comparing older dementia patients and controls.

125

126 In line with observations from previous work [15,16], our data confirm that community-dwelling  
127 dementia patients spend a large amount of time in sedentary behavior and have low levels of physical  
128 activity. We add the novel finding that differences between dementia patients and controls remain  
129 when corrected for sleep time. Even though we used an accelerometer validated to measure physical  
130 activity and sedentary behavior [10], time spent in moderate-to-vigorous intensity activity seems  
131 unusually high in both groups [17]. We have compared our findings to other studies that assessed  
132 physical activity and sedentary behavior in older adults with and without dementia, and we note that  
133 sedentary behavior ranged from 6.7 to 10.7 hours between studies [15,18,19]. Moreover, percentage of  
134 elderly meeting physical activity guidelines (150min/week of moderate-to-vigorous physical activity)

135 ranged from 27-69% [17,20]. Differences in sedentary behavior and physical activity duration between  
136 studies might relate to the use of different types of accelerometers, given that the reported studies  
137 used hip-worn accelerometers, wrist-worn accelerometers or questionnaires to estimate physical  
138 activity and sedentary behavior [21]. However, this does not invalidate our primary comparison  
139 between subjects with dementia and healthy peers. Moreover, this highlights the importance of  
140 including a control group to provide valid interpretation of the results.

141  
142 Our observation raises the question if differences in physical activity and sedentary behavior are  
143 simply a consequence of dementia. A decline in executive functioning (i.e. necessary for goal directed  
144 behavior such as physical activity) could lead to apathy [22], which is known to lower activity levels  
145 in Alzheimer's' patients [23]. However, it is important to realize that lower physical activity and  
146 higher sedentary behavior have already been reported in the preclinical stages of dementia [24] and in  
147 subjects with mild cognitive impairment) [25]. This might suggest that differences in physical activity  
148 and sedentary behavior are causally linked to progression from mild cognitive impairment to later  
149 stages of dementia. Future research is necessary to answer this question on cause of effect.  
150 Nevertheless, since higher physical activity and lower sedentary behavior are associated with better  
151 cognitive performance [7,25], benefits of interventions promoting physical activity and reducing  
152 sedentary behavior should be investigated.

153  
154 In response to our second research question, we found that older age was associated with a decline in  
155 physical activity and increase in sedentary behavior in controls. This observation can partly be  
156 explained by deterioration of walking and mobility and increased disability with older age [26].  
157 Interestingly, no further decline in physical activity and increase in sedentary behavior was found in  
158 dementia patients, despite the age-related increased number of walking aid users. This striking result  
159 suggests that cognitive impairment in dementia has a great impact on physical activity and sedentary  
160 behavior, and may be more important than the impact of other factors such as deterioration of walking  
161 and mobility. An alternative explanation is that a (near) minimum level is achieved in the decline in  
162 levels of physical activity and sedentary behavior in community-dwelling subjects [17].



163

164 In addition to the duration of sedentary behavior, previous work revealed that the frequency of  
165 breaking up sitting (and therefore duration of each sedentary bout) may have clinical relevance.  
166 Breaks in sedentary behavior can prevent cardiovascular impairments [5] and plays a role in  
167 maintaining glycemic control, which may positively influence brain health [27]. Our study found that  
168 the average duration of a sedentary bout was higher in dementia patients compared to controls. This  
169 observation suggests that not only reducing sedentary time, but also preventing prolonged sedentary  
170 bouts by regularly breaking up sedentary behavior, can be targeted as a lifestyle intervention [28].

171

172 *Limitations* Since we only included community-dwelling patients, our results cannot be generalized to  
173 institutionalized dementia patients. Furthermore, dementia patients in our study were enrolled in an  
174 exercise trial [9]. Therefore, this group may be more motivated to be physically active. Nonetheless,  
175 significant differences in physical activity characteristics were observed. Furthermore, physical  
176 activity characteristics were measured by wrist-worn accelerometry, which is associated with limited  
177 discriminative capacity between sedentary and very light intensity activities [29]. Consequently,  
178 differences between dementia patients and controls might even be more pronounced. Another  
179 limitation relates to our accelerometer, which has only been validated in a group of middle-aged  
180 females [10] and was unable to correct for potential presence of short (~1-min) periods of non-wear  
181 time. Nonetheless, we do not expect this will invalidate our findings of between-group differences in  
182 physical activity and sedentary behavior. In addition, using wrist-worn accelerometry may explain the  
183 two outliers in the younger dementia patients (Figure 2), which could relate to restless arm  
184 movements. Whilst this may affect exploring individual differences in physical activity *versus*  
185 sedentary behavior characteristics, significant differences remained present at group level.  
186 Furthermore, we did not discriminate between types of sedentary activities. Cognitively challenging  
187 sedentary activities, such as reading, might have a protective effect on cognition and are therefore less  
188 harmful than passive sedentary activities (e.g. television-viewing) [30]. The final limitation is use of  
189 the MMSE as a cognitive screening instrument since this measure, especially in healthy highly  
190 educated older adults, has limited discriminative power to detect mild cognitive deficits [31,32]. It is

191 important to indicate that diagnosis of dementia was not made using the MMSE, but included standard  
192 clinical procedures (including imaging if required).

193

194 *Clinical relevance.* Knowledge of physical activity characteristics across the entire activity spectrum  
195 in dementia is highly relevant given that physical activity is an important factor accelerating  
196 development and progression of dementia [3,7]. In addition, a high amount of sedentary behavior and  
197 low amount of physical activity are associated with higher mortality and morbidity [5,6]. Even though  
198 we found relatively small differences in physical activity characteristics between dementia patients  
199 and controls, these may be highly relevant. For example, even very short breaks of light intensity  
200 activity (i.e. 2 minutes walking) can already prevent acute metabolic [33] and cardiovascular [5]  
201 impairments. This underlines the importance to develop interventions suitable for this vulnerable  
202 patient group to safely engage in light intensity activities. However, future research should first  
203 explore the role of physical activity and sedentary behavior in the progression and prevention of  
204 dementia.

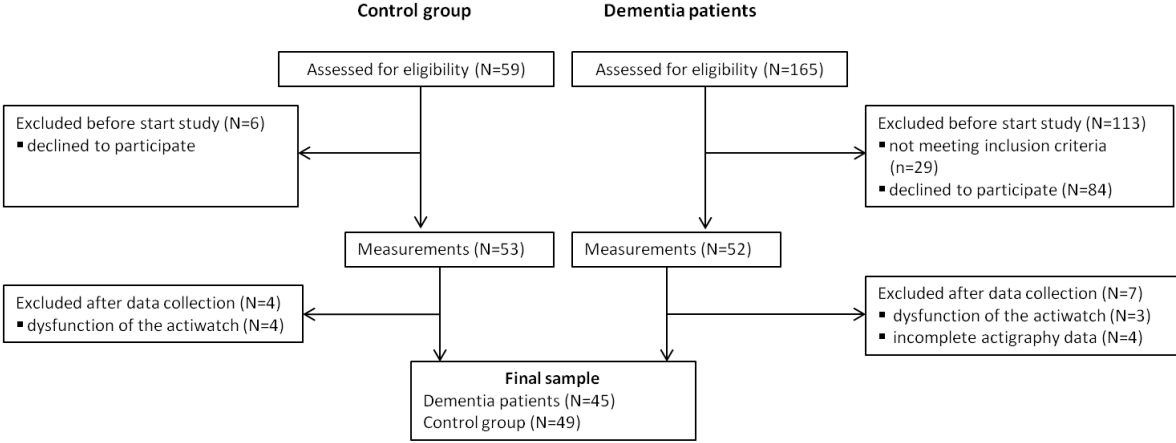
205

206 *Conclusion.* In the current study we objectively demonstrated that dementia patients spend  
207 significantly more of their waking hours in sedentary behavior and spend less time in light-to-  
208 moderate and moderate-to-vigorous intensity physical activity. Moreover, we found that older age  
209 attenuated sedentary behavior and physical activity in controls, whilst this age-related decline is absent  
210 in dementia patients. This means that patients with dementia (independent of age) lead a physically  
211 inactive lifestyle characterized with significant time spent sedentary.

212 Taken together, these data improve our understanding of physical activity and sedentary behavior  
213 characteristics in this highly relevant patient group and implies that targeting sedentary behavior and  
214 physical activity may be relevant in dementia patients, especially at a younger age.

215 **FIGURE CAPTIONS**

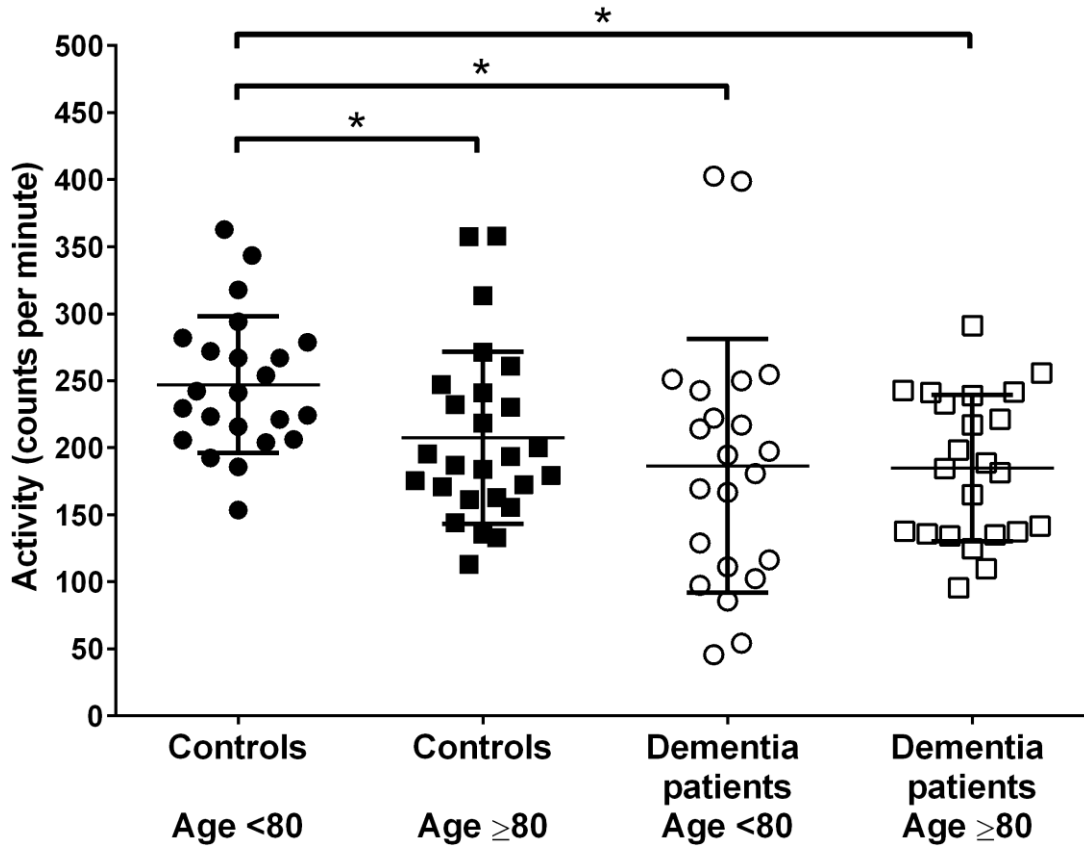
216 **Fig. 1: Flowchart of participants**



217

218

219 Fig 2: Activity levels of dementia patients and cognitively healthy controls



220 Activity levels of younger and older age groups. Mean activity score (counts per minute) grouped by age.  
 221 Controls Age<80 (n=23), Controls Age ≥80 (n=26), Dementia patients Age <80 (n=22), Dementia patients Age  
 222 ≥80 (n=23). Values represent median ± interquartile range. \* Significant difference between: Controls Age <80  
 223 and Controls Age ≥80 P=0.044, Controls Age <80 and Dementia patients Age <80 P=0.004, Controls Age <80  
 224 and Dementia patients Age ≥ 80 P=0.002.  
 225

226  
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 230

## Sedentary behavior in dementia

**Table 1.** Baseline characteristics

	Control (n=49)	Dementia (n=45)	P-value
Age (years), <i>mean ± SD</i>	80.0 ± 7.7	79.6 ± 5.9	0.744*
Females, <i>n (%)</i>	25 (51.0%)	22 (48.9%)	0.836†
Body Mass Index (kg/m <sup>2</sup> ), <i>mean ± SD</i>	25.5 (4.0)	26.3 (5.0)	0.411*
Mini Mental State Examination‡, <i>mean ± SD</i>	29.0 ± 1.2	22.8 ± 3.2	<0.001*
Number of walking aid users, <i>n (%)</i>	10 (20.4%)	16 (35.6%)	0.101†
Number of home-care receivers, <i>n (%)</i>	6 (12.2%)	24 (53.3%)	<0.001†
Number of comorbidities§, <i>mean ± SD</i>	2.7 ± 1.8	3.3 ± 1.9	0.150*
<b>Residence, <i>n (%)</i></b>			0.629†
- Independent, alone	18 (36.7%)	14 (31.1%)	
- Independent, together	30 (61.2%)	28 (62.2%)	
- Care home	1 (2.0%)	3 (6.7%)	
- Nursing home	0	0	
<b>Dementia type, <i>n (%)</i></b>			
- Alzheimer's disease	n/a	25 (55.6%)	
- Vascular dementia	n/a	2 (4.4%)	
- Alzheimer's Disease/Vascular Dementia (%)	n/a	12 (26.7%)	
- Dementia type not specified (%)	n/a	6 (13.3%)	

\*Differences between groups were tested with independent samples t-test; †Differences between groups were tested with Chi-Square Test; ‡ Scores on the Mini-Mental State Examination (MMSE) range from 0 (severe impairment) to 30 (no impairment); §Comorbidities are scored using the Older Persons and Informal Caregivers Survey-Minimum Dataset (TOPICS-MDS) with a theoretical range of 0-17 and a higher score indicates more comorbidities [34]

Sedentary behavior in dementia

**Table 2:** Physical activity and sedentary behavior characteristics

	<b>Control (n=49)</b>	<b>Dementia (n=45)</b>	<b>P-value</b>
Total waking time (h/day)	15.4 ± 1.0*	14.9 ± 1.3*	0.053†
Counts per minute (day <sup>-1</sup> )	226 ± 61*	186 ± 76*	<b>0.005</b> †
<b>Absolute values (h/day)</b>			
Sedentary time	8.1 (7.2 – 9.2)	8.5 (7.2 – 10.0)	0.216
Very light intensity activity	2.2 (1.9 – 2.6)	2.3 (1.7 – 2.9)	0.748
Light-to-moderate intensity activity	3.5 (2.7 – 4.0)	2.7 (2.0 – 3.7)	<b>0.006</b>
Moderate-to-vigorous intensity activity	1.5 (0.8 – 2.0)	0.8 (0.4 – 1.5)	<b>0.001</b>
<b>Relative values (% of total measuring time)</b>			
% sedentary time	55 (47 – 59)	57 (49 – 68)	<b>0.042</b>
% very light intensity activity	15 (12 – 16)	16 (12 – 19)	0.284
% light-to-moderate intensity activity	22 (18 – 25)	20 (15 – 23)	<b>0.017</b>
% moderate-to-vigorous intensity activity	10 (5 – 13)	5 (2 – 10)	<b>0.001</b>
<b>Sedentary behavior characteristics</b>			
Number of interruptions in sedentary behavior (day <sup>-1</sup> )	28.2 (26.2 – 32.5)	27.2 (24.5 – 31.0)	0.195

### Sedentary behavior in dementia

Number of 30 minutes prolonged sedentary bouts (day <sup>-1</sup> )	2.0 (0.9 – 3.3)	2.3 (1.0 – 4.1)	0.227
Duration of average sedentary bout (minutes)	16.6 (15.3 – 18.4)	18.3 (16.4 –21.1)	<b>0.008</b>

Median and Interquartile range are presented unless reported otherwise. P-values represent Mann-Whitney U test; \*Mean ± SD; †Differences between groups were tested with independent samples t-test

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