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Sleep in Parkinson's Disease: A Comparison of Actigraphy and Subjective Measures

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Abstract

Sleep disturbances are common in Parkinson's disease (PD). Actigraphy has emerged as an alternative to polysomnography to measure sleep, raising the question of its ability to capture sleep quality in PD patients. Our aim was to compare self-report data with actigraphic data and to examine associations with clinical variables. Thirty non-demented individuals with PD and 14 normal control participants (NC) were included. Sleep was measured using 24-hour wrist actigraphy over a seven-day period, during which time participants kept a sleep diary. Subjective sleep and arousal questionnaires included the Parkinson's Disease Sleep Scale, and Epworth Sleepiness Scale. Patients with PD presented with more sleep problems than NC. In NC, none of the actigraphic sleep variables were related to any of the self-report measures of sleep. In PD, scores on subjective sleep measures correlated with actigraphy-derived estimates of sleep quality. Our results suggest that actigraphy is an appropriate method of measuring sleep quality in PD.

Keywords

Parkinson's disease; sleep; actigraphy; subjective sleep ratings

Introduction

Sleep problems may occur in 75% of patients with Parkinson's disease (PD) over the course of the disease [1]. The most common are sleep fragmentation, sleep-related breathing disorders, restless legs/periodic leg movements, REM sleep behavior disorder (RBD), nocturnal hallucinations and altered sleep-wake cycle[2]. Patients with PD also experience disorders of arousal, namely sleep attacks and excessive daytime sleepiness[3].

Subjective and objective measures of sleep often show contradictory findings. In particular, middle-aged and older adults with insomnia tend to overestimate their lack of sleep and demonstrate large deviations between results obtained on subjective and objective measures[4,5]. Normal older adults with poor subjective sleep tend to consistently report

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shorter sleep durations than what is measured with actigraphy, while those with actigraphically measured poor sleep tend to report longer subjective sleep durations[6].

Few studies have compared subjective and objective measures of sleep in patients with chronic disease and only one study used both subjective and objective measures of sleep in PD[7]. The main focus of the study was to examine whether PD patients and healthy adults differ in how they report the quality of their sleep at home versus in the sleep lab, rather than conducting within-group comparisons of performance on subjective and objective measures.

Actigraphy has been used for many years to assess sleep and wake behavior[8] in healthy individuals and those with insomnia. Reliability and validity studies in healthy adults have demonstrated that actigraphy is highly correlated with polysomnography for differentiating sleep from wake states[9,10]. In PD, actigraphy has been used to study the impact of dopaminergic medication on sleep disruption[11-13], the efficacy of melatonin on improving sleep [14], and nocturnal motor activity[15]. To our knowledge, the utility of actigraphy in examining sleep quality in PD has not been investigated by comparing actigraphic measures of sleep quality to subjective measures but has been used to demonstrate improvement of sleep after treatment with transmagnetic stimulation[16]. Because actigraphy can be used in the home, actigraphy-derived results may represent more typical sleep patterns than those collected through polysomnography in a sleep laboratory.

Methods

Participants

Thirty patients with PD (19 men, 11 women) were recruited from the outpatient Movement Disorders Clinic at the Boston University School of Medicine. Fourteen age-matched control participants (NC) (7 men, 7 women) were recruited from the community. The study was approved by the Boston University Institutional Review Board and all participants provided informed consent. Individuals who scored 25 or below on the Mini-Mental State Examination (MMSE) were excluded, as were those with a history of substance abuse, head injury or neurologic disorders besides PD. None of the patients met criteria for Dementia with Lewy Bodies as per McKeith and colleagues[17]. All NC were healthy with no diagnosed sleep, psychiatric, or neurological disorders. All NC participants were right-handed and two PD participants were left-handed.

Medication information was obtained for all participants. For PD, levodopa equivalent dosages (LED) were calculated based on previous reports with LED: (regular levodopa dose × 1) + (levodopa controlled-release dose × 0.75) + (pramipexole dose × 67.0) + (ropinirole dose × 16.67) + (rotigotine × 16.67) + (pergolide dose and cabergoline dose × 67.0) + (bromocriptine dose × 10) + ((regular levodopa dose + levodopa controlled-release dose × 0.75) × 0.25) if taking tolcapone or entacapone)[18]. Table 1 describes all PD-group medications. None of the NC participants were taking any sleep or psychiatric medication. Motor symptom severity in PD was quantified using the Unified Parkinson's Disease Rating Scale (UPDRS) and Hoehn and Yahr stage. Based on the UPDRS, PD patients were further split into LPD (left-side onset, n=13) and RPD (right-side onset n=16). Data from one patient who reported bilateral onset of disease were excluded from side of onset subgroup analyses.

Comparison of clinical and demographic characteristics of PD and NC can be found in Table 1. There were no significant differences in age or education. Though the percentage of men was higher in the PD than in the NC group, the difference was not significant. Six patients were on medication for treatment of anxiety and depression and five patients were taking some form of sleep medication.

Sleep Measures

Objective Measure—To measure activity during the sleep/wake cycle, the participants wore wrist actigraphs (Actiwatch AW-64; Mini Mitter, Sunriver, OR) continuously over a 1-week period on each wrist. Data from the non-dominant wrist only was used for the current study, as per convention. The actigraphs were set to a medium sensitivity with 40 counts assessed as "wake" and an epoch length of 30 seconds. The Actiwatch data were downloaded to the Actiware sleep software version 5.3 (Mini Mitter). Results were averaged across the seven days of monitoring. The measures were sleep latency (first 10-minute period with less than two epochs of activity), sleep time (sum of time [in minutes] of epochs not exceeding the sensitivity threshold), sleep efficiency (sleep time divided by the time in bed multiplied by 100), wake after sleep onset (total time awake after the first sleep onset period) and movement and fragmentation index (number of 1-minute periods of immobility relative to the total number of immobility phases).

Subjective Measures—Each participant completed a sleep diary over the seven days of monitoring. The sleep diary was constructed using a previously published sleep diary from the National Sleep Foundation and adding questions pertinent to sleep/wake behaviors in PD. The diary included sections outlining daytime sleepiness, bed/rise times, time to sleep onset, total sleep time, number of daytime naps and number of awakenings.

Sleep complaints were assessed using the Parkinson's Disease Sleep Scale (PDSS)[19], which is used to identify sleep disturbances such as sleep maintenance, insomnia and excessive daytime sleepiness. The scale consists of 15 common symptoms. A score of 10 indicates worse symptoms and 0 indicates no symptoms. We examined the 15 items as nine factors, as described elsewhere[19]. Because of the common relation between sleep disorders and subjective daytime sleepiness, we administered the Epworth Sleepiness Scale (ESS)[20]. The score range is 0-24, with a score of 10 or more indicating excessive daytime sleepiness. The questionnaire is commonly used in PD[21,22].

Results

Statistical significance was set to a p-value of .01 for subjective/objective sleep-measures correlations to adjust for multiple comparisons. A p-value of .05 was used for all between subject comparisons of sleep measures and clinical variables.

Actigraphy—The results of the actigraphic measures (ACT) of sleep in PD and NC are shown in Table 2. PD patients had significantly worse sleep efficiency and more sleep fragmentation than NC. The groups did not differ on sleep onset latency or wake time after sleep onset.

Subjective sleep measures—The results of the comparisons between PD and NC on subjective sleep measures are shown in Table 3. Based on the sleep diary, there were no differences between PD and NC in the average estimated sleep onset latency or average total sleep time. PD patients reported taking more naps and feeling sleepy a greater proportion of the day than did NC participants. On the PDSS questionnaire, patients reported significantly more nocturnal motor symptoms and daytime dozing. There were no group differences on overall sleep quality or on sleep onset and maintenance. On the Epworth Sleepiness Scale, PD reported significantly more daytime sleepiness than did NC.

Subjective measures and actigraphy—In the NC group, none of the actigraphic sleep variables were significantly related to any of the self-report measures of sleep. In the PD group, there were multiple correlations between performance on the subjective sleep measures and the ACT (Table 4). In regard to the sleep diary, average estimated sleep time

was significantly related to the ACT total sleep time. The number of naps that the participant reported taking was significantly related to the average ACT sleep efficiency and total sleep time, indicating that those with worse sleep tended to take more naps. PDSS sleep quality was significantly related to ACT sleep efficiency, WASO, average total sleep time and sleep fragmentation. PDSS sleep onset and maintenance was significantly related to ACT average sleep onset latency and average sleep efficiency. PDSS nocturnal restlessness was significantly related to ACT sleep efficiency, average total sleep time and average sleep fragmentation. The PDSS total score was significantly related to ACT sleep efficiency and ACT sleep fragmentation. None of the other PDSS variables including nocturnal motor symptoms were significantly related to any of the ACT measures. ACT total sleep time was also significantly related to the total score on the ESS (r=-.480, p=.008).

Eleven of the PD patients were taking sedative, anxiolytic and antidepressant medication, which can impact both subjective and objective quality of sleep. When these patients were removed from the analyses, PDSS sleep quality was no longer significantly related to ACT WASO and PDSS daytime dozing was now significantly related to ACT total sleep time and sleep fragmentation. All the other main findings reported remained unchanged in this follow-up analysis.

Discussion

We evaluated subjective and objective sleep in patients with PD and healthy matched adults using actigraphy, a validated PD sleep questionnaire, a sleep diary, and questionnaires specifically assessing symptoms of insomnia and daytime sleepiness. Opposing the view that actigraphy may be too sensitive to PD nocturnal motor symptoms and not sensitive enough to measure immobility, we found significant correlations between actigraphic and all three subjective measures of sleep quality in the PD group, but not in NC.

The control participants overestimated their own sleep problems on the questionnaires relative to the objective measure, in accord with previous studies of healthy younger and older individuals assessed using actigraphy [6] and in the sleep lab[7,23]. In insomnia, there tend to be similar disparities between reported sleep quality and evidence from polysomnography [4,24]. By contrast, patients with PD may be more self-aware of their sleep deficits because these present as part of their symptom profile, and so are more likely to report problems that are consistent with their actual sleep difficulties[7]. The findings of older individuals over-reporting sleep problems and PD patients being more aware of their sleep deficits may account for the lack of significant group differences on the subjective measures of sleep quality.

The current study found that the frequency of napping reported by the patient was significantly associated with worse ACT quality of sleep. This is consistent with previous literature in healthy community-dwelling older adults showing that worse sleep quality is associated with increased diurnal nap duration measured using actigraphy [25]. Sleepiness in PD can arise from various etiologies, including sleep deprivation, dopaminergic medication and the pathology of the disease [26]. In the current study, we found that in addition to more frequent napping, worse ACT sleep quality is also associated with higher scores on the ESS, a measure of excessive daytime sleepiness. This merits further investigation into the association of sleep quality and daytime sleepiness in patients with PD using actigraphy, which allows longer-term objective measurement of daytime sleepiness than traditional questionnaire and objective measures.

A limitation of this study is that we used actigraphy and subjective sleep measures rather than using polysomnography, which is the gold standard for studying sleep.

Polysomnography requires several nights of sleep in a sleep lab, however, and contributes to patient burden and cost of the research. With actigraphy, patients are able to sleep in their own homes, which may increase patients' willingness to participate and enhance ecological validity. Further, relative to polysomnography, the duration of actigraphy can be increased to include more days, thereby enhancing reliability and providing more information on variability of sleep abnormalities. For these reasons, it is important to evaluate the utility of actigraphy in patients with PD, while acknowledging that future studies should validate actigraphy through comparison with polysomnography.

This study is the first to examine the utility of actigraphy in PD and to determine how actigraphy is related to the patients' subjective assessments of their sleep. Significant correlations between actigraphic measures and self-reported sleep problems indicate that actigraphy is an appropriate method of measuring sleep quality in PD.

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Table 1

Demographic and clinical variables in NC and PD participants. Means (SD) are reported.

	NC (n=14)	PD (n=30)	Significance
Age	62.8 (8.7)	66.1 (8.3)	ns
Education	16.9 (2.7)	16.8 (2.5)	ns
Men:women	7:7	18:11	ns
UPDRS total	n/a	27.8 (9.6)	n/a
Disease stage*	n/a	2 (2)	n/a
Disease duration	n/a	9.40 (5.2)	n/a
LED	n/a	625.5 (274.1)	n/a
Dopamine agonist (%)	n/a	79.3%	n/a

UPDRS –Unified Parkinson's Disease Rating Scale; LED – Levodopa Equivalent Dose; ns – not significant; n/a – not applicable

* Median (range)

Table 2

Actigraphy sleep variables in NC and PD participants. Means (SD) are reported.

	NC (n=14)	PD (n=30)	Significance
Sleep onset latency	20.0 (18.3)	25.8 (31.7)	ns
Sleep efficiency	79.5 (6.8)	69.1 (18.6)	p<.01
WASO	57.4 (12.8)	64.6 (34.8)	ns
Total sleep time	361.6 (41.5)	313.2 (118.2)	p<.05
Sleep fragmentation	17.1 (6.5)	28.2 (13.2)	p<.0001

WASO – wake after sleep onset; ns – not significant

Table 3

Subjective sleep variables in NC and PD participants. Means (SD) are reported.

	NC (n=14)	PD (n=30)	Significance
Diary sleep onset latency	20.7 (12.6)	13.4 (11.6)	ns
Diary total sleep time	407.4 (39.7)	407.5 (94.8)	ns
Diary number of awakenings	1.53 (.84)	1.80 (1.12)	ns
Diary daytime sleepiness	2.59 (.32)	2.18 (.40)	p<.001
Diary daytime naps	.24 (.28)	.84 (1.0)	p<.02
Epworth total	6.27 (3.5)	11.5 (4.6)	p<.002
PDSS sleep quality	3.86 (1.7)	4.82 (2.5)	ns
PDSS sleep onset and maintenance	7.07 (3.1)	7.43 (5.3)	ns
PDSS nocturnal restlessness	3.18 (2.8)	6.62 (4.9)	ns
PDSS nocturnal psychosis	1.46 (1.7)	3.47 (3.5)	ns
PDSS nocturia	5.35 (3.0)	7.28 (4.0)	ns
PDSS nocturnal motor symptoms	1.71 (2.3)	9.80 (7.0)	p<.0001
PDSS sleep refreshment	2.07 (1.3)	3.20 (2.5)	ns
PDSS daytime dozing	1.11 (1.9)	3.76 (2.8)	p<.001
PDSS total	25.8 (8.0)	45.8 (21.2)	p<.0001

PDSS – Parkinson's Disease Sleep Scale; ns – not significant

Table 4

Correlations between objective actigraphic measures and subjective questionnaire measures of sleep in patients with PD. Correlation coefficient (r-values) are reported.

	ACT SOL	ACT Sleep Effiency	ACT WASO	ACT TST	ACT Sleep Fragmentation
Diary SOL	.021	.069	.101	.270	−.031
Diary TST	.079	.347	.246	.604**	.013
Diary Daytime Sleepiness	−.138	−.010	−.194	−.175	−.338
Diary naps	.286	−.448*	−.033	−.544*	.328
PDSS Sleep Quality	.170	−.584**	.446*	−.564*	.503*
PDSS Sleep Onset and Maintenance	.550*	−.606**	.228	−.419	.385
PDSS Nocturnal Restlessness	.408	−.597**	.323	−.502*	.545*
PDSS Nocturnal Psychosis	.228	.−.147	.114	−.110	.290
PDSS Nocturia	.072	−.110	.343	.136	.275
PDSS Nocturnal Motor Symptoms	.340	−.221	.108	−.226	.236
PDSS Sleep Refreshment	−.108	.106	.144	.056	.132
PDSS Daytime Dozing	.024	−.202	.073	−.355	.164
PDSS Total	.411	−.489*	.330	−.413	.487*
ESS Total	.123	−.384	.199	−.537*	.413

SOL – Sleep Onset Latency; TST – Total Sleep Time; PDSS – Parkinson's Disease Sleep Scale; ESS – Epworth Sleepiness Scale; ACT – Actigraphic; WASO – Wake After Sleep Onset

* p<.01

** p<.0001