Abstracts on the SmartMe&You-TELEMAIA platform of the Rome Technopole and eBRAIN-Health Projects

Submitted to

1) The 20th Congress of the Italian Society of Neurology for the Study of Dementia (SINDEM), Rome, September 18-20, 2025
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ACCEPTABILITY AND USABILITY OF SERIOUS VIDEO GAMES OF THE SMARTME&YOU HOME TELEMONITORING PLATFORM FOR PATIENTS WITH COGNITIVE DEFICITS DUE TO ALZHEIMER'S AND PARKINSON'S DISEASES

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Objective

The SmartMe&You home telemonitoring platform (https://smartme.cloud.garr.it/) is designed to monitor four key dementia risk factors over a one-week period in older adults at risk of cognitive impairment or already diagnosed with cognitive disorders in aging: (1) sedentary behavior, (2) dysfunctions in the autonomic system's regulation of heart rate dynamics over 24 hours, (3) night sleep quality, and (4) cognitive executive functions. The dementia risk factors in (1), (2), and (3) are monitored using a smartwatch, while (4) is monitored using serious video games developed by our Workgroup.

Here, we tested the usability, acceptability, and validity of the SmartMe&You serious video games for assessing cognitive status in cognitively unimpaired older adults (Healthy) and patients with mild cognitive impairment and mild to moderate dementia due to Alzheimer's (ADCD) and Parkinson's (PDCD) diseases. Validity was assessed using the Mini-Mental State Examination (MMSE) score as the gold standard.

Materials and methods

As part of the Italian Rome Technopole (Italian Ministry of University), eBRAIN-Health (Horizon, European Commission), PREDICT-NEURODEGEN (Italian Ministry of Health), and TELEMAIA (Regione Lazio Innova) projects, clinical and demographic data were collected from 42 healthy individuals with intact cognitive status (Healthy), 81 ADCD patients, and 74 PDCD patients (Table 1). The participants received a clinical diagnosis according to international guidelines on the inclusion and exclusion criteria for individuals in clinical studies focused on ADCD and PDCD.

All participants participated in home telemonitoring for 1 week using the SmartMe&You platform. The SmartMe&You's serious video games included 7 unsupervised cognitive tasks implemented on a commercial tablet (see a short video demonstrating these serious video games at https://www.youtube.com/watch?v=wfBm7WxX_RY). They included two variants of a visual, simple reaction time task, three variants of Posner's visuo-spatial anticipatory attention task, an attentive inhibition of return task, and a visual Go-NoGo task. All tasks were based on the same visual grid on the tablet screen, where cue and go stimuli were presented, and the participant had to provide a hand motor response as accurately and quickly as possible.

Fluid blood biomarkers, resting-state electroencephalographic data, structural and functional magnetic resonance imaging, and clinical and neuropsychological data were collected in hospital settings. Participants and caregivers received training on the use of serious video games during the hospital visits for clinical and neuropsychological assessment. The MMSE score and performance (i.e., accuracy and reaction time) in the serious video games were used as core variables for the statistical analyses. These analyses were performed using the freeware tool Jamovi version 2.3.

Results

All participants and caregivers accepted the SmartMe&You serious video games. The ADCD and PDCD patients demonstrated significantly lower accuracy and slower reaction times in their video game performances compared to the Healthy group (Rank transformation ANCOVAs, $p < 0.05$; Table 2 and Figure 1). Furthermore, a statistically significant positive association was found between the MMSE score and the video game task performances in the Healthy, ADCD, and PDCD participants as a whole group (GLMs; $p < 0.001$; Table 3 and Figure 2).

Conclusions

The unsupervised serious video games on the SmartMe&You platform were usable in the majority of patients with ADCD and PDCD and were sensitive to global cognitive deficits in both patient groups. Along these lines, these serious video games demonstrate potential as a useful, practical, free, "green", and unsupervised tool for evaluating cognitive status and decline in older people, with and without cognitive deficits, in home telemonitoring. This potential opens up exciting possibilities for future applications not only in tertiary prevention, care, and telemedicine in patients with ADCD and PDCD, but also in primary prevention in older individuals with intact cognition but risk factors for cognitive decline.

Table 1

DEMOGRAPHIC AND CLINICAL DATA				
	Healthy	ADCD	PDCD	Statistical analyses
N	42	81	74	-
Age (years)	68.6 ± 0.9 SE	74.9 ± 0.7 SE	73.7 ± 0.9 SE	ANOVA: F = 12.3, p < 0.00001 (Healthy > ADCD, PDCD)
Sex (M/F)	20/22	44/37	57/17	Chi-Square Test: Chi-Square = 12.7, p < 0.001
Education (years)	14.6 ± 0.6 SE	11.3 ± 0.6 SE	11.5 ± 0.5 SE	ANOVA: F = 7.9, p < 0.0005 (Healthy > ADCD, PDCD)
MMSE score	29.4 ± 0.1 SE	23.4 ± 0.6 SE	25.3 ± 0.5 SE	Kruskal-Wallis ANOVA: H = 65.2, p < 0.00001 (Healthy > ADCD, PDCD)

Table 1. Mean values (± SE) of the demographic and clinical data, as well as the results of their statistical comparisons ($p < 0.05$), in the groups of Healthy (N = 40) and patients with ADCD (N = 58) and PDCD (N = 54) diseases. Abbreviations: M/F = males/females; MMSE = Mini-Mental State Evaluation; SE = standard error of the mean. Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive

impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease; SE = standard error of the mean.

Table 2

Global SmartMe&You video games performance				
	Healthy	**ADCD**	**PDCD**	**Rank transformation ANCOVA**
Accuracy (%)	91.7 ± 1.1 SE	66.1 ± 2.6 SE	60.8 ± 2.8 SE	F = 29.3, p < 0.00001 (Healthy > ADCD > PDCD)
Reaction time (ms)	296 ± 10 SE	366 ± 12 SE	396 ± 13 SE	F = 10.2, p < 0.00001 (Healthy > ADCD > PDCD)

Table 2. Mean values (± SE) of the overall ("global") performance (percent accuracy and reaction time) on the serious video games of the SmartMe&You home telemonitoring platform in the Healthy, ADCD, and PDCD groups. The performance values were calculated as the average of the accuracy and reaction time across the seven serious video games. The results of the statistical comparisons (Rank transformation ANCOVA; $p < 0.05$) are also included. Age, education, and sex were used as covariates in the statistical models. Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease; SE = standard error of the mean.

Table 3

General linear models (GLMs) assessing the association between the global SmartMe&You video game performance and the global cognitive status				
Predictor: Global SmartMe&You video game performance	**Dependent variable: Global cognitive status**	**β standardized**	**t**	**p**
Accuracy	MMSE	0.541	7.96	< 0.00001
Reaction time		-0.282	-4.02	< 0.0001

Table 3. Results of general linear models (GLMs) assessing the association between the global performance (percent accuracy and reaction time as predictors) in the serious video game and the MMSE score, as a measure of the global cognitive status (i.e., MMSE score; dependent variable), in the Healthy, ADCD, and PDCD participants as a whole group ($p < 0.05$). Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease.

Figure 1

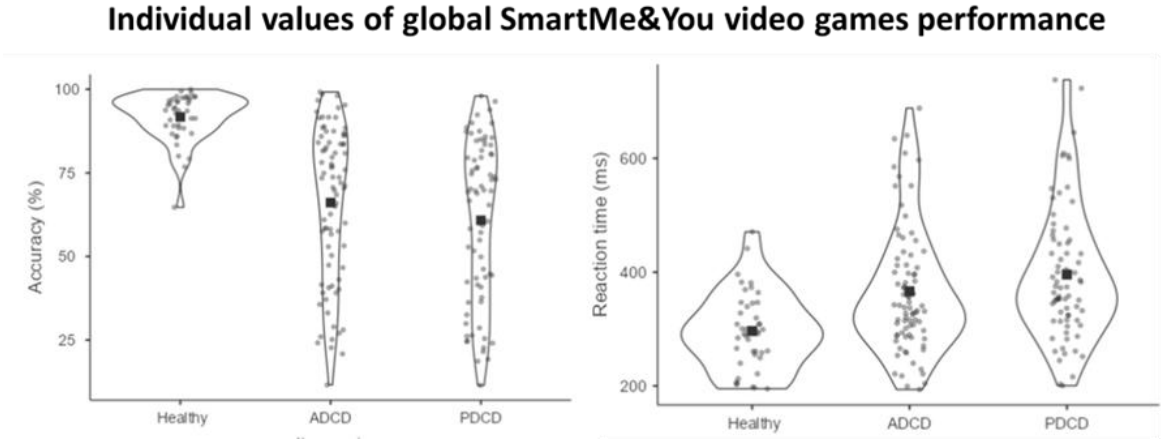

Figure 1. Individual values of the overall ("global") performance (percent accuracy and reaction time) in the serious video games of the SmartMe&You home telemonitoring platform in the Healthy, ADCD, and PDCD groups. Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive

impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease.

Figure 2

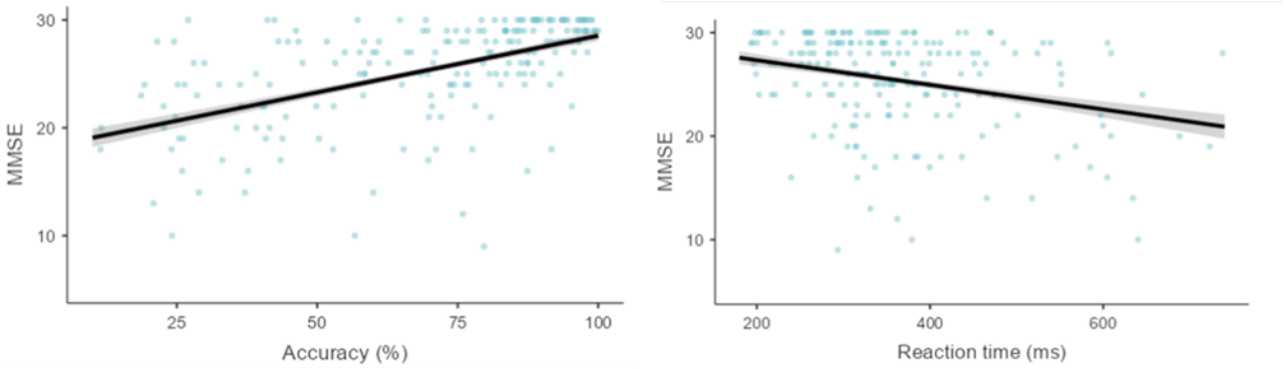

Figure 2. Scatterplots illustrating the association between overall ("global") performance (i.e., percent accuracy and response time to the seven serious video games) in the serious video games of the SmartMe&You home telemonitoring platform and the MMSE score in the Healthy, ADCD, and PDCD participants as a whole group (see Table 3 for more details). Abbreviations: MMSE = Mini-Mental State Evaluation; Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease.

RESTING-STATE ELECTROENCEPHALOGRAPHIC MARKERS ARE ASSOCIATED WITH THE PERFORMANCE ON THE SERIOUS VIDEO GAMES OF THE SMARTME&YOU HOME TELEMONITORING PLATFORM IN HEALTHY PARTICIPANTS AND PATIENTS WITH ALZHEIMER'S AND PARKINSON'S DISEASES

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Objective

The SmartMe&You serious videogames are part of a smart home telemonitoring platform (https://smartme.cloud.garr.it/) designed to monitor four key dementia risk factors over a one-week period in older adults at risk of cognitive impairment or already diagnosed with cognitive disorders in aging: (1) sedentary behavior, (2) dysfunctions in the autonomic system's regulation of heart rate dynamics over 24 hours, (3) night sleep quality, and (4) cognitive executive functions. The dementia risk factors in (1), (2), and (3) are

monitored using a smartwatch, while (4) is monitored using serious video games developed for commercial tablets by our Workgroup.

Here, we tested the validity of the SmartMe&You serious video games for assessing cognitive status in cognitively unimpaired older adults (Healthy) and patients with mild cognitive impairment and mild to moderate dementia due to Alzheimer's (ADCD) and Parkinson's (PDCD) diseases. The validity was assessed using the resting-state eyes-closed electroencephalographic (rsEEG) activity, which is typically abnormal in these patients, as the gold standard.

Materials and methods

As part of the Italian Rome Technopole (Italian Ministry of University), eBRAIN-Health (Horizon, European Commission), PREDICT-NEURODEGEN (Italian Ministry of Health), and TELEMAIA (Regione Lazio Innova) projects, clinical, demographic, and rsEEG datasets were collected from 32 Healthy, 39 ADCD, and 46 PDCD participants (Table 1). The participants received a clinical diagnosis according to international guidelines on the inclusion and exclusion criteria for individuals in clinical studies focused on ADCD and PDCD.

All participants participated in home telemonitoring for 1 week using the SmartMe&You platform. The SmartMe&You's serious video games included 7 unsupervised cognitive tasks implemented on a commercial tablet (see a short video demonstrating these serious video games at https://www.youtube.com/watch?v=wfBm7WxX_RY). They include two variants of a visual, simple reaction time task, three variants of Posner's visuo-spatial anticipatory attention task, an inhibition of return task, and a visual Go-NoGo task. All tasks were based on the same visual grid on the tablet screen, where cue and go stimuli were presented, and the participant had to provide a hand motor response as quickly and accurately as possible.

Fluid blood biomarkers, rsEEG (5 minutes with eyes closed) data, structural and functional magnetic resonance imaging, and clinical and neuropsychological data were collected in hospital settings. Participants and caregivers received training on the use of serious video games in hospital visits for clinical and neuropsychological assessment. The rsEEG data were processed using the EEGLAB toolbox. Artifact-free rsEEG activities were investigated in the individual delta (<4 Hz), theta (4-8 Hz), and alpha (8-12 Hz) bands, as well as the fixed beta (13-35 Hz) and gamma (35-40 Hz) bands. The eLORETA freeware was used to estimate cortical rsEEG sources (https://www.uzh.ch/keyinst/NewLORETA/Software/Software.htm). Statistical analyses were performed using the freeware tool Jamovi version 2.3.

Results

The large majority of the participants completed the seven serious video games of the SmartMe&You home telemonitoring platform, with performances worse in the ADCD and PDCD groups than in the Healthy group (Rank transformation ANCOVAs, $p < 0.01$; Table 2). As expected**,** compared to the Healthy group, the ADCD and PDCD groups exhibited widespread and abnormally greater rsEEG delta and theta source activities, as well as lower posterior rsEEG alpha source activities (ANCOVAs, $p < 0.001$; Figure 1). Notably, negative associations were observed between the rsEEG delta and theta source activities and the performance in the SmartMe&You serious video games in the Healthy, ADCD, and PDCD participants as a whole group (GLMs, $p < 0.001$; Table 3, Figures 2 and 3). The higher the rsEEG delta and theta source activities, the lower the performance in the SmartMe&You serious video games.

Table 1

DEMOGRAPHIC AND CLINICAL DATA				
	Healthy	ADCD	PDCD	Statistical analyses
N	32	39	46	-
Age (years)	68.6 ± 1.0 SE	77.1 ± 0.9 SE	73.7 ± 1.0 SE	ANOVA: F = 16.9, p < 0.0001 (Healthy > PDCD > ADCD)
Sex (M/F)	15/17	27/12	35/11	Chi-Square Test: Chi-Square = 16.9, p < 0.0001
Education (years)	15.0 ± 0.6 SE	10.0 ± 0.7 SE	11.3 ± 0.6 SE	ANOVA: F = 13.8, p < 0.05 (Healthy > PDCD, ADCD)
MMSE score	29.5 ± 0.1 SE	24.8 ± 0.7 SE	27.1 ± 0.3 SE	Kruskal-Wallis ANOVA: H = 48.7, p < 0.0001 (Healthy > PDCD, ADCD)

Table 1. Mean values (± SE) of the demographic and clinical data, as well as the results of their statistical comparisons ($p < 0.05$), in the groups of Healthy participants (N = 32) and those of ADCD (N = 39) and PDCD (N = 39) patients. Abbreviations: M/F = males/females; MMSE = Mini-Mental State Evaluation; Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease; SE = standard error of the mean; n.s. = not significant ($p > 0.05$).

Table 2

Performance of overall ("global") SmartMe&You serious video games performance				
	Healthy	ADCD	PDCD	Rank transformation ANCOVA
Accuracy (%)	92.3 ± 1.2 SE	69.0 ± 3.4 SE	67.3 ± 3.3 SE	F = 15.9, p < 0.0001 (Healthy > PDCD, ADCD)
Response time (ms)	286 ± 22 SE	383 ± 20 SE	386 ± 18 SE	F = 11.6, p < 0.001 (Healthy < PDCD, ADCD)

Table 2. Mean values (± SE) of the overall ("global") performance (percent accuracy and reaction time as predictors) on the serious video game of the SmartMe&You platform in the Healthy, ADCD, and PDCD groups. The results of the statistical comparisons (Rank transformation ANCOVA; $p < 0.05$) are also included. Age, education, and sex were used as covariates. Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease.

Conclusions

It is well known that ADCD and PDCD patients exhibit widespread and abundant rsEEG rhythms at delta (<4 Hz) and theta frequencies (4-7 Hz) during quiet wakefulness. These abnormal rhythms reflect pathological brain oscillatory synchronization mechanisms at those frequencies, underpinning abnormal cortical arousal, interfering with information processing, and affecting the ability to maintain an adequate level of vigilance during the daytime. The present study demonstrated an association between poor performance in the SmartMe&You serious video games and rsEEG delta and theta source activities in patients with ADCD and PDCD compared to Healthy participants. It is concluded that the serious video games of the SmartMe&You home telemonitoring platform may be a useful, practical, free, "green", and unsupervised tool for evaluating the cognitive status and decline not only in patients with ADCD and PDCD in the framework of tertiary prevention, but also in healhty older with intact cognition but risk to develop cognitive decline due to several dementia risk factors and frailty.

Table 3

General linear models (GLMs) assessing the association between the rsEEG markers and the overall ("global") SmartMe&You performances				
Predictor: rsEEG markers	Dependent variable: Overall ("global") SmartMe&You performance	β standardized	t	p
Global delta	Accuracy	-0.42	-5.2	< 0.00001
	Reaction time	0.29	3.3	< 0.005
Parietal delta	Accuracy	-0.35	-4.1	< 0.0001
	Reaction time	0.27	2.9	< 0.005
Occipital delta	Accuracy	-0.30	-3.6	< 0.001
	Reaction time	0.19	2.1	< 0.05
Parietal theta	Accuracy	-0.35	-4.3	< 0.0001
	Reaction time	0.19	2.1	< 0.05
Occipital alpha 3	Accuracy	-0.19	-2.1	< 0.05
	Reaction time	0.06	0.7	> 0.4

Table 3. Results of general linear models (GLMs) assessing the association between the rsEEG markers (i.e., global delta, parietal delta, occipital delta, parietal theta, and occipital alpha 3; predictors) and the overall ("global") performance (percent accuracy and reaction time as predictors) on the serious video games of the SmartMe&You platform in the Healthy, ADCD, and PDCD participants as a whole group. Age, education, and sex were used as covariates. Standardized beta, t, and p values are reported. Values at $p < 0.05$ Bonferroni corrected ($p = 0.05/10 = 0.005$) are reported in red bold. Values at $p < 0.05$ uncorrected are reported in bold. Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease.

Figure 1

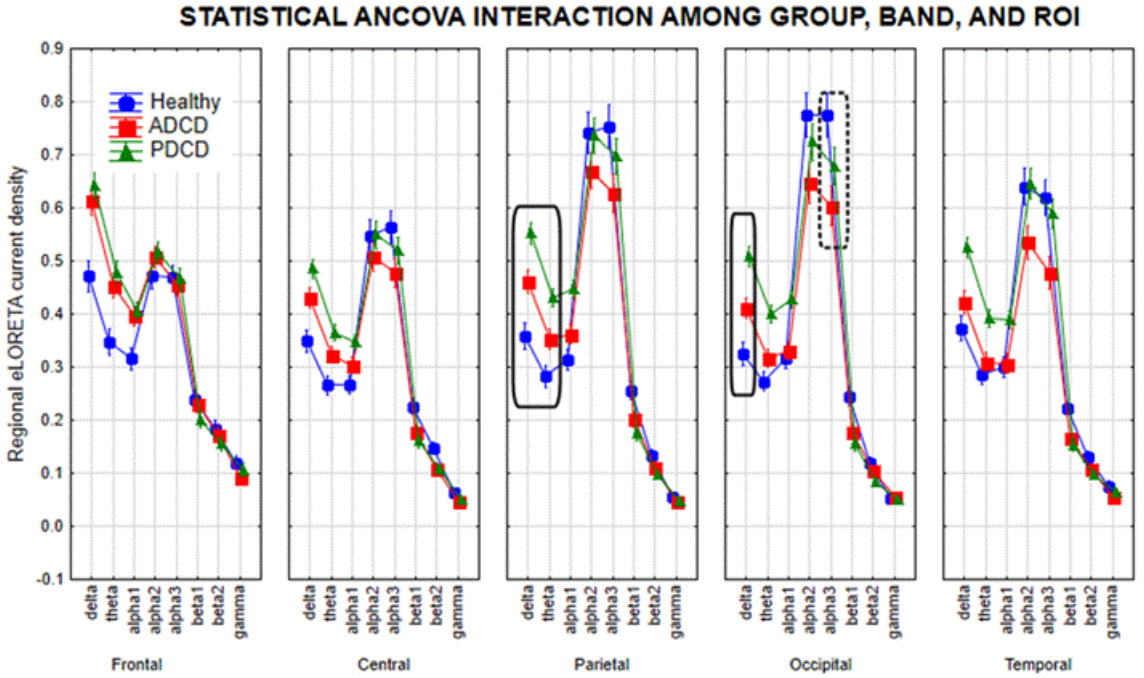

Figure 1. Mean values (± SE; log 10 transformed) of the regional rsEEG source activities relative to a statistical ANCOVA interaction effect ($F = 1.6, < 0.001$) among the factors Group (Healthy, ADCD, PDCD), Band (delta, theta, alpha1, alpha2, alpha3, beta1, beta2, and gamma), and ROI (frontal, central, parietal, occipital, and temporal). Age, education, and sex were used as covariates. The rsEEG recordings were performed with eyes closed for approximately 5 minutes. The rectangles indicate the frequency bands and ROIs in which the rsEEG source activities statistically presented a significant pattern, as indicated by the following comparisons: Healthy ≠ ADCD ≠ PDCD (i.e., $p < 0.05$, Bonferroni corrected). Abbreviations: ROI = region of interest; rsEEG = resting state electroencephalographic; eLORETA = exact Low-Resolution Brain Electromagnetic Source Tomography; Healthy = cognitively unimpaired older adults; ADCD = patients with

mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease.

Figure 2

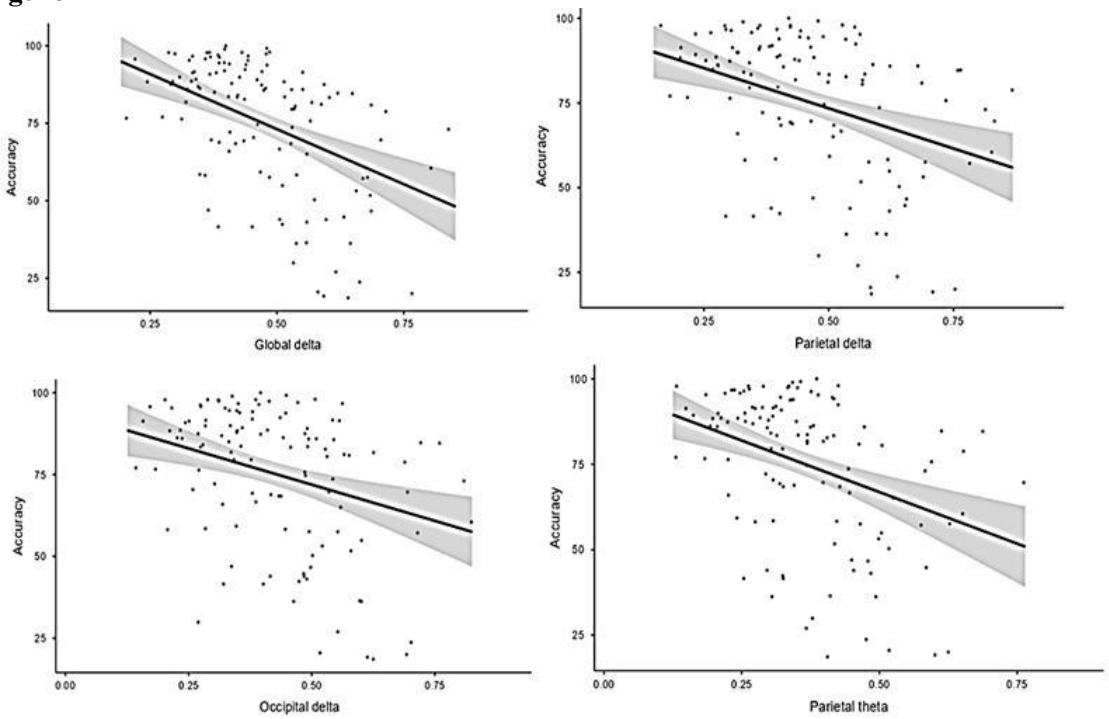

Figure 2. Scatterplots showing the negative association between the rsEEG source activity in slow frequency bands (i.e., global delta, parietal delta, occipital delta, and parietal theta) and the overall ("global") accuracy (%) in the performance (percent accuracy) in the serious video game of the SmartMe&You platform in the Healthy, ADCD, and PDCD participants as a whole group. Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease; rsEEG = resting state electroencephalographic.

Figure 3

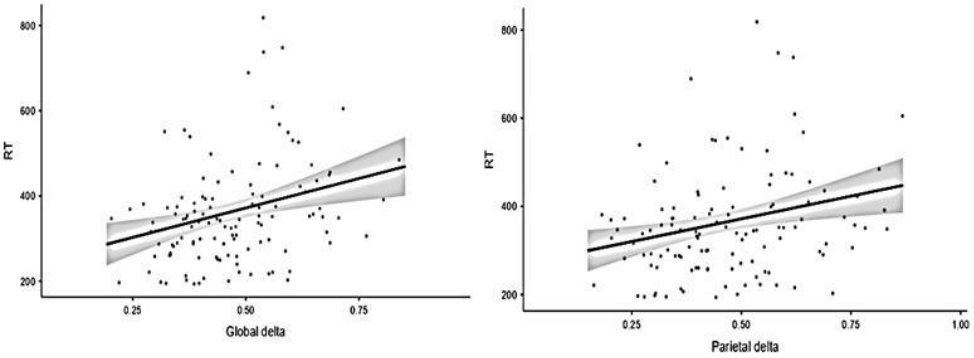

Figure 3. Scatterplots showing the association between the rsEEG source activity in slow frequency bands (i.e., global delta and parietal delta) and the overall ("global") performance (reaction time, RT) on the serious video game of the SmartMe&You platform in the Healthy, ADCD, and PDCD participants as a whole group. Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease; rsEEG = resting state electroencephalographic.

ASSOCIATION BETWEEN SLEEPINESS, SLEEP QUALITY, AND RESTING-STATE ELECTROENCEPHALOGRAPHIC ACTIVITY IN PATIENTS WITH COGNITIVE DEFICITS DUE TO ALZHEIMER'S AND PARKINSON'S DISEASES

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Objective

Patients with mild cognitive deficits and mild-moderate dementia due to Alzheimer's (ADCD) and Parkinson's (PDCD) diseases may show poor sleep quality and excessive daytime sleepiness. They may also exhibit abnormally high delta (<4 Hz), high theta (4-7 Hz), and low alpha (8-12 Hz) power density in widespread scalp regions, computed from resting-state eyes-closed electroencephalographic (rsEEG) rhythms. Here, we hypothesized that the sleep quality and excessive daytime sleepiness of these patients, measured with clinical scales, may be associated with abnormalities in rsEEG activity, suggesting that the neuropathology of these diseases affects the neurophysiological oscillatory mechanisms underlying both quiet vigilance during the daytime and nighttime sleep.

Materials and methods

As part of the Italian Rome Technopole (Italian Ministry of University), eBRAIN-Health (Horizon, European Commission), PREDICT-NEURODEGEN (Italian Ministry of Health), and TELEMAIA (Regione Lazio Innova) projects, clinical, demographic, and rsEEG data were recorded from 38 Healthy, 32 ADCD, and 47 PDCD participants (Table 1). The participants received a clinical diagnosis according to international guidelines on the inclusion and exclusion criteria for individuals in clinical studies focused on ADCD and PDCD.

Standard material and equipment, including sleep and sleepiness questionnaires, were used. Total scores were obtained for the Pittsburgh Sleep Quality Index (PSQI) and the Epworth Sleepiness Scale (ESS), which measure perceived sleep quality and daytime sleepiness, respectively. EEG data were processed using the EEGLAB toolbox.

Fluid blood biomarkers, rsEEG data (approximately 5 minutes with eyes closed), structural and functional magnetic resonance imaging, and clinical and neuropsychological data were collected in hospital settings. Participants and caregivers received training on the use of serious video games in hospital visits for clinical and neuropsychological assessment. The rsEEG data were processed using the EEGLAB toolbox. Artifact-free rsEEG activities were investigated in the individual delta (<4 Hz), theta (4-8 Hz), and alpha (8-12 Hz) frequency bands, as well as the fixed beta (13-35 Hz) and gamma (35-40 Hz) bands. The eLORETA freeware was used to estimate cortical rsEEG sources (https://www.uzh.ch/keyinst/NewLORETA/Software/Software.htm). Statistical analyses were performed using the freeware tool Jamovi version 2.3.

Results

Compared to the Healthy group, the ADCD and PDCD groups showed: (1) higher scores in PSQI and ESS clinical scales as indexes of poor sleep quality and excessive daytime sleepiness (Rank transformation ANCOVAs, $p < 0.05$; Table 2 and Figure 1); (2) abnormally greater and widespread rsEEG delta and theta activities and lower posterior rsEEG alpha activities (ANCOVAs, $p<0.01$; Figure 2). Moreover, consistent with our hypotheses, positive associations were observed between rsEEG delta and theta source activities and daytime sleepiness (ESS score) in the Healthy, ADCD, and PDCD participants considered as a whole group (General linear models, GLMs, $p < 0.05$; Table 3 and Figure 3). The higher the (abnormal) rsEEG delta and theta source activities, the higher the scores indicating greater daytime sleepiness.

Conclusions

The present results suggest that the neurophysiological synchronization mechanisms of brain neural activity at delta and theta frequencies (< 7 Hz) in quiet wakefulness may reflect dysfunctions in cortical arousal and vigilance associated with excessive daytime sleepiness in patients with ADCD and PDCD. A study in progress is investigating whether rsEEG activities may be associated with exaggerated morning naps and sleep fragmentation in patients with ADCD-PDCD, as revealed by 24-hour home telemonitoring using actigraphy.

The study supports the thesis that patients with ADCD and PDCD may exhibit significant abnormalities in the regulation of their wake-sleep cycle, as reflected in rsEEG recordings during the day. The study findings lay the groundwork for a prospective investigation of rsEEG slow-frequency rhythms and their relationships with cognitive functioning and daytime sleepiness, utilizing SmartMe&You home telemonitoring platforms in patients with ADCD and PDCD.

Table 1

DEMOGRAPHIC AND CLINICAL DATA				
	Healthy	ADCD	PDCD	Statistical analyses
N	38	32	47	-
Age (years)	68.9 ± 0.8 SE	75.8 ± 1.1 SE	74.5 ± 1.0 SE	ANOVA: F = 13.9, p < 0.0001 (Healthy > PDCD > ADCD)
Sex (M/F)	18/20	17/15	37/10	Chi-Square Test: F = 8.1, p < 0.0001
Education (years)	14.6 ± 0.6 SE	10.7 ± 1.0 SE	11.3 ± 0.7 SE	ANOVA: Chi-Square = 13.8, p < 0.05 (Healthy > PDCD, ADCD)
MMSE score	29.2 ± 0.2 SE	22.7 ± 1.2 SE	26.1 ± 0.5 SE	Kruskal-Wallis ANOVA: H = 35.7, p < 0.0001 (Healthy > PDCD, ADCD)

Table 1. Mean values (± SE) of the demographic and clinical data, as well as the results of their statistical comparisons ($p < 0.05$), in the groups of Healthy participants (N = 38) and patients with ADCD (N = 32) and PDCD (N = 47). Abbreviations: M/F = males/females; MMSE = Mini-Mental State Evaluation; Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease; SE = standard error of the mean.

Table 2

Sleep quality and daytime sleepiness				
	Healthy	ADCD	PDCD	Rank transformation ANCOVA
Pittsburgh Sleep Quality Index	4.8 ± 0.5 SE	6.4 ± 0.6 SE	7.5 ± 0.5 SE	F = 9.2, p < 0.0005 (Healthy < ADCD, PDCD)
Epworth Sleepiness Scale	5.0 ± 0.5 SE	6.1 ± 0.6 SE	9.1 ± 0.6 SE	F = 5.6, p < 0.005 (Healthy, ADCD < PDCD)

Table 2. Mean values (± SE) of the Pittsburgh Sleep Quality Index (PSQI) and the Epworth Sleepiness Scale (ESS), which measure, respectively, sleep quality and daytime sleepiness in the Healthy, ADCD, and PDCD

groups. The results of the statistical comparisons (Rank transformation ANCOVA; $p < 0.05$) are also included. Age, education, and sex were used as covariates. Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease; SE = standard error of the mean.

Table 3

General linear models (GLMs) assessing the association between the daytime sleepiness/sleep quality and the rsEEG markers				
Predictor: Daytime sleepiness/Sleep quality	**Dependent variable: rsEEG marker**	**β standardized**	**t**	**p**
Epworth Sleepiness Scale (ESS)	Global delta	**0.27**	**3.0**	**< 0.004**
	Parietal delta	**0.27**	**3.1**	**< 0.004**
	Occipital delta	**0.23**	**2.5**	**< 0.01**
	Temporal delta	**0.24**	**2.6**	**< 0.01**
	Parietal theta	**0.30**	**3.4**	**< 0.001**
	Occipital alpha2	-0.12	-1.2	> 0.2
	Parietal alpha3	-0.09	-0.8	> 0.3
	Occipital alpha3	-0.11	-1.6	> 0.1
Pittsburgh Sleep Quality Index (PSQI)	Global delta	0.17	1.8	> 0.05
	Parietal delta	0.17	1.8	> 0.05
	Occipital delta	**0.19**	**2.0**	**< 0.05**
	Temporal delta	0.17	1.8	> 0.05
	Parietal theta	0.11	1.2	> 0.2
	Occipital alpha2	-0.03	-0.3	> 0.7
	Parietal alpha3	-0.04	-0.5	> 0.6
	Occipital alpha3	-0.07	-0.7	> 0.4

Table 3. Results of general linear models (GLMs) assessing the association between the daytime sleepiness (i.e., Epworth Sleepiness Scale, ESS)/sleep quality (Pittsburgh Sleep Quality Index, PSQI; predictors) and the rsEEG markers (i.e., global delta, parietal delta, occipital delta, temporal delta, parietal theta, occipital alpha 2, parietal alpha3, and occipital alpha 3; dependent variables) in the Healthy, ADCD, and PDCD participants as a whole group. Age, education, and sex were used as covariates. Standardized beta, t, and p values are reported. Values at $p < 0.05$ Bonferroni corrected ($p = 0.05/8 = 0.00625$) are reported in red bold. Values at $p < 0.05$ are reported in bold. Abbreviations: rsEEG = resting state electroencephalographic; Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease.

Figure 1

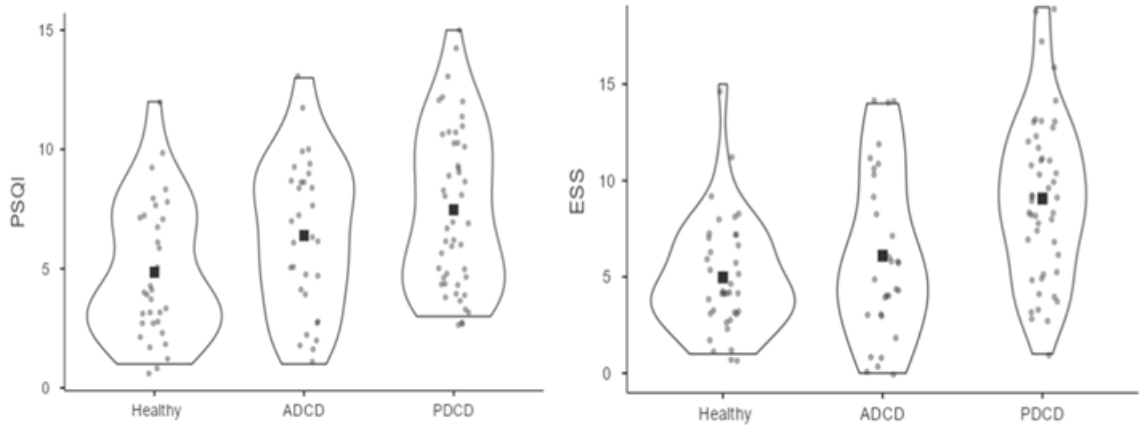

Figure 1. Individual values of the Pittsburgh Sleep Quality Index (PSQI) and the Epworth Sleepiness Scale (ESS) in the Healthy, ADCD, and PDCD groups. Abbreviations: Healthy = cognitively unimpaired older

adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease.

Figure 2

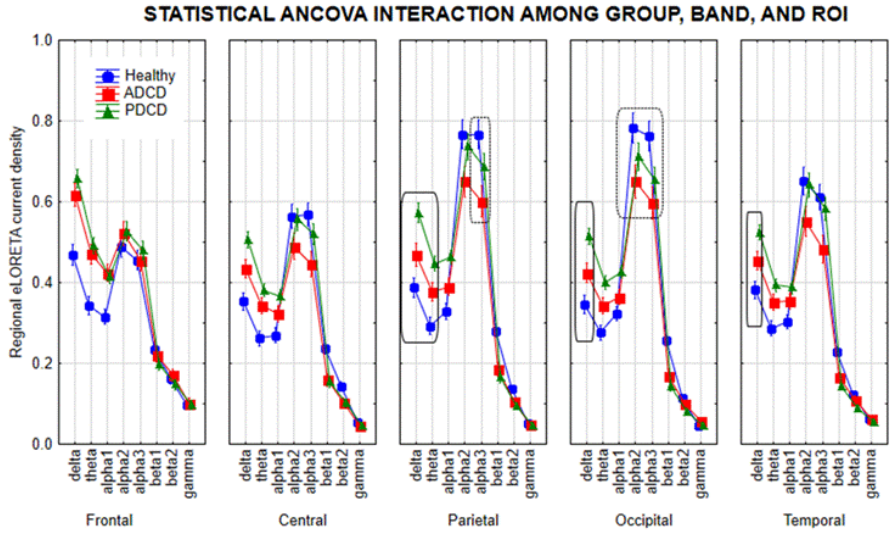

Figure 2. Mean values (± SE; log 10 transformed) of the regional rsEEG source activities relative to a statistical ANCOVA interaction effect (F = 1.8, < 0.0001) among the factors Group (Healthy, ADCD, PDCD), Band (delta, theta, alpha1, alpha2, alpha3, beta1, beta2, and gamma), ROI (frontal, central, parietal, occipital, and temporal). Age, education, and sex were used as covariates. The rsEEG recordings lasted approximately 5 minutes with eyes closed. The rectangles indicate the frequency bands and ROIs in which the rsEEG source activities statistically presented a significant pattern, as indicated by the following comparisons: Healthy ≠ ADCD ≠ PDCD (i.e., $p < 0.05$, Bonferroni corrected). Abbreviations: rsEEG = resting state electroencephalographic; eLORETA = exact Low-Resolution Brain Electromagnetic Source Tomography; Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease.

Figure 3

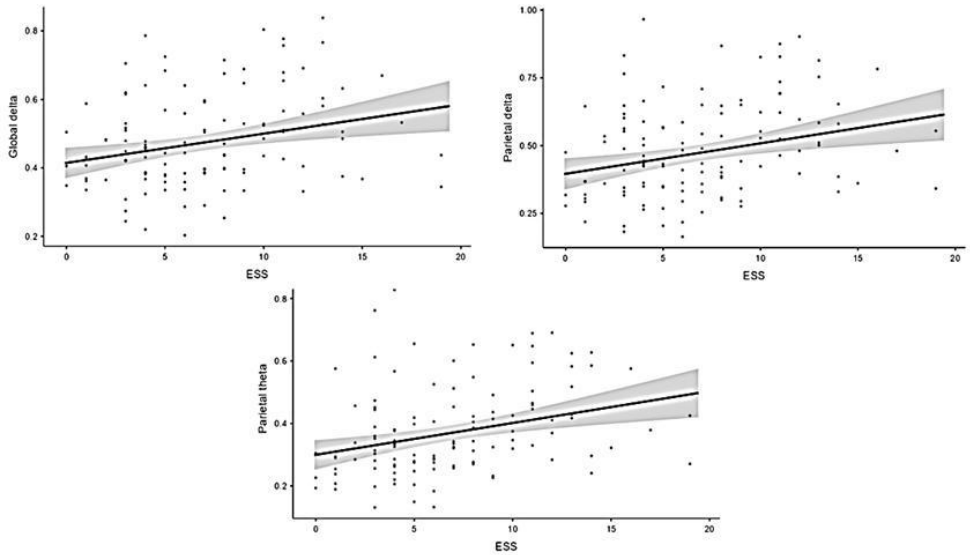

Figure 3. Scatterplots showing the association between the daytime sleepiness (i.e., Epworth Sleepiness Scale, ESS) and the rsEEG source activity (i.e., global delta, parietal delta, and parietal theta) in the Healthy, ADCD, and PDCD participants as a whole group. Abbreviations: Healthy = cognitively unimpaired older

adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease.

SMARTME&YOU HOME TELEMONITORING PLATFORM UNVEILS LOWER DAILY STEPS ASSOCIATED WITH COGNITIVE PERFORMANCE IN UNSUPERVISED SERIOUS VIDEO GAMES IN PATIENTS WITH COGNITIVE DEFICITS DUE TO ALZHEIMER'S AND PARKINSON'S DISEASES

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Objective

Sedentariness is a risk factor for cognitive decline in aging. Daily steps and serious video game performance may be optimal markers to quantify this risk. This study used the SmartMe&You home telemonitoring platform (https://smartme.cloud.garr.it/) to assess daily step count and cognitive performance in patients with mild cognitive impairment (MCI) and mild-moderate dementia due to Alzheimer's disease (ADCD) and patients with MCI and mild-moderate dementia due to Parkinson's disease (PDCD).

Materials and methods

As part of the Italian Rome Technopole (Italian Ministry of University), eBRAIN-Health (Horizon, European Commission), PREDICT-NEURODEGEN (Italian Ministry of Health), and TELEMAIA (Regione Lazio Innova) projects, sixteen healthy older adults (Healthy; mean age=70.1±6.7, 10 women), 52 MCI patients (mean age=73.3±7.1, 21 women; 27 ADCD, 25 PDCD), and 38 patients with dementia (DEM, mean age=75.0±7.3, 10 women; 17 ADCD, 21 PDCD) participants were enrolled (Table 1). The participants received a clinical diagnosis according to international guidelines on the criteria for inclusion and exclusion of individuals in clinical studies focused on ADCD and PDCD.
Fluid blood biomarkers, resting-state electroencephalographic data, structural and functional magnetic resonance imaging, and clinical and neuropsychological data were collected in hospital settings.
All participants were involved in the home telemonitoring for one week with the SmartMe&You platform. The SmartMe&You's serious video games included 7 unsupervised cognitive tasks implemented on a commercial tablet (see a short video demonstrating these serious video games at https://www.youtube.com/watch?v=wfBm7WxX_RY). They implemented two variants of a visual, simple reaction time task, three variants of Posner's visuo-spatial anticipatory attention task, an inhibition of return task, and a visual Go-NoGo task. All tasks were based on the same visual grid in the tablet screen, where cue and go stimuli were presented, and the participant had to provide a hand motor response as accurately and quickly as possible. Participants and caregivers received training on the use of serious video games in hospital visits for clinical and neuropsychological assessment.

Daily step counts over a one-week period were recorded using a commercial Samsung Galaxy Watch 6 smartwatch, and global cognitive status was evaluated in the statistical models using the Mini-Mental State Examination (MMSE). Average daily step counts and mean videogame accuracy scores were calculated. Exploratory statistical analyses were performed using the freeware jamovi (v2.3), with significance set at $p < 0.05$. Group comparisons (Healthy vs. MCI vs. DEM; Healthy vs. ADCD vs. PDCD) were conducted via ANCOVA, controlling for age, sex, and education. Pearson's partial correlations (controlling for age, sex, and education) assessed associations among step count, MMSE scores, and videogame performance in the ADCD and PDCDCS patients as a whole. Figure 1 illustrates the home telemonitoring devices.

Results

Compared to the Healthy group (mean daily steps, S = 6494.6), both MCI (S = 4818) and DEM (S = 2753) groups showed lower daily steps ($p < 0.001$). Similarly, ADCD (S = 4427) and PDCD (S = 3486) groups had reduced step counts (Figures 2 and 3). Daily steps were also significantly associated with the global SmartMe&You serious videogame performance (accuracy %) in the ADCD and PDCD patients combined ($r = 0.44$, $p < 0.001$).

Conclusions

These results indicate that SmartMe&You home telemonitoring measures of sedentary behavior, as captured by daily step counts, are associated with the ADCD and PDCD status. Furthermore, they are associated with cognitive performance reflecting sustained visual attention and motor speed in these patients. The SmartMe&You home telemonitoring platform provides practical and sensitive methods for evaluating cognitive function and global motor activity (sedentary dementia risk) in patients with ADCD and PDCD. It can be used for "green" and cost-effective primary and tertiary prevention, respectively, in cognitively unimpaired elderly as well as in patients with cognitive decline due to ADCD and PDCD.

	Healthy (n = 16)	PDCD (n = 46)	ADCD (n = 44)	Statistical test
Age (years)	70.1 ± 6.7	74.1 ± 7.3	73.9 ± 7.2	ANOVA: n.s.
Sex (M/F)	6/10	35/11	24/20	χ^2 test: $p < 0.05$
Education (years)	14.0 ± 5.0	11.2 ± 4.6	12.5 ± 5.6	*t*-test: $p < 0.05$
MMSE score	29.1 ± 0.9	24.9 ± 3.9	22.3 ± 5.6	Mann-Whitney test: $p < 0.001$

Table 1

Table 1. Mean values (± SE) of the Demographic information and clinical data of Healthy, PDCD, and ADCD participants. Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease; SE = standard error of the mean.

Figure 1

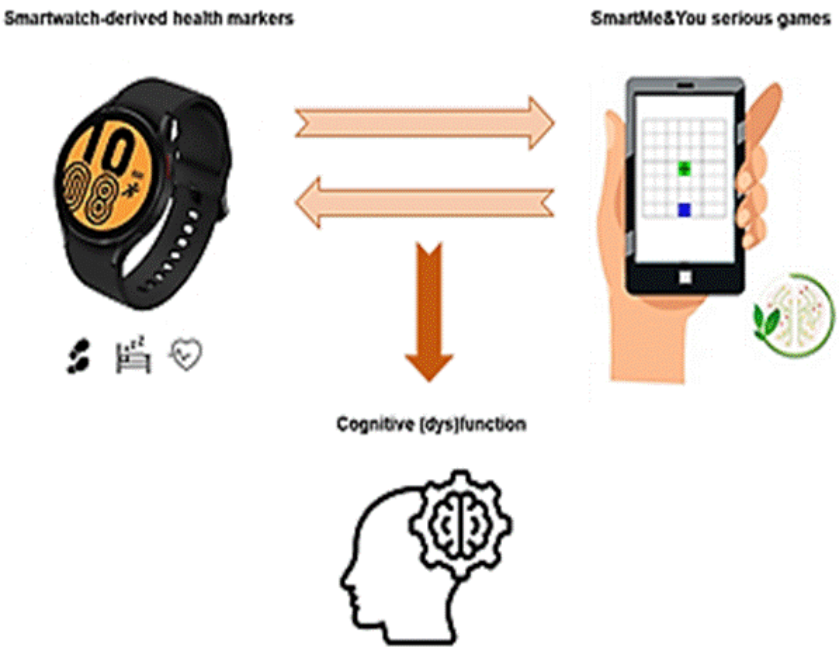

Figure 1. Conceptual outline and rationale of the SmartMe&You home telemonitoring platform. The serious video games of the SmartMe&You platform included 7 unsupervised cognitive tasks implemented on a commercial tablet (see a short video demonstrating these serious video games at https://www.youtube.com/watch?v=wfBm7WxX_RY). Daily step counts were recorded over 1 week using a Samsung Galaxy Watch 6.

Figure 2

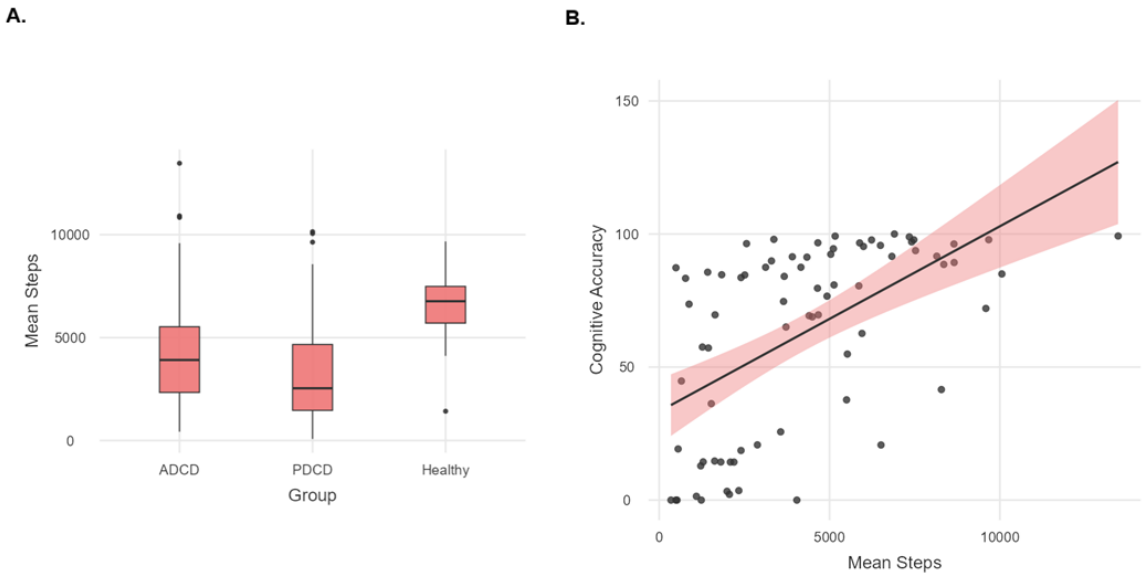

Figure 2. (A) Daily mean step counts for Healthy, ADCD, and PDCD participants. (B) Scatterplot showing the relationship between the global accuracy score (%) in the SmartMe&You serious games and the mean daily steps. Daily step counts were measured using Samsung Galaxy Watch 4-6 smartwatches over a 1-week period of home telemonitoring with the SmartMe&You platform. Abbreviations: Healthy = cognitively unimpaired older adults; AD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease; SE = standard error of the mean.

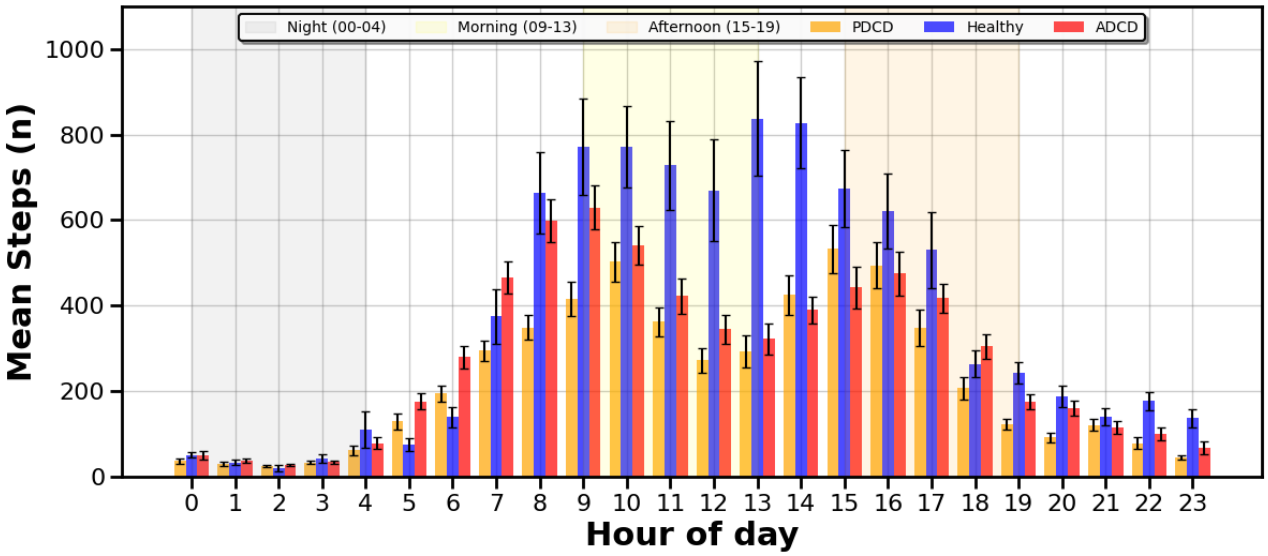

Figure 3. (A) Daily mean (± standard error) step counts for Healthy, ADCD, and PDCD participants, hour by hour in 24 hours. Daily step counts were measured using Samsung Galaxy Watch 4-6 smartwatches over 1 week of home telemonitoring with the SmartMe&You platform. Abbreviations: Healthy = cognitively unimpaired older adults; AD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease; SE = standard error of the mean.

EEG AND SMARTME&YOU HOME TELEMONITORING PLATFORM: INTEGRATING DATA FROM DAILY STEPS, COGNITIVE FUNCTIONS, AND RESTING-STATE EEG IN OLDER ADULTS WITH COGNITIVE IMPAIRMENT DUE TO ALZHEIMER'S AND PARKINSON'S DISEASES

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Objective

Sedentary behavior and poor cognitive performance in frontal executive tasks are recognized risk factors for cognitive decline in aging. Therefore, home telemonitoring of daily steps and serious video game performance for a few days may serve as ecologically valid proxies of cognitive status in older individuals at risk of or with cognitive deficits. Along this line, this study utilized the SmartMe&You home telemonitoring platform (https://smartme.cloud.garr.it/) to investigate daily motor activity (daily steps) comparatively and performance in serious video games based on frontal executive functions and working memory in older adults without

cognitive impairment (Healthy) and patients with mild cognitive impairment due to Alzheimer's (ADCD) and Parkinson's (PDCD) diseases. These measures were validated using the Mini-Mental State Examination (MMSE) as a measure of global cognitive status and spectral measures of resting-state electroencephalographic (rsEEG) activity, which reflect the brain's neurophysiological oscillatory mechanisms underlying vigilance regulation.

Materials and methods

As part of the Italian Rome Technopole (Italian Ministry of University), eBRAIN-Health (Horizon, European Commission), PREDICT-NEURODEGEN (Italian Ministry of Health), and TELEMAIA (Regione Lazio Innova) projects, clinical, demographic, and rsEEG data were recorded from a cohort of 64 patients with cognitive impairment due to Alzheimer's disease (ADCD, N = 26) and Parkinson's disease (PDCD, N = 38), and 17 Healthy individuals (Table 1). These participants received a clinical diagnosis in accordance with international guidelines for participant inclusion and exclusion criteria in clinical studies focused on patients with ADCD and PDCD. Fluid blood biomarkers, rsEEG activity (approximately 5 minutes with eyes closed), structural and functional magnetic resonance imaging, and clinical and neuropsychological data were collected in hospital settings.
The rsEEG data were processed using the EEGLAB toolbox. Artifact-free rsEEG activities were investigated in the individual delta (<4 Hz), theta (~4-8 Hz), and alpha (~8-12 Hz) frequency bands, as well as the fixed beta (13-35 Hz) and gamma (35-40 Hz) bands. The eLORETA freeware was used to estimate cortical rsEEG sources (https://www.uzh.ch/keyinst/NewLORETA/Software/Software.htm). Statistical analyses were performed using the freeware tool Jamovi version 2.3.
All participants participated in home telemonitoring for 1 week using the SmartMe&You platform. The SmartMe&You's serious video games included 7 unsupervised cognitive tasks implemented on a commercial tablet (see a short video demonstrating these serious video games at https://www.youtube.com/watch?v=wfBm7WxX_RY). They implemented two variants of a simple visual reaction-time task, three variants of Posner's visuo-spatial anticipatory attention task, an inhibition-of-return task, and a visual Go-NoGo task. All tasks were based on the same visual grid on the tablet screen, where cue and go stimuli were presented, and the participant had to provide a hand motor response as quickly and accurately as possible. Participants and caregivers received training on the use of serious video games in hospital visits for clinical and neuropsychological assessment.
Daily step counts were recorded over 1 week (mean days: 7.5 ± 1.2) using a Samsung Galaxy Watch 6. Average daily step counts and mean videogame accuracy scores were calculated. The global cognitive status for the statistical models was evaluated using the MMSE score. Group comparisons (Healthy vs. ADCD vs. PDCD) were conducted via ANCOVA, controlling for age, sex, and education. Pearson's partial correlations (controlling for age, sex, and education) assessed associations among step count, MMSE scores, and SmartMe&You videogame performance in the ADCD and PDCD patients combined.

Results

Figures 1 and 2 illustrate the results**.** Compared to the Healthy participants (mean age: 69.4 ± 5.5, 9 women), patients with ADCD (mean age: 75.6 ± 5.8, 11 women) and PDCD (mean age: 74.5 ± 7.2, 11 women) showed lower step counts (Healthy: 6744.1, ADCD: 4331.8, PDCD: 3015.5; $p < 0.001$, $\eta^2 = 0.19$) and game accuracy ($p = 0.005$, $\eta^2 = 0.13$). Patients (both ADCD and PDCD) also exhibited higher global rsEEG delta ($p < 0.001$, $\eta^2 = 0.18$) and theta ($p < 0.001$, $\eta^2 = 0.17$), and slower individual alpha frequency (IAF; $p < 0.001$, $p < 0.001$, $\eta^2 = 0.19$) compared to the Healthy group. Step count was significantly correlated with global delta ($r = -0.52$, $p < 0.001$), global theta ($r = -0.44$, $p < 0.001$), and IAF ($r = 0.48$, $p < 0.001$) in the ADCD+PDCD group, but not in the Healthy group.

Conclusions

This exploratory study highlights behavioral and neurophysiological alterations in older adults with cognitive decline due to two highly prevalent neurodegenerative diseases, such as ADCD and PDCD. These alterations could be investigated through SmartMe&You home telemonitoring for one week and standard, cost-effective rsEEG recordings in a hospital setting. Reduced general mobility (steps) and poor cognitive performance in the serious video games were associated with a slowing of rsEEG rhythms recorded in quiet wakefulness in those ADCD and PDCD patients. These findings suggest that early disruptions in cortical arousal regulation occur in both diseases from the early stages of cognitive impairment. Therefore, the SmartMe&You home telemonitoring platform and rsEEG recordings in hospital settings can collect clinically relevant information on dementia risk factors and brain dysfunctions in the regulation of quiet vigilance in older individuals with cognitive decline of different etiologies (ADCD and PDCD), providing an important perspective for tertiary prevention in these individuals. The present methodological approach is also promising for primary prevention in older individuals with intact cognition but significant dementia risk factors.

Table 1

	ADCD (N = 26)	**PDCD (N = 38)**	**Healthy (N = 17)**	**Statistical test**
Age (years)	75.6 ± 5.8	74.5 ± 7.2	69.4 ± 5.5	ANOVA: $p < 0.01$
Sex (M/F)	15/11	27/11	8/9	χ^2 test: n.s.
Education (years)	10.8 ± 4.4	11.2 ± 4.5	14.4 ± 4.8	ANOVA: $p < 0.05$
MMSE score	24.0 ± 6.5	26.2 ± 3.4	29.2 ± 1.0	Kruskal-Wallis test: $p < 0.001$

Table 1. Demographic and clinical characteristics of Healthy (N = 17), ADCD (N = 26), and PDCD (N = 38) participants in the present study who participated in the SmartMe&You home monitoring of daily steps and cognitive functions. Abbreviations: ADCD: cognitive decline due to Alzheimer's disease; Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease; SE = standard error of the mean; MMSE: Mini-Mental State Examination.

Figure 1

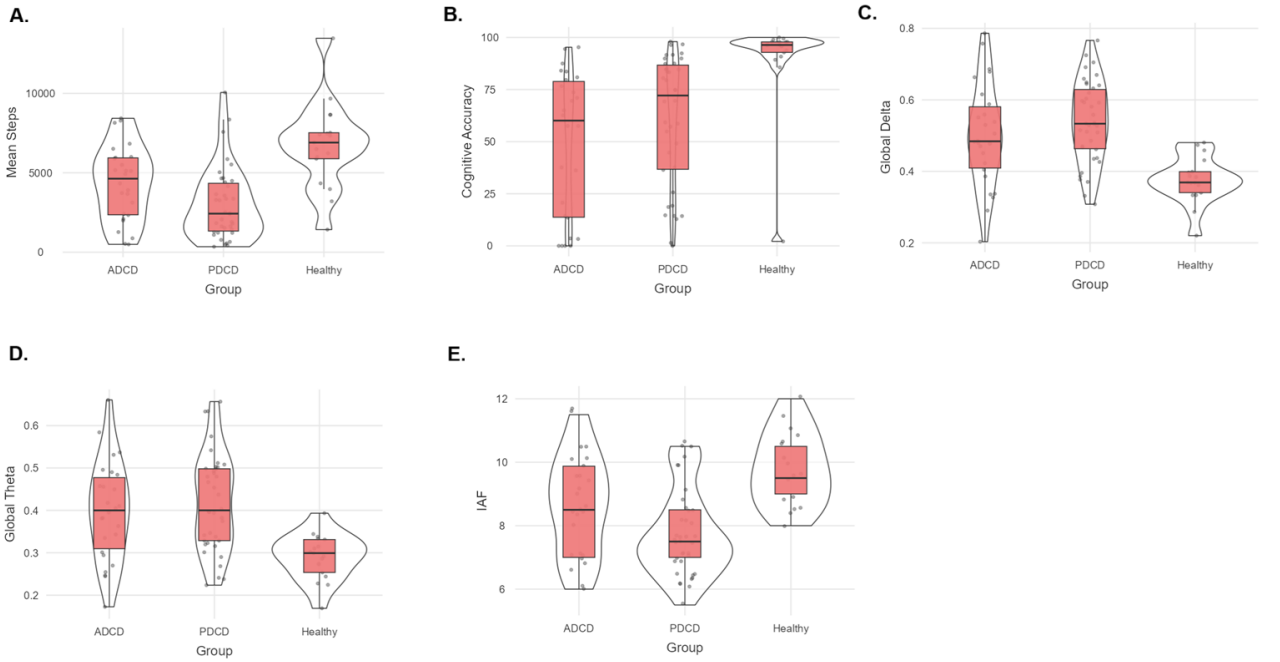

Figure 1. (A) Mean daily step counts, (B) global percentage accuracy (%) of the cognitive performance computed by averaging the accuracy over seven serious video games of the SmartMe&You platform, (C) global rsEEG delta (< 4 Hz) and (D) theta (~ 4-7 Hz) source activities, and (E) individual alpha frequency (IAF) peak from rsEEG source activity in Healthy, ADCD, and PDCD participants. Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease.

Figure 2

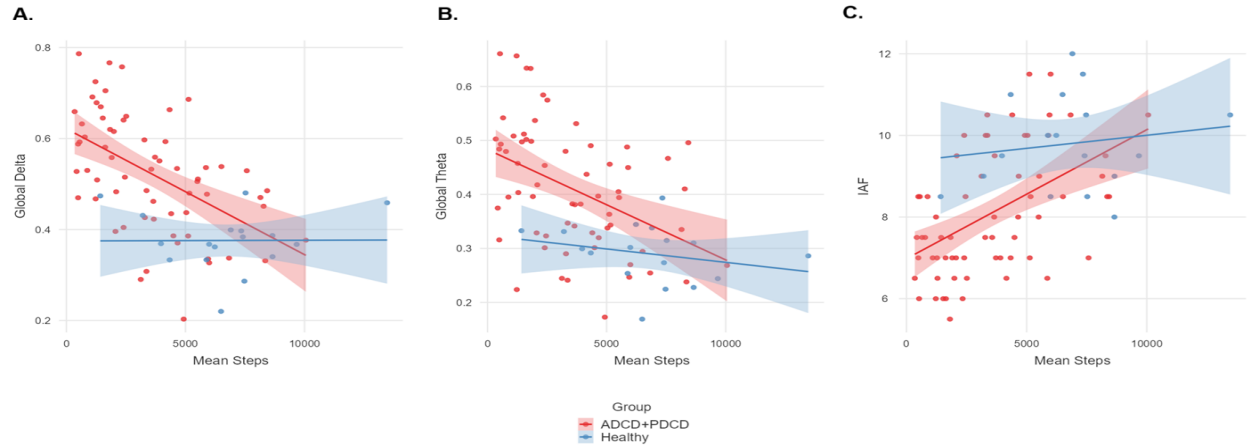

Figure 2. Scatterplots showing the associations between mean daily steps and (A) rsEEG global delta source activity, (B) rsEEG global theta source activity, and (C) rsEEG individual alpha frequency (IAF) peak in ADCD+PDCD participants. Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease.

SMARTME&YOU HOME TELEMONITORING UNVEILS LOWER HEART RATE CHANGES IN 24 HOURS ASSOCIATED WITH GLOBAL COGNITIVE STATUS IN PATIENTS WITH COGNITIVE DEFICITS DUE TO ALZHEIMER'S AND PARKINSON'S DISEASES

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Objective

Dysfunctions in the autonomic nervous system, which regulates heart rate (HR), are a known risk factor for cognitive decline in aging. This study used the SmartMe&You home telemonitoring platform (https://smartme.cloud.garr.it/) to investigate 24-hour HR dynamics in healthy controls (Healthy) and patients

with mild cognitive impairment and mild-to-moderate dementia due to Alzheimer's disease (ADCD) and Parkinson's disease (PDCD). HR metrics were analyzed in relation to global cognition, as assessed by the Mini-Mental State Examination (MMSE).

Materials and methods

As part of the Italian Rome Technopole (Italian Ministry of University), eBRAIN-Health (Horizon, European Commission), PREDICT-NEURODEGEN (Italian Ministry of Health), and TELEMAIA (Regione Lazio Innova) projects, we enrolled 17 healthy controls (Healthy; age = 70.6 ± 6.3 years; 5 men, 12 women) and 84 patients with cognitive deficits (CD; age = 74.5 ± 7.2 years; 55 men, 29 women) according to international inclusion/exclusion criteria for ADCD and PDCD studies. These participants received a clinical diagnosis in accordance with international guidelines for participant inclusion and exclusion criteria in clinical studies focused on patients with ADCD and PDCD. Fluid blood biomarkers, rsEEG activity (approximatively 5 minutes with eyes closed), structural and functional magnetic resonance imaging, and clinical and neuropsychological data were collected in hospital settings.

The rsEEG data were processed using the EEGLAB toolbox. Artifact-free rsEEG activities were investigated in the individual delta (<4 Hz), theta (~4-8 Hz), and alpha (~8-12 Hz) frequency bands, as well as the fixed beta (13-35 Hz) and gamma (35-40 Hz) bands. The eLORETA freeware was used to estimate cortical rsEEG sources (https://www.uzh.ch/keyinst/NewLORETA/Software/Software.htm). Statistical analyses were performed using the freeware tool Jamovi version 2.3.

All participants participated in home telemonitoring for 1 week using the SmartMe&You platform. The SmartMe&You's serious video games included 7 unsupervised cognitive tasks implemented on a commercial tablet (see a short video demonstrating these serious video games at https://www.youtube.com/watch?v=wfBm7WxX_RY). HR was continuously monitored via Samsung Galaxy Watch (series 4–6) smartwatches. HR indices: Night: 00:00–04:00 (minimum HR); Morning: 09:00–13:00 (maximum HR); and Afternoon: 15:00–19:00 (maximum HR). Hourly HR means were computed after removing daily extreme values. Daily averages were calculated over the seven monitoring days. Global cognition was assessed via MMSE. Statistical analyses included ANOVA for group comparisons (Healthy vs. CD) and Pearson correlations between HR changes and MMSE scores.

Table 1

DEMOGRAPHIC AND CLINICAL DATA				
	Healthy	**ADCD**	**PDCD**	**Statistical analyses**
N	17	39	45	-
Age (Years)	70.6 ± 6.3	75.0 ± 6.6	74.0 ± 6.9	t-test PDCD vs ADCD: p = 0.858 PDCD vs Healthy: p=0.069 ADCD vs Healthy: p=0.055
Sex (M/F)	5/12	22/17	33/12	Fisher's test PDCD vs ADCD: p = 0.011*

				PDCD vs Healthy: p = 0.001* ADCD vs Healthy: p = 0.164
Education (Years)	14.6 ± 3.8	11.4 ± 5.4	10.9 ± 4.4	t-test PDCD vs ADCD: p = 0.363 PDCD vs Healthy: p = 0.004* ADCD vs Healthy: p = 0.047*
MMSE Score	29.3 ± 0.9	21.3 ± 6.9	26.0 ± 3.5	Mann-Whitney PDCD vs ADCD: p = 0.002* PDCD vs Healthy: p < 0.001* ADCD vs Healthy: p < 0.001*
Heart Rate (Afternoon-Night)	19.4 ± 6.7	22.7 ± 8.2	21.2 ± 7.7	t-test PDCD vs ADCD: p = 0.088 PDCD vs Healthy: p = 0.447 ADCD vs Healthy: p = 0.051

Table 1. Demographic and clinical characteristics of Healthy (N = 17) and patients with CD (N = 84). Abbreviations: Healthy = healthy older with intact cognition as controls; CD = participants with mild cognitive impairment and mild-to-moderate dementia due to Alzheimer's or Parkinson's diseases; MMSE = Mini-Mental State Examination.

Results

Healthy, ADCD, and PDCD participants exhibited lower mean HR at night (00:00–04:00) than in the morning and afternoon periods (Figure 1). The difference between night and afternoon HR was smaller in ADCD and PDCD patients compared to healthy participants (Figure 2; $p < 0.001$). A significant positive correlation was observed between MMSE scores and night–afternoon HR differences across the entire cohort of Healthy, ADCD, and PDCD participants (Figure 3; $p < 0.001$). Lower MMSE scores were associated with smaller HR differences.

Figure 1

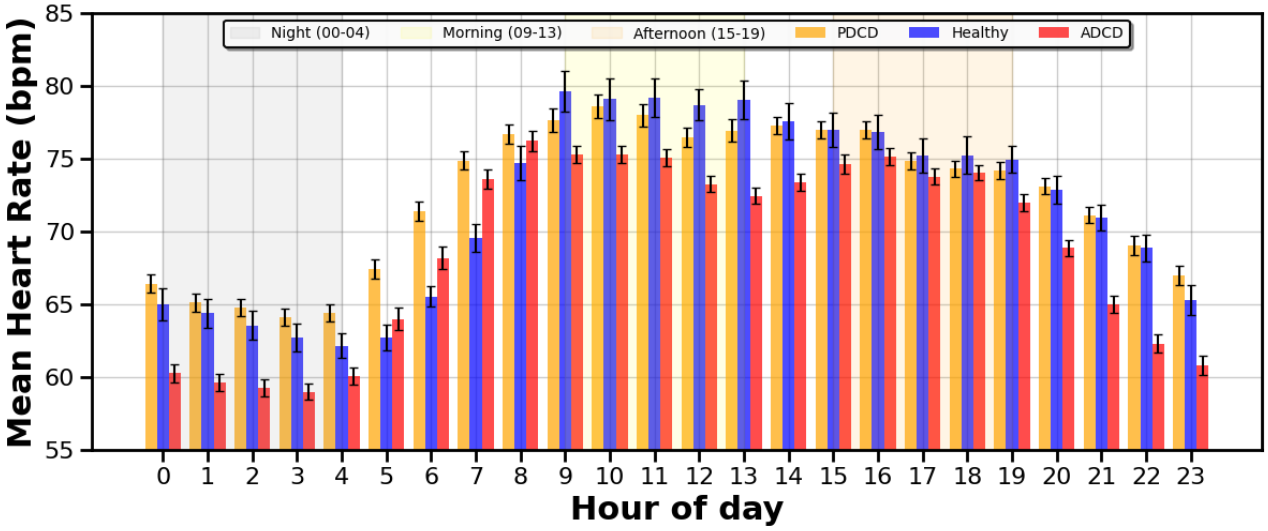

Figure 1. Grand average of the mean (± SE) HR (beats per minute, bpm) over 24 hours for Healthy participants and patients with ADCD and PDCD during one week of home monitoring with the SmartMe&You platform. HR was continuously recorded using Samsung Galaxy Watch series 4–6 smartwatches, and daily mean values were averaged across all monitoring days. The SE is shown in light blue around the dashed blue line for Healthy participants, and in light red and brown around the dashed lines for ADCD and PDCD participants, respectively. Three periods of interest are highlighted: nighttime (00:00–04:00), morning (09:00–13:00), and afternoon (15:00–19:00). Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease; HR = heart rate; SE = standard error of the mean.

Figure 2

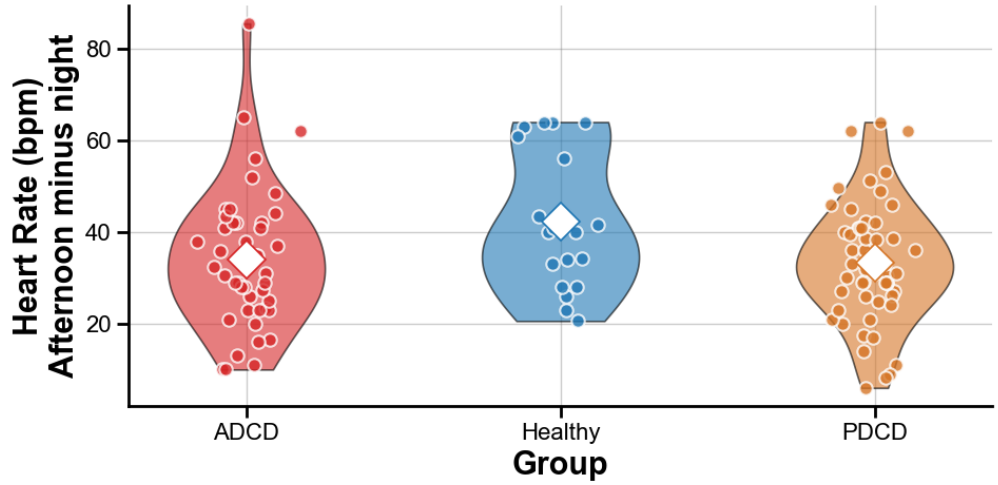

Figure 2. Individual differences in mean heart rate (beats per minute, bpm) between the afternoon (15:00–19:00) and nighttime (00:00–04:00) periods of interest are shown for Healthy participants and patients with ADCD and PDCD over 24 hours of home monitoring using the SmartMe&You platform for one week. HR was continuously measured with Samsung Galaxy Watch series 4–6 smartwatches, and daily mean values were averaged across all monitoring days. The observed differences between afternoon and nighttime HR were statistically significant ($p < 0.001$). Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease; HR = heart rate; SE = standard error of the mean.

Figure 3

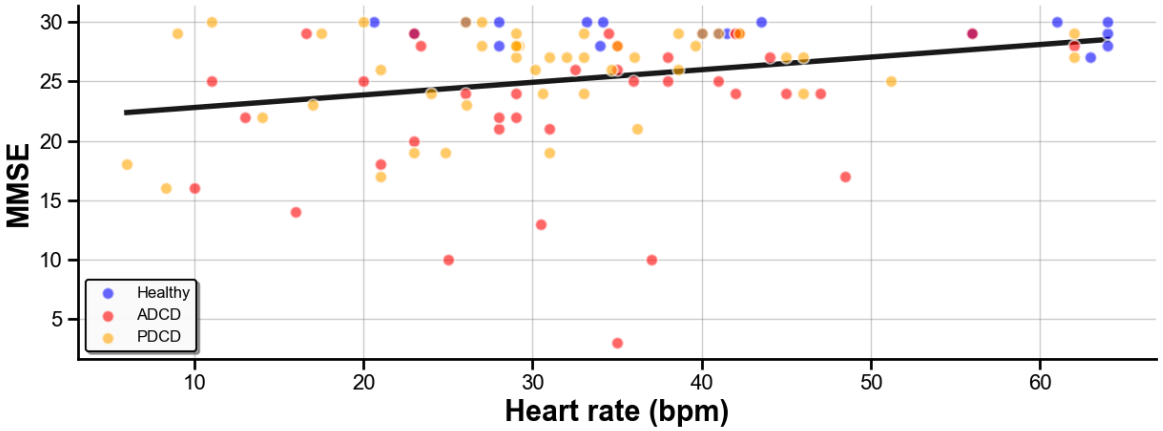

Figure 3. The scatterplot shows a significant positive association ($p < 0.05$) between mean heart rate (HR, beats per minute, bpm), calculated as the difference between the afternoon (15:00–19:00) and nighttime (00:00–04:00) periods, and cognitive status as assessed by MMSE scores in the overall sample of Healthy participants and patients with ADCD and PDCD. HR was continuously recorded over 24 hours for one week using the SmartMe&You home telemonitoring platform with Samsung Galaxy Watch series 4–6 smartwatches, and daily mean HR values were averaged across the monitoring days. The difference in HR between afternoon and night was statistically significant ($p < 0.001$). Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease; HR = heart rate.

Conclusions

In the present study, reduced mean heart rate (HR) variability over 24 hours, likely reflecting diminished autonomic regulation from night to morning, was associated with poorer global cognitive status, as measured by MMSE scores, in both healthy controls (Healthy) and patients with cognitive deficits due to Alzheimer's (ADCD) and Parkinson's disease (PDCD). These results suggest that autonomic dysregulation, which reduces HR physiological variability throughout the day, can be effectively monitored using the SmartMe&You home telemonitoring platform, providing clinically relevant information on a significant dementia risk factor. Overall, the platform proved to be a feasible, sensitive, and ecologically valid tool for home-based HR monitoring, with potential applications in cost-effective primary and tertiary prevention for both Healthy individuals and patients with ADCD and PDCD.

SMARTME&YOU HOME TELEMONITORING UNVEILS LOWER HEART RATE CHANGES IN 24 HOURS ASSOCIATED WITH COGNITIVE PERFORMANCE IN UNSUPERVISED SERIOUS VIDEOGAMES OF THE SMARTME&YOU HOME TELEMONITORING PLATFORM IN PATIENTS WITH MILD COGNITIVE IMPAIRMENT DUE TO ALZHEIMER'S AND PARKINSON'S DISEASES

Veronica Henao Isaza[1], Mina De Bartolo[1], Matteo Carpi[1], Roberta Lizio[1], Claudio Del Percio[1], Susanna Lopez[1], Burcu Bolukbas[1], Antonio Pio Afragola[1], Lorenc Barjami[1], Federica Fiorentino[1], Filippo Carducci[1], Giuseppe Noce[2], Paolo Barone[2,3], Arianna Cappiello[3], Federico Di Filippo[3], Dora Riemmai[3], Giuliana Costanzo[3], Angelo Barone[3], Angelo Antonini[4], Simone Cauzzo[4], Francesca Vianello[4], Fabrizio Stocchi[5], Chiara Coletti[5], Francesco Infarinato[5], Giacomo Maria Russo[6], Cristina Ranallo[6], Michela Bonaccorsi[6], Lorenzo Angeloni[6], Andrea Rosati[7], Andrea Baldas[7], Vittorio Luigi Diana[7], Delia Passalaqua[8], Sabrina Tommassini[8], Eleonora Fiorenzato[4], Claudio Babiloni[1,9]

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Objective

Autonomic and cognitive impairments often co-occur in neurodegenerative diseases, typically during pathological brain aging. This study used the SmartMe&You home telemonitoring platform (https://smartme.cloud.garr.it/) to test whether the daily course of heart rate (HR), as a marker of autonomic nervous system dysregulation, is associated with cognitive performance measured via unsupervised serious video games in patients with mild cognitive impairment (MCI) due to Alzheimer's disease (ADCD) and Parkinson's disease (PDCD).

Dysfunctions in the autonomic nervous system, which regulates HR, are a known risk factor for cognitive decline in aging. Home telemonitoring of HR may therefore index this risk factor and provide clinically relevant information for patient management. This study used the SmartMe&You platform to compare 24-hour HR dynamics in older adults without cognitive impairment (healthy controls, Healthy) and in patients with mild cognitive impairment and mild-to-moderate dementia due to Alzheimer's (ADCD) and Parkinson's (PDCD) diseases. Measures of 24-hour HR dynamics were related to participants' global performance in the SmartMe&You serious video games, probing cognitive functions used during the home telemonitoring period.

Materials and methods

As part of the Italian Rome Technopole (Italian Ministry of University), eBRAIN-Health (Horizon, European Commission), PREDICT-NEURODEGEN (Italian Ministry of Health), and TELEMAIA (Regione Lazio Innova) projects, a total of 81 participants were enrolled, according to available data. This group included 14 healthy controls (Healthy; age = 70.6 ± 5.4 years, education = 15.1 ± 5.0 years, Mini-Mental State Examination [MMSE] score = 29.2 ± 1.0) and 67 participants with cognitive decline. The cognitive decline group was divided into 30 participants with Alzheimer's disease-related cognitive decline (ADCD; age = 74.4 ± 6.0 years, education = 10.8 ± 5.1 years, MMSE = 23.8 ± 4.9) and 37 participants with Parkinson's disease-related cognitive decline (PDCD; age = 74.5 ± 7.0 years, education = 10.8 ± 4.4 years, MMSE = 26.4 ± 3.2) (Table 1). Participants received a clinical diagnosis according to international guidelines for inclusion and exclusion criteria for clinical studies of patients with ADCD and PDCD. Fluid blood biomarkers, resting-state electroencephalographic (rsEEG) activity (approximately 5 minutes with eyes closed), structural and functional magnetic resonance imaging, and clinical and neuropsychological data were collected in hospital settings.

All participants participated in home telemonitoring for 1 week using the SmartMe&You platform. The SmartMe&You's serious video games included 7 unsupervised cognitive tasks implemented on a commercial tablet (see a short video demonstrating these serious video games at https://www.youtube.com/watch?v=wfBm7WxX_RY). The SmartMe&You serious video games included seven unsupervised cognitive tasks implemented on a commercial tablet, comprising two variants of a simple visual reaction time task, three variants of Posner's visuospatial anticipatory attention task, an inhibition-of-return task, and a visual Go-NoGo task. All tasks were based on the same visual grid on the tablet screen, where cues and go stimuli were presented, and participants had to provide a hand motor response as accurately and quickly as possible.

HR was continuously monitored via Samsung Galaxy Watch (series 4–6) smartwatches. HR indices: Night: 00:00–04:00 (minimum HR); Morning: 09:00–13:00 (maximum HR); and Afternoon: 15:00–19:00 (maximum

HR). Hourly HR means were computed after removing daily extreme values. Daily averages were calculated over the seven monitoring days. Global cognition was assessed via MMSE. Statistical analyses included ANOVA for group comparisons (Healthy vs.ADCD and PDCD as a unique pathological group with cognitive deficit, CD) and Pearson correlations between HR changes and MMSE scores. Visualizations included group-specific markers and regression lines to illustrate associations between HR fluctuations and cognitive performance.

Results

Healthy, ADCD, and PDCD participants exhibited lower mean HR at night (00:00–04:00) than in the morning and afternoon periods (Figure 1). HR changes from afternoon to night periods of interest were positively associated with the global performance in the SmartMe&You serious video games (Pearson's partial $r = 0.404$, $p < 0.0001$, controlling for age and education; $R^2 = 0.276$), as were morning-to-night differences (partial $r = 0.360$, $p < 0.01$; $R^2 = 0.247$), Figure 2. Across all participants, larger morning-to-night HR differences were associated with better cognitive performance in the serious video games, and this relationship remained significant after controlling for demographic variables, including age and education.

In addition, significant correlations between these autonomic measures and resting-state electroencephalographic (rsEEG) activity. HR differences between morning (09:00–13:00) and nighttime (00:00–04:00) were negatively correlated with global rsEEG delta source activity ($r = –0.29$, $p < .05$) and positively correlated with global rsEEG theta source activity ($r = 0.32$, $p < .05$) (Figure 3). Similarly, HR differences between afternoon (15:00–19:00) and nighttime (00:00–04:00) showed positive correlations with both global delta ($r = 0.20$, $p < .05$) and global theta source activity ($r = 0.29$, $p < .05$) (Figure 4).

These relationships remained significant after controlling for age, sex, and education, indicating that greater day–night HR changes were associated with EEG patterns characterized by lower delta and higher theta activity, typically reflecting better cortical functional integrity and cognitive efficiency. Altogether, these findings support a functional interplay between autonomic cardiac regulation and cortical activity, observed across healthy participants and those with Alzheimer's disease–related (ADCD) and Parkinson's disease–related (PDCD) cognitive decline.

Table 1

DEMOGRAPHIC AND CLINICAL DATA				
	Healthy	**ADCD**	**PDCD**	**Statistical analyses**
N	14	30	37	-
Age (Years)	70.6 ± 5.4	74.4 ± 6.0	74.5 ± 7.0	ANOVA $F(2,78) = 2.06$, $p = 0.134$
Sex (M/F)	5/9	18/12	26/11	$\chi 2$ test $\chi^2(2) = 5.08$, $p = 0.079$
Education (Years)	15.1 ± 5.0	10.8 ± 5.1	10.8 ± 4.4	ANOVA $F(2,78) = 4.60$, $p < 0.05$ *
MMSE Score	29.2 ± 1.0	23.8 ± 4.9	26.4 ± 3.2	ANOVA $F(2,78) = 10.68$, $p < 0.0001$ ***

Table 1. Mean (± SD) of the demographic and clinical characteristics in Healthy (N = 14) and patients with CD due to Alzheimer's and Parkinson's diseases (N = 67). Healthy = cognitively unimpaired healthy controls; CD = older participants with mild cognitive impairment due to Alzheimer's and Parkinson's diseases; MMSE = Mini-Mental State Examination; SE = standard error of the mean.

Figure 1

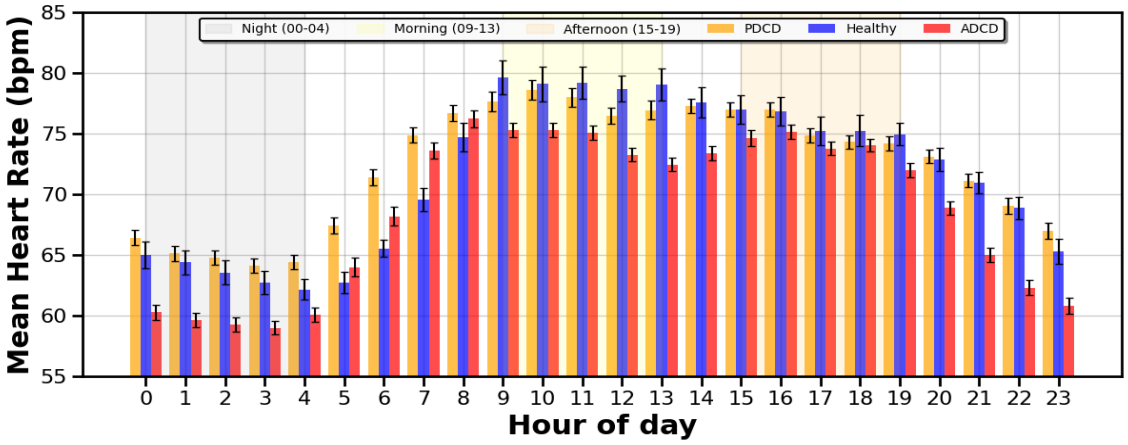


Figure 1. Grand average of the mean (± SE) HR (beats per minute, bpm) over 24 hours for Healthy participants and patients with ADCD and PDCD during one week of home monitoring with the SmartMe&You platform. HR was continuously recorded using Samsung Galaxy Watch series 4–6 smartwatches, and daily mean values were averaged across all monitoring days. The SE is shown in light blue around the dashed blue line for Healthy participants, and in light red and brown around the dashed lines for ADCD and PDCD participants, respectively. Three periods of interest are highlighted: nighttime (00:00–04:00), morning (09:00–13:00), and afternoon (15:00–19:00). Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease; HR = heart rate; SE = standard error of the mean.

Figure 2

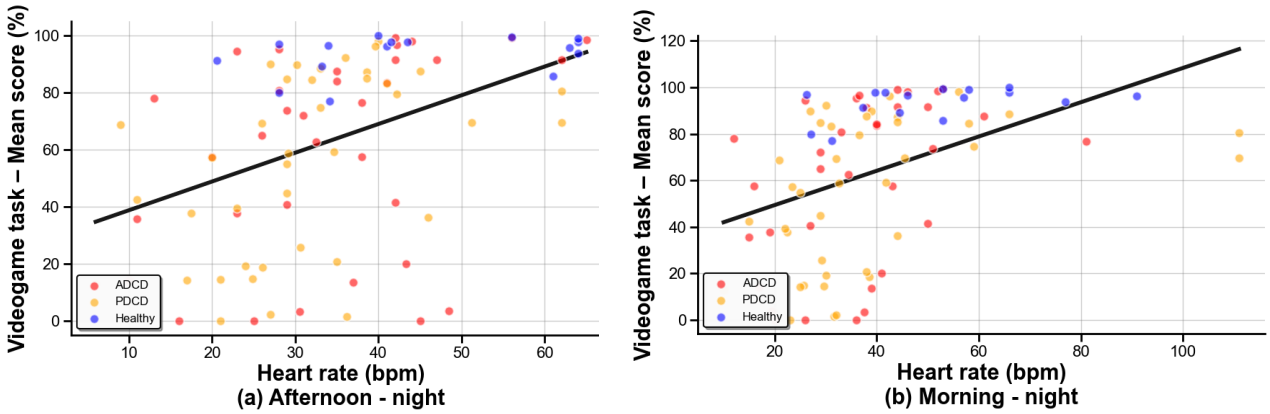
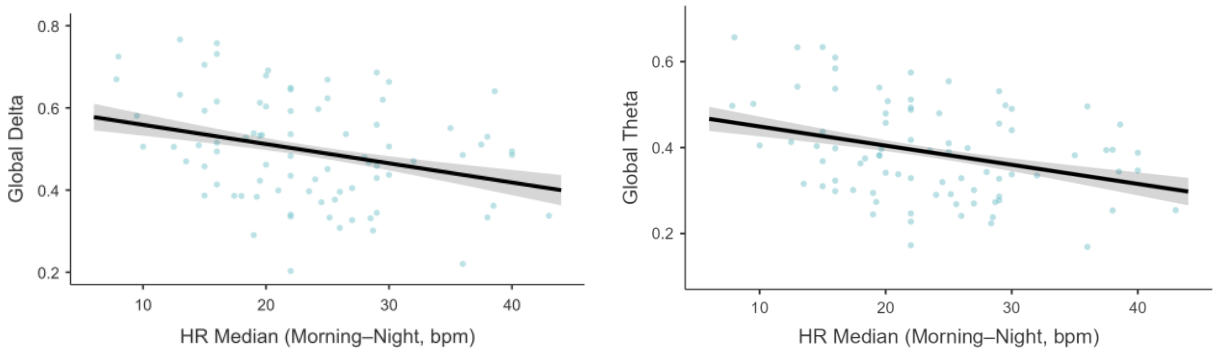


Figure 2. (a) Scatterplot showing the significant positive association ($p < 0.05$) between the difference in mean HR (beats per minute, bpm) between the afternoon (15:00–19:00) and nighttime (00:00–04:00) periods and global accuracy (%) in the SmartMe&You serious video games for Healthy participants and patients with ADCD and PDCD. (b) Scatterplot showing the significant positive association ($p < 0.01$) between the difference in mean HR (bpm) between morning (09:00–13:00) and nighttime (00:00–04:00) periods and global

performance accuracy (%) in the performance of the SmartMe&You serious video games for Healthy participants and patients with ADCD and PDCD. HR was recorded over 24 hours using Samsung Galaxy Watch 4–6 smartwatches for a period of one week. Daily mean HR values were averaged across monitoring days. Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease; HR = heart rate.

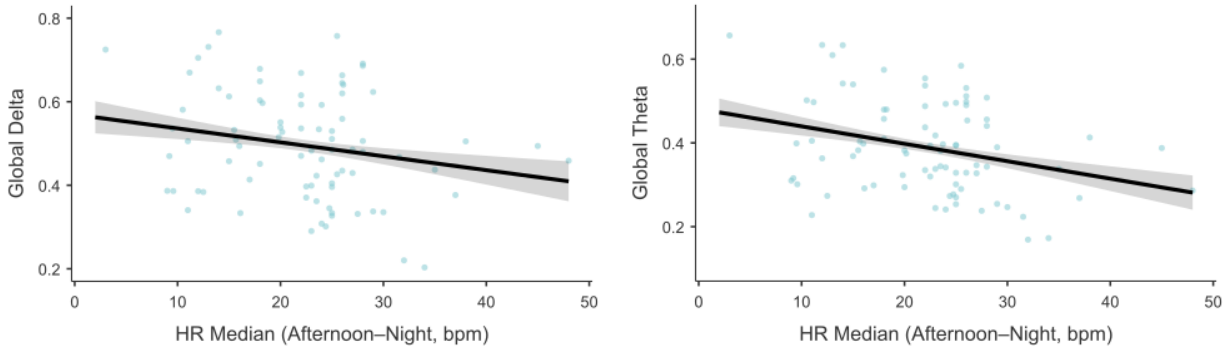
Figure 3



(A) (B)

Figure 3. Scatterplots illustrating the associations between the difference in mean HR (beats per minute, bpm) between the morning (09:00–13:00) and nighttime (00:00–04:00) and (A) rsEEG global delta source activity ($r=-0.29$, $p < 0.05$), (B) rsEEG global theta source activity ($r=0.32$, $p < 0.05$), for Healthy participants and patients with ADCD and PDCD. Sleep quality was measured over one week using the Samsung Galaxy Watch 4-6 smartwatches. SmartMe&You's serious video games are implemented on commercial tablets. Associations were tested using a general linear model controlling for age, sex, and education.

Figure 4



(A) (B)

Figure 4. Scatterplots illustrating the associations between the difference in mean HR (beats per minute, bpm) between the afternoon (15:00–19:00) and nighttime (00:00–04:00) and (A) rsEEG global delta source activity ($r=0.20$, $p < .05$), (B) rsEEG global theta source activity ($r=0.29$, $p < .05$), for Healthy participants and patients with ADCD and PDCD. Sleep quality was measured over one week using the Samsung Galaxy Watch 4-6 smartwatches. SmartMe&You's serious video games are implemented on commercial tablets.
Associations were tested using a general linear model controlling for age, sex, and education.

Conclusions

Reduced HR variability over 24 hours, as indexed by diminished autonomic regulation from night to morning, was associated with poorer cognitive performance in unsupervised serious video games on the SmartMe&You home telemonitoring platform in Healthy participants and patients with ADCD and PDCD. This finding

suggests that autonomic nervous system dysregulation of HR may represent a significant dementia risk factor in early ADCD and PDCD stages and should be regularly monitored. The SmartMe&You home telemonitoring platform enables ecologically valid remote assessment of autonomic and cognitive functions, supporting individualized monitoring and interventions aimed at dementia prevention in at-risk older populations with intact cognition, as well as in patients with ADCD and PDCD.

Moreover, the associations observed in the rsEEG analysis further support the link between autonomic and cortical mechanisms. Specifically, larger day–night HR differences were associated with lower global delta and higher global theta rsEEG source activity, suggesting that better autonomic regulation of heart rate is associated with more efficient cortical functional organization. These convergent findings highlight a potential neurophysiological bridge between cardiac autonomic dynamics and brain oscillatory activity, reinforcing the value of multimodal home telemonitoring in capturing early markers of neurodegenerative processes.

ASSOCIATION BETWEEN SLEEP QUALITY AND COGNITIVE PERFORMANCE ASSESSED WITH THE SMARTME&YOU SERIOUS GAMES PLATFORM AND RESTING-STATE ELECTROENCEPHALOGRAPHIC ACTIVITY IN PATIENTS WITH COGNITIVE DEFICITS DUE TO ALZHEIMER'S AND PARKINSON'S DISEASES

Veronica Henao Isaza[1], Mina De Bartolo[1], Matteo Carpi[1], Roberta Lizio[1], Claudio Del Percio[1], Susanna Lopez[1], Burcu Bolukbas[1], Antonio Pio Afragola[1], Lorenc Barjami[1], Federica Fiorentino[1], Filippo Carducci[1], Giuseppe Noce[2], Paolo Barone[2,3], Arianna Cappiello[3], Federico Di Filippo[3], Dora Riemmai[3], Giuliana Costanzo[3], Angelo Barone[3], Angelo Antonini[4], Simone Cauzzo[4], Francesca Vianello[4], Fabrizio Stocchi[5], Chiara Coletti[5], Francesco Infarinato[5], Giacomo Maria Russo[6], Cristina Ranallo[6], Michela Bonaccorsi[6], Lorenzo Angeloni[6], Andrea Rosati[7], Andrea Baldas[7], Vittorio Luigi Diana[7], Delia Passalaqua[8], Sabrina Tommassini[8], Eleonora Fiorenzato[4], Claudio Babiloni[1,9]

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Objective

Patients with mild cognitive deficits or mild-moderate dementia due to Alzheimer's disease (ADCD) and Parkinson's disease (PDCD) often exhibit poor sleep quality. Here, we hypothesized that sleep quality, as measured by smartwatches during home telemonitoring, and performance in unsupervised serious video games may be associated in patients with ADCD and PDCD.

Materials and Methods

As part of the Italian Rome Technopole (Italian Ministry of University), eBRAIN-Health (Horizon, European Commission), PREDICT-NEURODEGEN (Italian Ministry of Health), and TELEMAIA (Regione Lazio Innova) projects, data were collected from 15 healthy controls (Healthy) and 90 participants with cognitive deficits due to Alzheimer's disease (ADCD, N = 36) and Parkinson's disease (PDCD, N = 54; Table 1). Participants received a clinical diagnosis according to international guidelines for inclusion and exclusion in clinical studies on patients with ADCD and PDCD. Fluid blood biomarkers, rsEEG activity (approximatively 5 minutes with eyes closed), structural and functional magnetic resonance imaging, and clinical and neuropsychological data were collected in hospital settings.

The rsEEG data were processed using the EEGLAB toolbox. The artifact-free rsEEG activities were investigated at individual delta (<4 Hz), theta (~4-8 Hz), and alpha (~8-12 Hz) frequency bands, as well as fixed beta (13-35 Hz) and gamma (35-40 Hz) bands. The eLORETA freeware was used to estimate cortical rsEEG sources (https://www.uzh.ch/keyinst/NewLORETA/Software/Software.htm).

All participants were also involved in the home telemonitoring for one week with the SmartMe&You platform. The SmartMe&You's serious video games included 7 unsupervised cognitive tasks implemented on a commercial tablet (see a short video demonstrating these serious video games at https://www.youtube.com/watch?v=wfBm7WxX_RY). The SmartMe&You serious video games included seven unsupervised cognitive tasks implemented on a commercial tablet, comprising two variants of a simple visual reaction time task, three variants of Posner's visuospatial anticipatory attention task, an inhibition of return task, and a visual Go-NoGo task. All tasks were based on the same visual grid on the tablet screen, where cues and go stimuli were presented, and participants had to provide a hand motor response as accurately and quickly as possible. Furthermore, sleep quality was monitored over the same one-week period using a Samsung Galaxy Watch 4-6 smartwatch worn by the participants. The global cognitive status for the statistical models was assessed using the Mini-Mental State Examination (MMSE). Statistical analyses were conducted using Jamovi (v2.3). Between-group comparisons were made using t-tests, Mann–Whitney U, or Fisher's exact test, depending on the variable distribution (Table 3). Significance was set at $p < 0.05$ for all statistics.

Table 1

DEMOGRAPHIC AND CLINICAL DATA				
	Healthy	**ADCD**	**PDCD**	**Statistical analyses**
N	15	36	54	-
Age (Years)	69.6 ± 5.3	74.9 ± 6.5	73.6 ± 7.2	t-test p = n.s
Sex (M/F)	6/9	20/16	39/15	Fisher's test p < 0.05*
Education (Years)	14.5 ± 5.1	12.6 ± 5.5	11.6 ± 4.6	t-test p < 0.05*
MMSE Score	29.2 ± 0.9	23.1 ± 6.4	25.4 ± 3.6	Mann-Whitney p < 0.001*
Quality Sleep	76.1 ± 14.2	67.2 ± 14.7	54.3 ± 16.2	t-test p < 0.001*

Table 1. Mean values (± SD) of demographic and clinical data, and results of statistical comparisons ($p < 0.05$) between Healthy participants and patients with ADCD and PDCD. Abbreviations: Healthy = cognitively unimpaired older adults; ADCD = patients with mild cognitive impairment and mild-moderate dementia due to Alzheimer's disease; PDCD = patients with mild cognitive impairment and mild-moderate dementia due to Parkinson's disease; MMSE = Mini-Mental State Examination; SD = standard error; n.s. = not significant ($p > 0.05$).

Results

Compared to Healthy participants (mean sleep quality = 76.1 ± 14.2), the patients with ADCD (67.2 ± 14.7) and PDCD (54.3 ± 16.2) exhibited reduced sleep quality. The difference was statistically significant between the PDCD and Healthy groups ($p < 0.001$), but not between the ADCD and Healthy groups ($p = 0.06$). Furthermore, sleep quality was lower in patients with PDCD than in those with ADCD ($p < 0.001$). When considering sleep quality from the smartwatch data collection as a predictor in the general linear model, the higher the sleep quality (%), the higher the performance (accuracy %) averaged across all SmartMe&You serious video games ($r = 0.229$, $p < 0.05$; Figure 1) across all participants as a whole group. In contrast, the association between that sleep quality and MMSE scores did not reach statistical significance at a $p < 0.05$ statistical threshold.

Additionally, Figure 2 shows that night sleep quality was negatively correlated with both rsEEG global delta source activity ($r = –0.37$, $p < 0.001$) and rsEEG global theta source activity ($r = –0.35$, $p < 0.001$). These results indicate that participants with lower sleep quality exhibited higher slow-frequency (delta and theta) resting-state EEG activity — a pattern typically associated with cortical hypoactivation and cognitive slowing in neurodegenerative disorders. The associations remained significant after controlling for age, sex, and education, and were consistent across Healthy, ADCD, and PDCD groups.

Figure 1

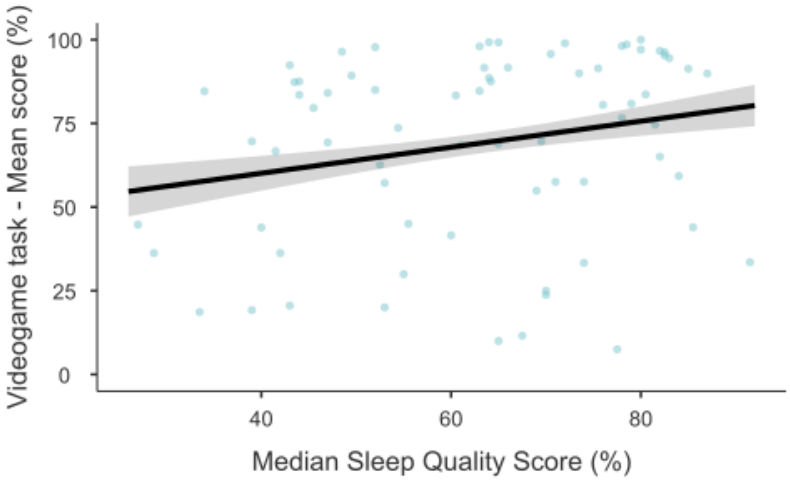
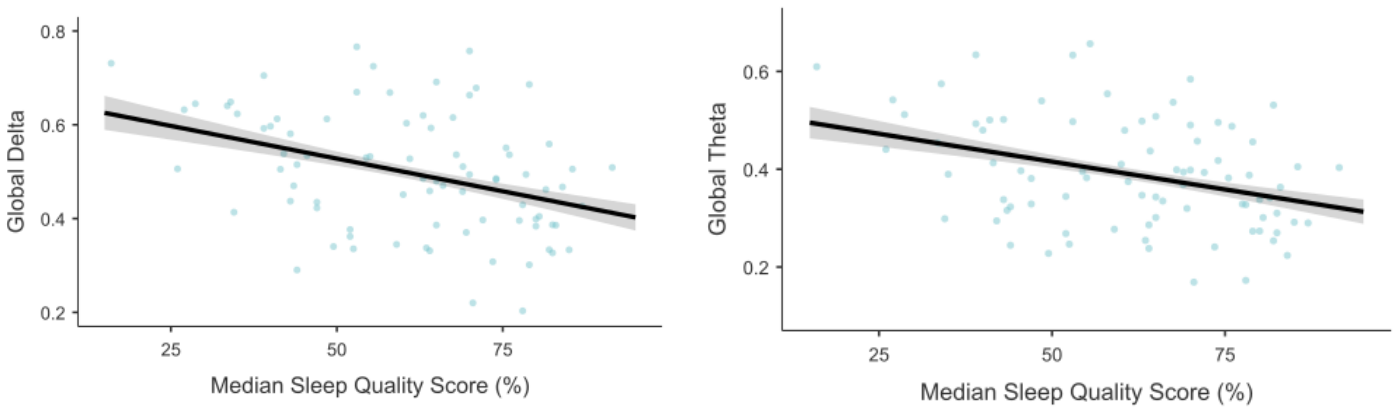


Figure 1. Scatterplots illustrate the relationship between night sleep quality and mean performance accuracy (%) in the serious video games of the SmartMe&You home telemonitoring platform for Healthy participants and patients with ADCD and PDCD. Sleep quality was measured over one week using the Samsung Galaxy Watch 4-6 smartwatches. SmartMe&You's serious video games are implemented on commercial tablets. Associations were tested using a general linear model controlling for age, sex, and education.

Figure 2



(A) (B)

Figure 2. Scatterplots illustrating the associations between night sleep quality and (A) rsEEG global delta source activity ($r = –0.37$, $p < 0.001$), (B) rsEEG global theta source activity ($r = –0.35$, $p < 0.001$), for Healthy participants and patients with ADCD and PDCD. Sleep quality was measured over one week using the Samsung Galaxy Watch 4-6 smartwatches. SmartMe&You's serious video games are implemented on commercial tablets.
Associations were tested using a general linear model controlling for age, sex, and education.

Conclusions

These findings indicate that night sleep quality, as measured through home-based telemonitoring with the Samsung Galaxy Watch 4–6 smartwatch, is positively associated with global performance in unsupervised serious video games on the SmartMe&You home telemonitoring platform in Healthy participants and patients with ADCD and PDCD.

Furthermore, the rsEEG results (Figure 2) revealed that poorer sleep quality is linked to increased global delta and theta source activity ($r = –0.37$ and $r = –0.35$, respectively; both $p < 0.001$), reflecting electrophysiological signatures of reduced cortical efficiency at rest. Taken together, these behavioral and neurophysiological findings support the role of sleep quality as a relevant, modifiable biomarker of cognitive and brain health in older adults.

The SmartMe&You platform, combining smartwatch-based sleep assessment, rsEEG monitoring, and digital cognitive testing through serious video games, provides a feasible, cost-effective, and environmentally sustainable approach for large-scale remote assessment of dementia risk factors. It may thus serve as a valuable tool for primary prevention in older adults at risk of cognitive decline and tertiary prevention in individuals with ADCD and PDCD, facilitating continuous, ecologically valid tracking of both cognitive and neurophysiological health indicators.

SUBJECTIVE SLEEP DYSFUNCTION AND DAYTIME SLEEPINESS ARE LINKED TO RESTING-STATE EEG RHYTHMS AND COGNITIVE PERFORMANCE IN OLDER ADULTS WITH COGNITIVE IMPAIRMENT DUE TO ALZHEIMER'S AND PARKINSON'S DISEASES

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Objective
Sleep dysfunction and excessive daytime sleepiness are common in neurodegenerative conditions such as Alzheimer's disease (AD) and Parkinson's disease (PD), and may reflect disrupted vigilance regulation and cognitive decline. This study examined the associations between subjective sleep variables, daytime functioning, resting-state EEG rhythms, and cognitive performance, as assessed via serious games within the SmartMe&You platform (https://smartme.cloud.garr.it/), in older adults with and without cognitive impairment.

Materials and methods

As part of the Italian Rome Technopole (Italian Ministry of University), eBRAIN-Health (Horizon, European Commission), PREDICT-NEURODEGEN (Italian Ministry of Health), and TELEMAIA (Regione Lazio Innova) projects, 64 older adults – 22 healthy controls (Healthy; mean age: 66.6 ± 6.2, 9 women), 15 with cognitive decline due to AD (ADCD; mean age: 74.5 ± 6.8, 5 women), and 28 with cognitive decline due to PD (PDCD; mean age: 74.8 ± 6.1, 6 women) – completed standardized sleep questionnaires, 19-channel EEG, and home-based cognitive assessment using seven SmartMe&You serious games.
Participants completed the Pittsburgh Sleep Quality Index (PSQI; total and seven component scores assessing diverse domains of subject sleep quality and quantity) and the Epworth Sleepiness Scale (ESS), and performed tablet-based SmartMe&You tasks targeting attention and visuomotor speed. Resting-state EEG (~5 min, eyes closed) was analyzed using eLORETA to extract source-level current density estimates in individual delta, theta, alpha1, alpha2, and alpha3 frequency bands. General linear models (GLMs) were used to test group differences; Spearman's correlations examined the associations among EEG, subjective sleep, sleepiness, and cognitive variables.

Results

Both cognitively impaired groups (ADCD and PDCD) showed significantly higher PSQI ($p = 0.01$, $\eta^2p = 0.16$) and ESS ($p = 0.02$, $\eta^2p = 0.13$) scores than the Healthy Group. Delta ($p= 0.01$, $\eta^2_p = 0.18$) and theta ($p= 0.03$, $\eta^2_p = 0.12$) EEG power were increased in ADCD and PDCD. ESS and the PSQI component for daytime dysfunction (C7) were positively associated with delta (rho = 0.36 and 0.39) and theta (rho = 0.38 and 0.42) power (all $p < 0.01$), and both measures negatively correlated with game accuracy (rho = -0.43 and -0.38 with $p < 0.01$, respectively).

Conclusions

These findings suggest that poor sleep-related daytime functioning is accompanied by increased slow-wave EEG activity and reduced cognitive performance in older adults with neurodegenerative conditions.
The SmartMe&You platform, coupled with EEG and subjective sleep measures, provides a scalable, ecologically valid means of detecting neurobehavioral alterations in early AD and PD. Findings support the value of sleep-focused monitoring in age-related cognitive decline, encouraging further efforts in prolonged home-based monitoring of rest-activity rhythms.

Table 1

	ADCD (N = 15)	**PDCD (N = 28)**	**Healthy (N = 22)**	**Statistical test**
Age (years)	74.5 ± 6.8	74.8 ± 6.1	66.6 ± 6.2	ANOVA: $p < 0.001$
Sex (M/F)	10/5	22/6	13/9	χ^2 test: n.s.
Education (years)	11.9 ± 3.6	12.4 ± 4.4	14.7 ± 3.8	ANOVA: n.s.
MMSE score	25.8 ± 3.1	26.1 ± 3.9	29.4 ± 1.0	Kruskal-Wallis test: $p < 0.001$

Table 1. Demographic and clinical characteristics of Healthy (N = 22), ADCD (N = 15), and PDCD (N = 28) participants involved in the study. Abbreviations: ADCD: cognitive decline due to Alzheimer's disease; Healthy: cognitively unimpaired older adults; MMSE: Mini-Mental State Examination; PDCD: cognitive decline due to Parkinson's disease.

Figure 1

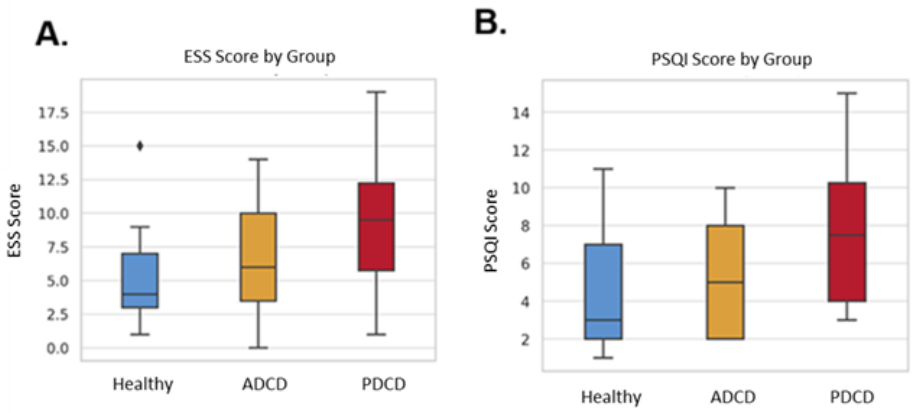

Figure 1. Group differences in subjective sleep quality (PSQI: Pittsburgh Sleep Quality Index), daytime sleepiness (ESS: Epworth Sleepiness Scale), and EEG slow-wave power. Cognitively impaired groups (ADCD and PDCD) showed significantly higher PSQI and ESS scores, as well as increased delta and theta EEG current density (all $p < 0.05$). Abbreviations: ADCD: cognitive decline due to Alzheimer's disease; ESS: Epworth Sleepiness scale; Healthy: cognitively unimpaired older adults; MMSE: Mini-Mental State Examination; PDCD: cognitive decline due to Parkinson's disease; PSQI: Pittsburgh Sleep Quality Index.

Figure 2

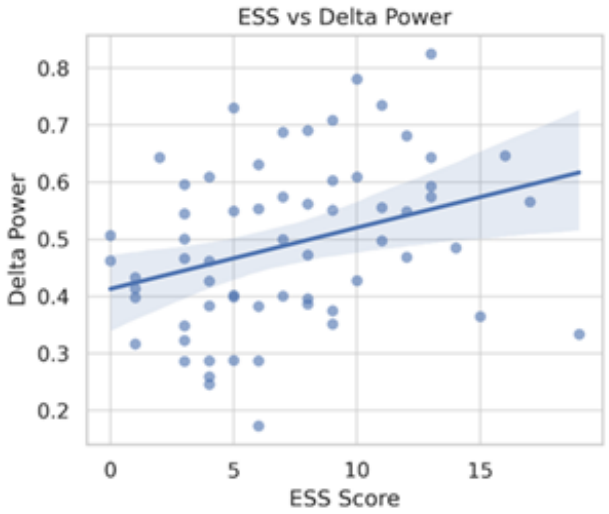

Figure 2. Scatterplot showing the association between EEG delta eLORETA current density and daytime sleepiness (ESS: Epworth Sleepiness Scale) in the whole sample. Higher delta activity was associated with greater daytime sleepiness ($p < 0.01$). Abbreviations: ESS: Epworth Sleepiness Scale.