

Differential physical activity patterns in cognitively impaired vs healthy older adults using accelerometers

Massimiliano Pau¹, Gesuina Asoni², Daniela Viale², Valeria Putzu²

¹ Department of Mechanical, Chemical and Materials Engineering, University of Cagliari, Cagliari, Italy; ² Center for Cognitive Disorders and Dementia, Distretto Area Vasta ASL Cagliari, Cagliari, Italy

Objective. Physical Activity (PA) plays a pivotal role as a protective factor against the development of dementia and is associated with cognitive performance. However, quantitative data collected on older adults under ecological conditions remain limited. In the present study, a continuous longitudinal assessment of PA parameters was performed to clarify if differences in daily and hourly patterns of PA exist in older adults who differ by cognitive status.

Methods. Seventy-two adults aged 65+ were categorized by cognitive status (cognitively impaired [CI] vs healthy controls [HC]) and monitored using wrist-worn accelerometers to assess daily and hourly PA levels, including the percentage of time spent in PA at different intensities.

Results. In those of CI group, a significant reduction in overall PA volume and intensity was observed. This was evidenced by lower step counts, increased time spent in sedentary behavior and decreased engagement in PA of light and moderate-to-vigorous intensity.

Conclusions. The objective analysis of daily PA patterns using wearable accelerometers holds significant promise for quantifying changes associated with cognitive disorders and may optimize interventions to enhance their activity, thus reducing the impact of cognitive decline.

Key words: older adults, accelerometer, inertial measurement unit (IMU)

Received: July 16, 2025

Accepted: July 28, 2025

Correspondence

Massimiliano Pau

E-mail: massimiliano.pau@unica.it

How to cite this article: Pau M, Asoni G, Viale D, et al. Differential physical activity patterns in cognitively impaired vs healthy older adults using accelerometers. *Journal of Gerontology and Geriatrics* 2025;73:41-45. <https://doi.org/10.36150/2499-6564-N872>

INTRODUCTION

Rising life expectancy and declining fertility rates, combined with advances in medical care and improved living conditions, are increasing the proportion of older individuals worldwide, especially in industrialized countries. Unfortunately, this shift is accompanied by a growing number of individuals affected by major neurocognitive disorders (e.g., dementia), which is expected to double every 20 years and surpass 115 million by 2050 ¹.

Among the modifiable risk factors for dementia and its prodromal stages, physical activity (PA) is considered highly influential ². Substantial evidence indicates that higher levels of PA, particularly at moderate to vigorous intensity, are associated with a reduced risk of all-cause dementia ³. However, obtaining accurate measures of PA presents a significant challenge. In particular, among older adults, PA is commonly assessed using self-report questionnaires, which are inherently subjective and susceptible to various biases, including recall inaccuracies and social desirability bias ⁴.

© Copyright by Società Italiana di Gerontologia e Geriatria (SIGG)



OPEN ACCESS

This is an open access article distributed in accordance with the CC-BY-NC-ND (Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International) license. The article can be used by giving appropriate credit and mentioning the license, but only for non-commercial purposes and only in the original version. For further information: <https://creativecommons.org/licenses/by-nc-nd/4.0/deed.en>

These tools typically lack sufficient detail regarding activity type, frequency, duration, and intensity, limiting their clinical value. Challenges are further compounded in cognitively impaired populations, where memory deficits, difficulty understanding questions, and temporal disorientation can reduce the accuracy of self-reports. Even when caregivers provide proxy responses, reliability may be compromised by unintentional omissions or observational limitations⁵. Additionally, the lack of validated self-report PA tools tailored for individuals with dementia further reduces the credibility of such assessments in this population.

To overcome these limitations, the use of wearable movement sensors – especially accelerometers – has become increasingly common over the past two decades for tracking PA patterns in older adults. While this objective approach has helped clarify the link between PA and cognitive function, its application in cognitively impaired individuals remains underexplored⁶. This gap may stem from practical challenges that impact data quality, including user acceptance, device management, and ensuring adequate compliance and wear time.

In this study, wearable accelerometers were employed to examine differences in the amount and intensity of PA among community-dwelling older adults with and without cognitive impairments. Special attention was given to hourly activity patterns derived from accelerometer data. These insights may be useful not only in quantifying activity limitations related to cognitive impairment but also in guiding the development and optimization of targeted PA interventions.

METHODS

PARTICIPANTS

In the period August 2022 - October 2024, 72 adults aged over 65, consecutively examined at the Center for Cognitive Disorders and Dementia (Distretto Area Vasta ASL Cagliari, Italy) were enrolled in the study. They were referred to the facility by their primary care physician for suspected cognitive impairment, or for a routine geriatric screening.

All of them were free from severe orthopedic and neurologic disorders able to affect mobility significantly. The objectives and procedures of the study were thoroughly communicated to all participants, or to their family members/caregivers, and informed consent was obtained. They underwent a comprehensive geriatric and psychological evaluation, which included an assessment of overall cognitive function using the Italian version of the Mini-Mental State Examination (MMSE). Based on the cut-off scores for the Italian population⁷, they were then

categorized into two groups: healthy controls (HC, $n = 35$) and cognitively impaired (CI, $n = 37$). The latter group included individuals with mild ($n = 24$), moderate ($n = 8$), and severe ($n = 5$) cognitive impairments.

Age, anthropometric features, and female-to-male ratio were similar across the two groups while, as expected, MMSE score was significantly lower in those of CI group (19.8 vs 26.9, $p < 0.001$).

DATA ACQUISITION AND PROCESSING

The amount and intensity of PA were assessed using data collected over seven consecutive days with a clinically validated accelerometer (Actigraph GT3X, Actigraph Co., USA) previously used in similar studies involving older adults⁸. Each participant was given a device to wear on their non-dominant wrist continuously for 24 hours a day and instructed to keep it on during daily activities, removing it only for water-based tasks or personal hygiene. At the end of the monitoring period, raw data – triaxial acceleration recorded in 60-second epochs at 30 Hz – were downloaded and processed using the manufacturer's proprietary software (ActiLife v6.13.6, Actigraph Co., USA). The following metrics were calculated:

- vector magnitude counts per minute (VM cpm). This parameter represents the overall magnitude of the movement;
- percentage of time spent performing PA at different intensities, namely sedentary behavior (SB, 0-1.5 metabolic equivalent of task, METs), light-intensity PA (LPA, 1.5-3 METs), and moderate-to-vigorous PA (MVPA, 3-6 METs). This was carried out using the cut-points recently proposed by Migueles et al.⁹, based on experiments in which a group of older adults wore accelerometers while performing various activities of daily living and having their energy expenditure simultaneously measured with portable calorimetry. Of note, these are among the few existing cut-point sets available for accelerometer placement on the non-dominant wrist in older adults;
- steps count.

A day was considered valid for analysis if the device was worn for at least 16 hours. In this regards, it should be noted that compliance with the use of the device was automatically checked by the manufacturer' software using the algorithm proposed by Choi et al.¹⁰. Moreover, in order to verify that wear time value was not influenced by misclassification of inactivity or diurnal sleep, a visual analysis of the graphic representation of the whole-day activity was carried out before to process the accelerometric data.

STATISTICAL ANALYSIS

Differences in PA parameters related to the cognitive status of participants were explored using one-way

Table 1. Physical activity parameters (average value of 7 consecutive days) as calculated on the basis of the accelerometric data. Values are expressed as mean (SD).

	HC	CI	p value	Partial η^2	95% CI
Accelerometric counts per minute	1746.1 (482.9)	1312.3 (473.6)	< 0.001	0.175	HC 1584.1, 1907.3 CI 1155.6, 1469.1
Percentage of time spent in:					
Sedentary behavior (SB)	68.9 (9.4)	75.9 (9.5)	0.002	0.124	HC 65.7, 72.1 CI 72.8, 79.0
Light Physical Activity (LPA)	25.3 (6.8)	20.4 (7.6)	0.006	0.103	HC 22.9, 27.7 CI 18.1, 22.8
Moderate-to-vigorous physical activity (MVPA)	5.8 (4)	3.6 (2.9)	0.009	0.095	HC 4.7, 7.0 CI 2.5, 4.8
Daily steps	11815 (3702)	8732 (3326)	< 0.001	0.165	HC 10630, 12999 CI 7580, 9884
Wear time (percentage calculated across the 24 h period)	92.4 (5.6)	89.6 (8.5)	0.121	-	

multivariate analysis of variance (MANOVA), following verification of the basic assumptions for this approach (i.e., normal distribution of the variables, homogeneity of variance-covariance matrices, multicollinearity).

The independent variable was the group (HC/CI) and the dependent variables were the 5 parameters previously listed. The level of significance was set at $p = 0.05$, and the effect size was assessed using the eta-squared (η^2) coefficient. Univariate ANOVAs were carried out as a post-hoc test by reducing the level of significance to $p = 0.01$ ($0.05/5$) after a Bonferroni correction for multiple comparisons.

RESULTS

The PA variables of interest for the two groups are summarized in Table 1, while Figure 1 shows the average hourly values trends of the accelerometric counts and the percentage of time spent in PA of different intensities. Both groups demonstrated high (and similar) levels of compliance as the average wear time was approximately 22 hours, thus well above the 16-hour cut-off defined to include a certain day in the analysis. In all participants except one, 7 valid days were considered for the analysis.

MANOVA revealed a significant main effect of group on PA parameters [$F(5,66) = 3.65$, $p = 0.006$, Wilks $\lambda = 0.78$, $\eta^2 = 0.22$]. Post-hoc analyses indicated that individuals with cognitive impairment were less active overall, with lower PA amount (as indicated by the VM cpm value), step count, and a peculiar distribution of PA through different levels of intensity. They spent more time sedentary and less time in LPA and MVPA.

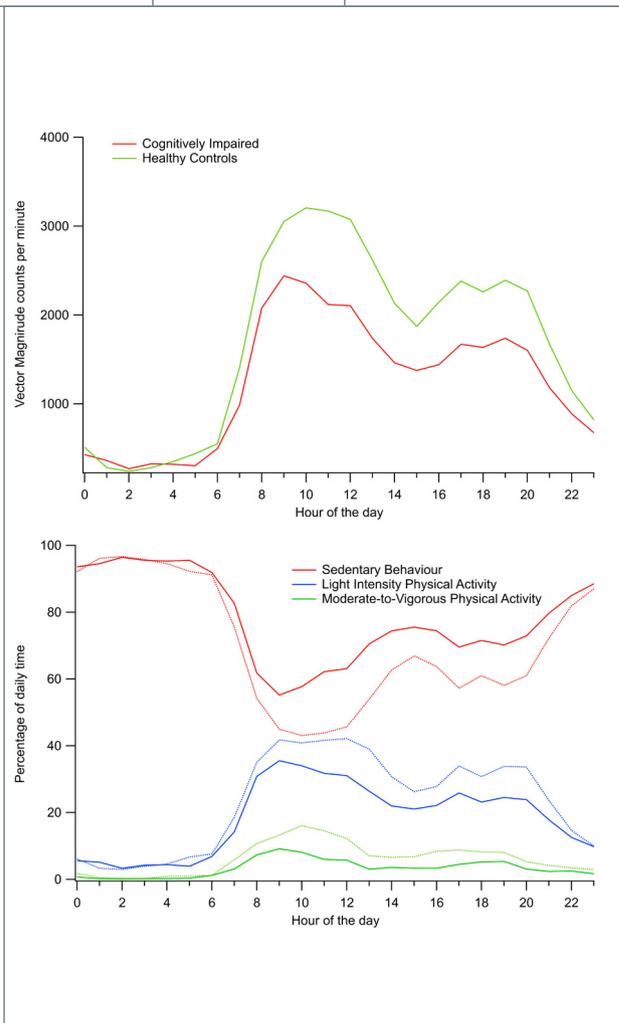


Figure 1. Top: hourly trend of VM cpm (measure of overall PA). For each hour of the day, the mean value calculated across the 7-day monitoring period is reported. Bottom: percentage of time spent in SB, LPA and MVPA: solid lines refer to cognitively impaired group, dotted lines refer to healthy individuals.

Hourly PA patterns showed consistently lower activity across the day in this group (Fig. 1, top), with the most pronounced differences observed in the morning (9-12 AM; Fig. 1, bottom).

DISCUSSION

Consistent with prior accelerometry-based investigations⁶, our findings indicate that individuals with cognitive disorders are generally less active compared to healthy controls. Specifically, data of the CI group revealed a distinct activity profile marked by a reduction in overall PA amount and mobility indicators (i.e., VM cpm and steps) and reduced intensity, with increased time spent in SB and decreased engagement in both LPA and MVPA.

The observed differences in SB and LPA can be explained considering that most unstructured PA usually performed by older adults (which is of light intensity) involve standing and walking while performing household chores or everyday mobility in the local environment¹¹. It is, thus, reasonable to hypothesize that those cognitively impaired are not able to engage in housework and social activities, due to a combination of poor cognitive and motor performance (the latter often associated with neurocognitive disorders¹²). Even more evident was the reduction in the percentage of time spent in MVPA, approximately 40% lower with respect to unaffected individuals. This result, aligned with previous observations¹³, can be attributed to physical, cognitive, and mental barriers such as health conditions (i.e., comorbidities, depression, etc.), medication side effects, impaired bodily function, low energy, attention and memory issues, lack of motivation, emotional barriers and negative feelings¹⁴. Other relevant factors that might contribute to such reduced PA levels involve the role of the caregivers¹⁵. Since they are often heavily burdened with daily care tasks, PA is not always prioritized when energy is focused on safety, hygiene, and medication. Also, caregivers who are inactive themselves are less likely to encourage or model PA (i.e., if the caregiver is sedentary, so is the older adult with cognitive impairment).

Further insights were gained through the analysis of the hourly distribution of accelerometric counts and PA intensity. As regards the former, the data revealed a bimodal pattern, with the primary peak occurring between 9 and 10 AM, and a secondary, less pronounced peak observed between 5 and 7 PM, which is qualitatively similar to what was reported in previous studies involving older adults¹⁶. This trend is likely influenced by the favorable climatic conditions in Sardinia, which support outdoor physical activity throughout the day and

across seasons. Looking at the different intensities, we observe that in those with cognitive disorders SB and LPA are almost constant between 9 and 12 AM, while the MVPA curve exhibits a distinct peak approximately at 9 AM. After that, the value markedly decreases up to 1 PM, remains stable until 4 PM and then rises again to reach the second peak at 6 PM. Overall, the distance between the MVPA curves of CI and HC remains large through all the period 9 AM-6 PM. Although further studies are necessary to better clarify the reasons for the differences here observed in terms of hourly distribution of PA, we can hypothesize that factors like medication timing or caregiving patterns might play an important role. In future research, a simultaneous assessment of PA in both older adult with cognitive impairment and their caregivers is advisable, together with an accurate reporting of type and time of medications.

The main limitations of this study include a relatively small sample size and the lack of control for potential confounding factors, such as overweight/obesity status, educational attainment, and socioeconomic background, all of which may affect different aspects of mobility. It is also to be considered that, since all participants were recruited through a specialized center in cognitive disorders, a selection bias might have occurred. As a result, caution should be exercised when generalizing these findings.

CONCLUSIONS

Objective analysis of daily PA patterns using wearable accelerometers holds significant promise for quantifying changes associated with cognitive disorders. This approach is both feasible and reliable, as evidenced by high compliance rates, and the resulting data may prove valuable in informing and optimizing interventions aimed at enhancing activity in individuals with cognitive impairments. Particularly informative are metrics related to diurnal movement propensity – which may guide the timing of structured activities – and trends in MVPA, given its established benefits for cognitive functions. It would also be desirable that, in future studies, PA activity data are integrated with sleep data (which are available using the same device) and possibly employed to assess the effectiveness of controlled intervention trials.

Conflict of interest statement

The authors declare no conflict of interest.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author contributions

MP, VP: conceptualization; MP, DV, GA, VP: investigation, formal analysis, data curation; MP: writing – original draft; DV, GA, VP: writing – review & editing.

Ethical consideration

This study was approved by the Ethics Committee of ATS Sardegna (protocol number 2713, 05/11/2021). The research was conducted ethically, with all study procedures being performed in accordance with the requirements of the World Medical Association's Declaration of Helsinki.

Written informed consent was obtained from each participant/patient for study participation and data publication.

References

- 1 Prince M, Bryce R, Albanese E, et al. The global prevalence of dementia: a systematic review and meta-analysis. *Alzheimers Dement* 2013; 9:63-75. <https://doi.org/10.1016/j.jalz.2012.11.007>
- 2 Norton S, Matthews FE, Barnes DE, et al. Potential for primary prevention of Alzheimer's disease: an analysis of population-based data. *Lancet Neurol* 2014;13:788-794. [https://doi.org/10.1016/S1474-4422\(14\)70136-X](https://doi.org/10.1016/S1474-4422(14)70136-X)
- 3 Iso-Markku P, Kujala UM, Knittle K, et al. Physical activity as a protective factor for dementia and Alzheimer's disease: systematic review, meta-analysis and quality assessment of cohort and case-control studies. *Br J Sports Med* 2022;56:701-709. <https://doi.org/10.1136/bjsports-2021-104981>
- 4 Blondell SJ, Hammersley-Mather R, Veerman JL. Does physical activity prevent cognitive decline and dementia? A systematic review and meta-analysis of longitudinal studies. *BMC Public Health* 2014;14:510. <https://doi.org/10.1186/1471-2458-14-510>
- 5 Farina N, Hughes LJ, Watts A, et al. Use of physical activity questionnaires in people with dementia: a scoping review. *J Aging Phys Act* 2019;27:413-421. <https://doi.org/10.1123/japa.2018-0031>
- 6 Hegberg N, Dev S, Hayes SM. The relationship between accelerometer-derived metrics of physical activity and cognition among older adults. In: Thomas AK, Gutches A, eds. *The Cambridge handbook of cognitive aging: a life course perspective*. Cambridge Handbooks in Psychology. Cambridge University Press 2020:645-665. <https://doi.org/10.1017/9781108552684.040>
- 7 Carpinelli Mazzi M, Iavarone A, Russo G, et al. Mini-mental state examination: new normative values on subjects in Southern Italy. *Aging Clin Exp Res* 2020;32:699-702. <https://doi.org/10.1007/s40520-019-01250-2>
- 8 Pau M, Brandas B, Fastame MC. Women have the power: when motor efficiency makes the difference in older individuals of the Sardinian blue zone. *Physiol Behav* 2025;291:114811. <http://doi.org/10.1016/j.physbeh.2025.114811>
- 9 Migueles JH, Cadenas-Sanchez C, Alcantara JMA, et al. Calibration and cross-validation of accelerometer cut-points to classify sedentary time and physical activity from hip and non-dominant and dominant wrists in older adults. *Sensors (Basel)* 2021;21:3326. <https://doi.org/10.3390/s21103326>
- 10 Choi L, Liu Z, Matthews CE, Buchowski MS. Validation of accelerometer wear and nonwear time classification algorithm. *Med Sci Sports Exerc* 2011;43:357-364.
- 11 Ustad A, Sverdrup K, Tangen GG, et al. Daily physical activity in older adults across levels of care: the HUNT Trondheim 70+ study. *Eur Rev Aging Phys Act* 2024;21:20. <https://doi.org/10.1186/s11556-024-00355-6>
- 12 Mc Ardle R, Del Din S, Donaghy P, et al. Factors that influence habitual activity in mild cognitive impairment and dementia. *Gerontology* 2020;66:197-208. <https://doi.org/10.1159/000502288>
- 13 Liu ML, Jiang LJ, Wang WX, et al. The relationship between activity level and cognitive function in Chinese community-dwelling elderly. *Res Sports Med* 2022;30:92-100. <https://doi.org/10.1080/15438627.2021.1888096>
- 14 van Alphen HJ, Hortobágyi T, van Heuvelen MJ. Barriers, motivators, and facilitators of physical activity in dementia patients: a systematic review. *Arch Gerontol Geriatr* 2016;66:109-118. <http://doi.org/10.1016/j.archger.2016.05.008>
- 15 Hobson N, Dupuis SL, Giangregorio LM, et al. Perceived facilitators and barriers to exercise among older adults with mild cognitive impairment and early dementia. *J Aging Phys Act* 2020;28:208-218. <http://doi.org/10.1123/japa.2019-0010>
- 16 Sartini C, Wannamethee SG, Iliffe S, et al. Diurnal patterns of objectively measured physical activity and sedentary behaviour in older men. *BMC Public Health* 2015;15:609. <https://doi.org/10.1186/s12889-015-1976-y>