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ORIGINAL ARTICLE

Evaluation of sleep quality in individuals with Parkinson's disease using objective and subjective measures

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Abstract

The aim of this study is to investigate sleep quality in Parkinson's disease (PD) and to correlate subjective measures, through clinical scales and sleep diary, with objective measures obtained by means of actigraphy. In this prospective comparative study, the population consisted of PD patients with a moderate stage of the disease, who were evaluated by subjective scales such as the Pittsburgh Sleep Quality Index—PSQI, Epworth Sleepiness Scale—ESS, Parkinson's Disease Sleep Scale—PDSS and by sleep diary, besides objective measures from actigraphy recording over seven consecutive days. Participants were categorized into two groups: "good sleep" = PDSS > 100 and "poor sleep" = PDSS ≤ 100. In total, 48 individuals were evaluated, and the overall median (inter-quartile range) was 68 (55–70) for years of age, 95.3 (73.1–111.8) for PDSS, 8 (5–11) for PSQI. Twenty-eight (58.3%) participants had poor sleep quality according to the PDSS. Poor sleep quality was associated with higher depression score ($p = 0.01$) and with living without partner ($p = 0.04$). A significant difference was observed in all items of PDSS, except in the item daytime dozing ($p = 0{,}10$). Actigraphy—and sleep diary-based parameters did not vary according to the sleep quality measured with the PDSS. In general, subjective and objective sleep parameters presented weak to moderate correlation, except for sleep latency and sleep efficiency. Sleep quality is impaired in PD when assessed by actigraphy, clinical sleep scales and sleep diary. Parameters measured objectively should not be replaced by subjective parameters and vice versa due to the complexity of individual's perception about sleep.

Keywords Parkinson's disease · Sleep · Actigraphy · Rehabilitation

Introduction

Although Parkinson's disease (PD) is classically characterized through motor symptoms [1, 2], there are a variety of non-motor symptoms (NMSs) that can be observed from the earliest stages of the disease [3]. Epidemiological studies indicate that NMSs, such as hyposmia, neuropsychiatric dysfunctions, behavioral changes, autonomic, gastrointestinal and sensory alterations, are often mentioned by patients as leading to substantial reductions to their quality of life [3, 4].

Among the NMSs of PD, circadian and sleep disturbances, such as insomnia, excessive daytime sleepiness and rapid eye movement (REM), sleep behavior disorder (RBD) occurs in the majority of patients (between 74%-81%) [5]. The underlying pathophysiological mechanisms of sleep–wake abnormalities are multifactorial. These include widespread neurodegeneration due to deposition of α-synuclein and Lewy bodies within the brain stem, the hypothalamus, and the basal forebrain, areas known to be part of the circuitry controlling sleep–wake behavior [5, 6]. Additionally, motor and some NMSs contribute as secondary causes to the disorganization of the circadian pattern of sleep–wake behavior. The reemergence of resting tremor during microarousals, sleep-state changes, restless legs syndrome, periodic limb movements in sleep, nocturnal hypokinesia, painful dystonia, dyskinesia, respiratory sleep

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disorders and nocturia may contribute to the fragmentation of sleep [5, 7].

On the one hand, nocturnal hypokinesia has been objectively demonstrated to worsen as the night progresses in patients who did not receive extra night-time doses of dopaminergic [7]. On the other hand, therapy to alleviate PD is another factor that may induce the disruption of the sleep pattern. The mechanism of sleep–wake disruption by dopaminergic medication is complex and appears to be dependent on the dose, the time of administration, and the dopaminergic receptors targeted [5, 8].

In this context, Marinus et al. gathered studies concerning the risk factors of developing excessive daytime sleepiness and insomnia. The following variables were independently associated with the future development or severity of excessive daytime sleepiness, (in descending order of weight): male sex, the use of dopamine agonists, insomnia, disability, cognitive impairment, and depression. Related to insomnia, the variables that were independently associated were: depression, longer disease duration, female sex, dopamine agonist use, and cognitive impairment [9].

Unquestionably recognized for its biological importance, sleep has become a fertile field of research in PD, since there is widespread concern about the prevalence of its disturbance, affecting up to 88% of this population, and also in the relationship with poor quality of life, the presence of excessive daytime drowsiness, and reduced enthusiasm and efficiency in activities of daily living [3]. According to patient reports, the major complaints related to sleep disorders are: non-restorative sleep, excessive daytime sleepiness, respiratory sleep disorders, restless legs syndrome and periodic movements of the limbs during sleep [10].

In this context, the majority of studies available in the literature evaluate the quality of sleep through subjective measures in individuals with PD [10, 11]. Currently, studies that use objective measures, such as actigraphy, are gaining relevance in the evaluation of sleep in neurology, since it is a method that evaluates the state of sleep and wakefulness, through the presence or absence of movement [12, 13].

Therefore, the most appropriate route seems to be an association between subjective and objective sleep evaluations, as an essential parameter for the diagnosis of PD sleep disturbances. However, the relationship between subjective and objective measures is still obscure, and it is not known which parameter more accurately reflects the framework of sleep alterations in these patients. For an individual, there may be the sensation that their sleep was not restorative, while in the objective evaluation, the parameters analyzed may be normal or very close to normal [14].

There are few studies that have investigated this condition and the results are inconsistent and limited as they present methodological differences [15, 16]. Thus, the objective of the present study was to investigate sleep quality in individuals with PD and to correlate subjective measures, through clinical sleep scales and a sleep diary, with objective measurements obtained through actigraphy.

Participants and methods

This is a cross-sectional study, composed of a group of 48 individuals diagnosed with idiopathic PD, from the Specialties Outpatient Clinic of the University Hospital of the State University of Londrina, performed at the Neurofunctional Physiotherapy Outpatient Clinic in association with the Agape Social Support Center (CASA), between March 2015 and April 2016, in the city of Londrina-Paraná, Brazil.

The study was developed for an estimated sample of 40 individuals considering a prevalence of 0.1% [17, 18] and maximum standard error of 1% [19], respecting the following inclusion criteria: aged over 50 years, a medical diagnosis of idiopathic PD according to the criteria of the London Brain Bank [20], non-institutionalized, classified between stages 1.5 and 3 on the modified Hoehn & Yahr (HY) scale, a score above 24 on the Mini Mental State Examination—MMSE [21], stable dose of L-dopa for at least 4 weeks and who agreed to participate in the study after signing the informed consent, according to the criteria approved by the Local Ethics Committee in Research with Human Beings, under the opinion of the CEP-UEL approval no. 1.356.676. Individuals with other forms of Parkinsonism, other associated neurological pathologies, and those whose actigraph did not record at least 1 day of the weekend and/or at least 3 of 5 days of the week were excluded.

To characterize the participants, weight and height were measured to calculate the body mass index (BMI). Data on the diagnosis of the disease, schooling and marital status were obtained through self-reporting. In addition, the daily equivalent dose of Levodopa (LEDD) was calculated [22]. After that, evaluation of the patients, always performed in the on-stage of medication, was carried out using the following tests and instruments:

Unified Parkinson's Disease Rating Scale (UPDRS) To monitor the progression of the disease, motor (III—108 points) and daily life (II—52 points) domains are used, which together (III + II) add up to a score of 160 [23], where the higher the score, the greater the patient's impairment.

Yesavage Geriatric Depression Scale (GDS-15—reduced version) For depression screening, scores greater than or equal to 5 indicate signs of depression [24].

Sleep diary The questions contained in the instrument were collected and recorded directly by the evaluator, after daily calls to the patient, for seven consecutive days, as follows: time woke up in the morning (hh:mm); time went to bed (hh:mm); time turned off the light with the intention of sleeping (hh:mm); time it took to sleep—sleep latency

(min). From the data collected, it was possible to calculate the following variables: total time in bed (difference between the time woke up and the time went to bed); total sleep time (difference between time woke up and sleep latency); sleep efficiency (total night-time sleep time × 100/total time in bed).

Actigraphy Actigraphs, model Actiwatch 2 (Respironics Incorporation, Philips), were used to record periods of movement and rest of each individual, to objectively infer periods of motor activity, exposure to ambient light, and inactivity (sleep) of participants. The equipment was configured with patient identification data, and the individual was directed to keep the device on their preferred wrist for 7 days, and not to take it even in the shower. After the recording period, the data were obtained by connecting the device to a microcomputer and retrieving it using the software Respironics Actiware (Respironics Incorporation, Philips), version 6.0. In the device, transducers and microprocessors transform acceleration into a digital signal so that each movement generates a voltage proportional to its acceleration. The variables obtained from the records were: time the patient went to bed (hh:mm); time the patient woke up (hh:mm); sleep latency (min); total time in bed (h); total sleep time (h); and sleep efficiency (%).

Pittsburgh Sleep Quality Index (PSQI) Is a generic scale and assesses sleep quality over the last month in different patient groups through a combination of qualitative and quantitative information, with scores ranging from 0 to 21 where, the higher the score, the worse the quality of sleep. A global PSQI score greater than 5 indicates major difficulties in at least 2 components or moderate difficulties in more than 3 components [25].

Parkinson's Disease Sleep Scale (PDSS) Is a visual analog scale, specific for PD and composed of 15 sleep-related items. Scores less than or equal to 100 indicate sleep disturbances [26]. We also used the items separately to evaluate: (1) overall quality of night's sleep (item 1); (2) sleep onset and maintenance insomnia (items 2 and 3); (3) nocturnal restlessness (items 4 and 5); (4) nocturnal psychosis (items 6 and 7); (5) nocturia (items 8 and 9); (6) nocturnal motor symptoms (items 10–13); (7) sleep refreshment (item 14); (8) daytime dozing (item 15) [27].

Epworth Sleepiness Scale (ESS) Used to measure the degree of daytime sleepiness, consisting of 8 items, ranging from 0 to 3. Values above 9 points indicate the presence of excessive daytime sleepiness (EDS) [28].

Regarding the descriptive analysis of the data, these were presented as median and interquartile range according to their distribution of normality, through the Shapiro–Wilk test. The Mann–Whitney test was used to compare medians of continuous variables between good and poor sleepers, and the Chi-squared test for the comparison of the frequencies of good and poor sleepers according to sociodemographic variables, depression (GDS ≥ 5) and overweight or obesity (BMI > 25 kg/m^2). Last, the Spearman test was applied to analyze both the correlation between subjective and objective sleep parameters (with scatter plot figures presented) and for other associations of interest between continuous study variables. The significance level adopted was 5% and the analysis was performed through the program Statistical Package for Social Sciences (SPSS) version 20.

Results

The sample initially recruited was 52 individuals. Of these, four participants were excluded: one because did not reach the minimum score in the MMSE according to the inclusion criteria and three because of insufficient capture by the actigraph. Thus, the sample analyzed totaled 48 participants. The data referring to the characterization of the individuals, according to the continuous variables analyzed in the study, are presented in Table 1.

Table 2 presents data related to age, diagnosis time, daily dose of levodopa, the Hoehn & Yahr scale, UPDRS scale (II + III domain), MMSE, schooling (with and without higher education), marital status (with and without partner), depression (GDS-15) and body mass index (BMI—normal and overweight/obese), according to the stratification of the sample, taking into account the classification "good sleep" = PDSS > 100 and "poor sleep" = PDSS ≤ 100. No statistically significant differences were found for the variables cited, except for marital status and the GDS score.

According to the classification of sleep by the PDSS cut-off, Table 3 contains the data resulting from the evaluation of the individuals through the clinical scales, actigraphy, and sleep diary. A significant difference was observed in all items of PDSS, except in the item related with daytime dozing ($p = 0.10$). Also, no difference was observed in the ESS (0.64). Otherwise, no significant difference was observed between the groups in relation to the measurements obtained with the actigraph or diary.

Regarding the study of correlation between objective and subjective sleep variables, it was chosen to perform them as follows:

Results from the correlation analysis between the clinical sleep scales (PDSS, ESS, and PSQI) and data related to the characterization of the sample according to age, MMSE, HY, UPDRS, and GDS are obtained. For this block of analysis, we found weak but significant correlations between: PDSS and HY ($r_s = -0.30$; $P = 0.03$), PDSS and UPDRS ($r_s = -0.37$; $P = 0.008$), and PDSS and GDS values ($r_s = -0.43$; $P = 0.002$).

Results from the correlation analysis between the sleep diary variables (time went to bed, waking time, total bed time, total sleep time, latency, and efficiency) and data

Table 1 Data from individuals with PD ($n=48$) presented as median and interquartile ranges referring to all continuous variables analyzed

Variables	Median (25%–75%)
Age (years)	68.0 (64.7–69.6)
PD diagnostic time (years)	6 (2–8.75)
LEDD (mg)	587.5 (400–891)
HY (stage)	2.5 (2.3–2.7)
UPDRS (points)	31.0 (30.9–37.3)
MMSE (points)	27.0 (26.1–27.5)
GDS (points)	3.0 (2.0–6.0)
PSQI (points)	8.0 (5.0–11.0)
PDSS (points)	95.3 (73.1–111.8)
ESS (points)	9.0 (7.0–14.0)
Sleep diary	
Time went to bed (hh:mm)	22:30 (23:00–23:12)
Time woke up (hh:mm)	06:10 (05:34–06:56)
Total time in bed (h)	7.5 (7.1–8.5)
Total sleep time (h)	7.2 (6.5–8.1)
Latency (min)	15.0 (10.0–30.0)
Efficiency (%)	95.0 (91.0–97.0)
Actigraphy	
Time went to bed (hh:mm)	21:47 (20–22:50–:21)
Time woke up (hh:mm)	05:58 (05:10, 26–06:10)
Total time in bed (h)	9.0 (8.0–9.8)
Total sleep time (h)	7.0 (5.9–7.9)
Latency (min)	34.0 (19.0–58.0)
Efficiency (%)	77.0 (72.0–82.0)

LEDD levodopa equivalent daily dose, *HY* Hoehn & Yahr scale, *UPDRS* unified Parkinson's Disease Rating Scale (domains II and III), *MMSE* Mini Mental State Examination, *GDS* Yesavage Geriatric Depression Scale, *PSQI* Pittsburgh Sleep Quality Index, *PDSS* Parkinson's Disease Sleep Scale, *ESS* Epworth Sleepiness Scale, *hh:mm* hours:minutes

from the clinical sleep scales (PDSS, ESS, and PSQI) are obtained. For this block of analysis, there were also weak but significant correlations between the ESS scale and the hour that the individual went to bed ($r_s = 0.3$; $P=0.02$) and between PSQI and sleep efficiency ($r_s = -0.4$; $P=0.00$).

Results from the correlation analysis between the variables of the actigraph and the variables of the sleep diary are obtained. As presented in Fig. 1, bed time and wake-up time were moderately correlated, while total time in bed and total sleep time presented only weak correlations. No correlation was observed for sleep latency and sleep efficiency.

In an additional study, the data from the actigraph did not present significant correlations with any of the applied clinical scales, such as the MMSE, HY, UDPRS, or GDS, or with the clinical sleep scales PDSS, ESS, and PSQI.

Finally, there was a weak but significant correlation between the daily equivalent dose of levodopa and the HY scale ($r_s = 0.32$; $P=0.03$) and UPDRS ($r_s = 0.33$; $P=0.02$). However, when compared with the clinical scales of the disease, other sleep scales, actigraph variables, and sleep diary variables, no significant correlations were found.

Discussion

This study aimed to evaluate sleep quality in PD and the influence of notable aspects of the disease on sleep in this population. To be innovative, we also proposed to compare the methods used to obtain sleep information, to include subjective and objective monitoring in a real-life environment. Our results showed that patients present an overall reduction in sleep quality assessed with generic and specific sleep scales, with high frequency of those classified as having poor sleep quality. Moreover, sleep parameters measured objectively should not be replaced by subjective parameters and vice versa, since they evaluate distinct aspects. While subjective scales and registries refer to complexity of individual's perception about sleep, objective data obtained through actigraphy estimate sleep parameters based on the presence or the absence of movement.

In general, in the evaluation of sleep quality through clinical scales, considering all participants, we obtained results of alterations in subjective sleep quality according to the PSQI, PDSS and ESS scales. Because PSQI is a generic sleep rating scale (less sensitive tool to evaluate sleep in PD) and PDSS is a specific PD scale, we chose to use PDSS to categorize our sample into two groups, "good sleep" and "poor sleep". To complete the subjective evaluation, excessive daytime sleepiness (EDS) was analyzed. Even though the group median was below the EDS score, 21 (44%) of the 48 participants in the study presented scores above 10 on the ESS scale, corresponding to the EDS configuration point. In addition, the objective quality measured by the actigraph revealed sleep efficiency of 77%. These findings corroborate studies investigating sleep quality in PD, which used similar instruments of subjective evaluation and obtained similar results but presented smaller sample size than the present study [10, 11, 13].

The data derived from the study of the sleep diary and the actigraphy were similar with regard to time went to bed, waking time, total bed time, and total sleep time. However, it was noticed that the participants had difficulty in accurately assessing sleep latency, which possibly influenced the efficiency calculation. Although total sleep time was about 7 h for both sleep diary and actigraphy, the sleep latency varied from 15 min in self-reports to 35 min in actigraphic registries, producing a result of 95% efficiency obtained through the diary as opposed to 77% obtained by the objective measure of the actigraph. According to the recommendations of the Brazilian Sleep Association (Associação Brasileira do Sono) for the adult population, a normal night of sleep

Table 2 Overall results according to the classification between good and poor sleep by the PDSS scale

Variables	Good sleep ($n=20/42\%$)	Poor sleep ($n=28/58\%$)	p value*
Age (years)	68.0 (61.5–70.8)	69.0 (62.3–71.8)	0.73
Diagnostic time (years)	7.0 (2.5–9.0)	4.5 (2.0–8.0)	0.36
LEDD (mg)	663 (400–900)	500 (400–800)	0.16
HY (stage)	2.5 (2.0–3.0)	2.5 (2.5–3.0)	0.33
UPDRS (points)	29.0 (27.0–35.8)	34.0 (27.0–44.8)	0.17
MMSE (points)	27.5 (26.0–28.8)	27.0 (25.0–29.0)	0.61
GDS-15 (points)	2.0 (1.0–4.8)	4.5 (2.0–7.0)	0.01**
Gender (n—%)			
Women (21)	6–29.6%	15–71.4%	0.10
Men (27)	14–51.9%	13–48.1%	
Schooling (n—%)			
With higher education (11)	5–45.5%	6–54.5%	0.77
Without higher education (37)	15–40.5%	22–59.5%	
Marital status (n—%)			
With partner (36)	18–50.0%	18–50.0%	0.04**
Without partner (12)	2–16.7%	10–83.3%	
GDS-15 (n—%)			
With depression (19)	5–26.3%	14–73.7%	0.08
Without depression (29)	15–51.7%	14–48.3%	
BMI (n—%)			
Overweight/obese (32)	12–37.5%	20–62.5%	0.40
Normal weight (16)	8–50.0%	8–50.0%	

PDSS Parkinson's Disease Sleep Scale, *LEDD* Levodopa equivalent daily dose, *HY* Hoehn & Yahr scale, *UPDRS* Unified Parkinson's Disease Rating Scale (domains II and III), *MMSE* Mini Mental State Examination, *GDS* Yesavage Geriatric Depression Scale, *BMI* body mass index

*Obtained with the Mann–Whitney test for continuous variables and chi-square test for categorical variables

**p value < 0.05 (statistically significant values)

should last 7–8 h, with efficiency above 85% [29]. Therefore, in this study, the participants did not present satisfactory sleep efficiency through the objective measure, which is a reliable method and has been widely used in studies evaluating sleep quality in individuals with PD [12, 13].

The correlation analysis between the data from the actigraph and the diary supports these results, since the participants were able to report in a similar way the values regarding the time went to bed and waking time; data that influence the calculation of total bed time and total sleep time. On the other hand, the latency and efficiency data between the diary and actigraph did not correlate, possibly due to the difficulty patients had to accurately measure sleep latency. Similar results regarding the poor correlation for sleep latency and efficiency were found in a highly educated population of schoolteachers in Brazilian [30]. These data are similar to those found in a population-based study with healthy elderly individuals [31], which compared sleep quality through an actigraph and sleep diary, analyzing the variable total sleep time. As a result, they observed that participants overestimated the duration of their sleep through the diary, coinciding with our findings. Thus, we would discourage the use of diaries for the evaluation of sleep latency and efficiency in PD patients, as they inconsistently translate the sleep habits of these individuals.

General studies show that PD patients suffer from poorer night-time sleep in comparison with healthy controls using objective and subjective parameters but did not compare PD patients with each other. Klingelhorfer et al. [32] compared subjective measures (diary and scales) with objective measures (Parkinson's KinetiGraph—PKG) between patients with and without EDS. To our knowledge, no previous study compared subjective and objective sleep parameters between Brazilian PD patients. Therefore, for the detailed study of the possible differences of certain variables on sleep quality regarding "good sleep" and "poor sleep" groups, we verified that age, time of diagnosis, LEDD, staging, disease progression, and cognitive aspects were similar in both groups. With respect to the item depression, although the GDS score was significantly higher in the "poor sleep" group, these values are not compatible with depression in the group. We noticed that although the medians of the groups were below 5, there were 19 individuals (39.5%) with a score greater than or equal to 5, yet the frequency of distribution of depression

Table 3 Results of the clinical scales, actigraphy, and sleep diary according to the classification between good and poor sleep by the PDSS scale

Variables	Good sleep ($n=20/42\%$)	Poor sleep ($n=28/58\%$)	p value*
Scales			
PDSS (score)			
Overall quality of night's sleep	8.0 (5.3–9.4)	4,7 (4.0–5.5)	$<0.001^{**}$
Sleep onset and maint. insomnia	18.5 (13.1–19.6)	9.1 (6.2–13.2)	$<0.001^{**}$
Nocturnal restlessness	14.7 (10.5–18.5)	10.0 (5.1–11.8)	0.001^{**}
Nocturnal psychosis	19.5 (16.5–20.0)	10.5 (9.3–15.5)	$<0.001^{**}$
Nocturia	13.4 (10.0–16.1)	10.0 (6.0–10.3)	0.003^{**}
Nocturnal motor symptoms	33.4 (28.1–37.4)	21.5 (15.0–28.6)	0.001^{**}
Sleep refreshment	9.2 (7.7–10.0)	2.5 (1.0–5.3)	$<0.001^{**}$
Daytime dozing	9.3 (6.4–10.0)	8.5 (3.9–9.6)	0.10
Total score	117.3 (107.3–124.8)	75.0 (58.9–90.5)	$<0.001^{**}$
ESS (score)	8.0 (6.3–11.8)	8.5 (7.0–14.0)	0.64
Actigraphy			
Time went to bed (hh:mm)	21:41 (20:51–22:26)	21:45 (20:45–22:20)	0.88
Time woke up (hh:mm)	05:44 (04:46–06:39)	06:03 (05:27–06:29)	0.45
Total time in bed (h)	9.0 (7.5–10.3)	9.0 (8.3–9.6)	0.91
Total sleep time (h)	7.3 (5.7–9.7)	7.0 (5.9–7.9)	0.88
Latency (min)	31.7 (17.1–60.2)	36.7 (20.0–59.8)	0.55
Efficiency (%)	78.1 (72.4–82.6)	77.6 (69.3–84.3)	0.90
Sleep diary			
Time went to bed (hh:mm)	22:29 (21:53–23:20)	22:30 (22:00–23:11)	0.90
Time woke up (hh:mm)	06:33 (05:18–07:10)	06:18 (05:35–07:22)	0.91
Total time in bed (h)	7.4 (6.9–8.2)	7.8 (7.2–8.8)	0.10
Total sleep time (h)	7.0 (6.1–7.5)	7.5 (6.7–8.4)	0.13
Latency (min)	16.4 (10.4–25.5)	14.6 (10.0–30.0)	0.79
Efficiency (%)	96.4 (92.7–98.2)	95.1 (91.9–97.0)	0.33

PDSS Parkinson's Disease Sleep Scale, *ESS* Epworth Sleepiness Scale, *PSQI* Pittsburgh Sleep Quality Index, *hh:mm* hours:minutes, *h* hours, % percentage

*Obtained with the Mann–Whitney test for continuous variables and chi-square test for categorical variables

**p value <0.05 (statistically significant values)

among the groups of good and poor sleepers was still statistically similar. On the other hand, there was a correlation between the PDSS and GDS data ($r_s = -0.43$; $p=0.002$), characterizing the relationship between poor sleep and depression, which corroborates the results of other studies [14, 33]. The prevalence of depression in the population with PD is estimated at 23%, according to a recent meta-analysis [34]; however, this value is still variable, due to the different methodologies used to detect depression, either through the evaluation methods used, the interference of motor symptoms, or level of independence of the patient, and may often be under diagnosed [35]. In light of the foregoing, in-depth research designed to study the relationship between depression and sleep needs to be performed.

When analyzed according to gender, schooling, marital status, and BMI, only the marital status was different between groups, since the majority of participants without partners were allocated to the "poor sleep" group. In sample of married or cohabiting adults, Selcuk et al. [36] found that better quality of sleep was significantly associated with higher perceived partner responsiveness. Troxel et al. [37] reviewed the literature regarding the relation between marital quality and sleep, and concluded that relationship quality is importantly implicated with sleep and vice versa. Thus, it is reasonable to suggest that living without a partner predicts higher risk of sleep disturbances, what is consistent with our cross-sectional results for PD individuals. In other words, individuals with partners feel supported and accepted, so that the partner represents a psychological support for coping with the problems, especially the difficulties imposed by the disease.

Comparable data were found in studies with similar designs to ours that compared and classified individuals into good and poor sleepers through the PSQI scale. In these studies, variables such as age, gender, diagnostic time, LEDD, UPDRS score, disease staging, length of education,

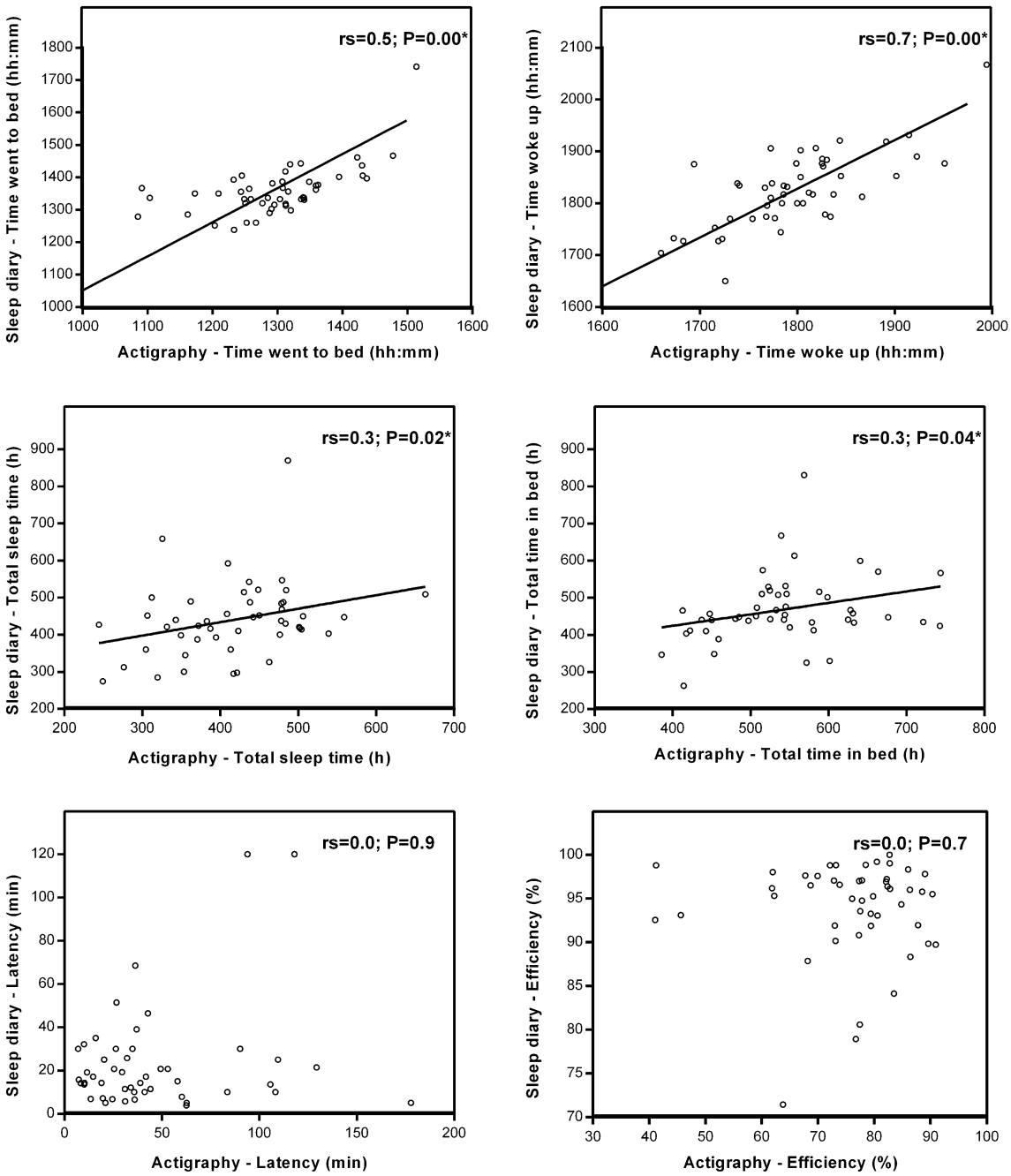

Fig. 1 Scatter plot indication of the correlation between variables related to the actigraph and sleep dairy. *hh:mm* hours, % percentage. *Statistically significant values

cognitive aspects, and EDS were not different between groups, and did not seem to exert an influence on the sleep quality of the participants [38–40].

Still detailing the measurements derived from the scales, diary and actigraph, and studying them according to the groups "good sleep" and "poor sleep", our participants presented differences in all domains of the PDSS, except for the item "daytime dozing". Correlation analysis between PKG and PDSS showed moderate–high correlations of the night-time sleep quality markers measured by the PKG with different domains of the PDSS representing reasons for nocturnal sleep disturbances such as sleep onset and maintenance insomnia, nocturnal restlessness as an indirect evidence of RLS, nocturnal psychosis and nocturnal motor symptoms with signs for RBD [32]. Although polysomnography is the gold standard to diagnose RLS and RBD, PDSS

domains may point out the need to investigate these symptoms accurately.

Moreover, the participants did not present differences in excessive daytime sleepiness analyzed by ESS and in time-measuring outcomes (or derived data) analyzed by diary and actigraph. That is, the collection of information from the diary and the actigraph were very similar among patients who were designated good and poor sleepers according to the PDSS. For the present authors, it seems that the subjective parameters (measured by the scales) exert a greater influence on sleep quality than the objective parameters, as even with almost identical results in the objective evaluation the patient still has the sensation of poor sleep quality, non-restorative sleep, tiredness, and fatigue. Harvey et al. [41] reported that sleep expectations and concerns are factors that may exacerbate sleep disturbances, leading the individual to overestimate the sleep deficit, and foster strategies to compensate for this perception of lack of sleep, such as excessive naps and extended periods of time in bed.

Although the NMS are well defined and present a high prevalence in PD, it is believed that the evaluation of sleep and management of these symptoms continues to be a challenge in the treatment of patients [42]. Considering the benefits of good sleep quality, such as maintenance of homeostasis, memory consolidation, favoring of physical performance, the restorative process, and neuroplasticity [43], this theme becomes even more relevant and worthwhile [31].

A better understanding of the factors influencing sleep quality in PD patients will lead to better therapeutic proposals in the control of these symptoms. For most PD patients, the longest time they spend without any pharmacological intervention is at night. Many clinicians prefer to avoid night-time dopaminergic therapy as it can worsen insomnia, hallucinations, dyskinesia and urinary frequency. Controlled release levodopa is often suggested as one solution; however, its duration of action does not provide full night-time coverage, particularly during the second half of the night where bed immobility has been shown to worsen. Another solution is the use of rotigotine transdermal patches which in many cases caused improvement in nocturnal outcomes (hypokinesia), clinical rating scales (UPDRS, PDSS, PSQI), polysomnography (sleep efficiency, sleep latency, REM sleep) and early-morning motor disability compared to placebos [44, 45]. Additionally, studies with non-pharmacological options such as physical exercise and rehabilitation programs should be performed. Associated with new treatment approaches, simple but effective measures can be applied, including sleep hygiene measures, such as adopting regular sleep times, avoiding prolonged naps in the afternoon, avoiding electronic devices in the room, reducing lighting in the nocturnal period, and avoiding stimulant agents such as coffee, tea, and nicotine. These precautions, in the long term, could improve the sleep quality of these individuals and minimize the impact of the disease on patients and their caregivers [29].

As limitations of the study, it should be considered that these results cannot be generalized for patients who are in advanced stages of the disease and that although actigraphy is a robust method and well accepted in the literature, it does not represent the gold standard for sleep evaluation. Although polysomnography is the gold standard method for objective assessment of sleep and allows the evaluation of electroencephalographic patterns (essential for REM sleep augmentation), respiratory changes, physiological aspects, and cardiorespiratory characteristics, it requires high expense with installation and maintenance, placing the individual in a different reality from the setting of their home and making it difficult to carry out studies with larger or population groups [13].

The relevance of this study, therefore, lies in the systematic investigation of sleep quality (still underestimated) in PD individuals, providing subsidies for a deeper analysis of sleep in this population based on instruments that are easy to apply and access, as well as low-to-medium cost. It is worth mentioning that for comprehensive analysis of the patient we recommend the use of clinical scales that represent the sensation of the patient's sleep, and actigraphy, which provides quantitative measures that serve as reference for the classification of the patient's sleep.

Conclusion

Sleep quality is impaired in PD when assessed by actigraphy and by clinical sleep scales. The management of sleep impairment is certainly a challenge in PD patients, thus detailed assessments are important to diagnose it. Parameters measured objectively should not be replaced by subjective parameters and vice versa due to the complexity of individual's perception about sleep.

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Compliance with ethical standards

Conflict of interest There are no potential conflicts of interest.

Ethical standards All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Ethical Committee Permission: Local Ethics Committee in Research with Human Beings, under the opinion of the CEP-UEL approval no. 1.356.676.

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