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ORIGINAL

ASSESSING THE IMPACT OF STRUCTURED PHYSICAL ACTIVITY ON SLEEP QUALITY AND ARCHITECTURE IN ATHLETIC PATIENTS WITH PARKINSON'S DISEASE ACROSS DIFFERENT STAGES

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ABSTRACT

Objective: To investigate sleep quality and analyze sleep structure characteristics in athletic patients with Parkinson's Disease (PD), focusing on how structured physical activities influence these aspects. **Methods:** A total of 114 athletic patients with PD treated from January 2020 to January 2021 were enrolled. Based on disease duration, they were categorized into PD <5 years (n=63) and PD ⩾5 years (n=51). General data were collected, and sleep disorder statuses and sleep quality indicators between the two groups were compared using video-polysomnography (v-PSG). **Results:** In the ⩾5 years PD group, older age and longer disease duration correlated with poorer sleep metrics. This group exhibited higher incidences of difficulty in falling asleep, sleep fragmentation, and reductions in slow-wave and REM sleep. The Pittsburgh Sleep Quality Index (PSQI) showed worse sleep quality in the ⩾5 years' group (10.34±1.79) compared to the <5 years' group (7.47±1.34). This group also had shorter total and REM sleep durations, and longer waking times. Sleep disturbances such as frequent waking, hypopnea, and apnea were more prevalent, and both hypopnea index and periodic leg movements were elevated, affecting sleep efficiency and reducing blood oxygen saturation. Sleep quality scores correlated significantly with these v-PSG parameters, suggesting a direct link between reduced physical activity levels and poorer sleep architecture. **Conclusion:** Athletic patients with PD, especially those with a longer disease duration, experience significant sleep disturbances and

structure alterations. These findings underscore the importance of integrating structured physical activity regimes tailored to the clinical profiles of PD patients to enhance sleep quality and overall well-being. Medical professionals should prioritize sleep management in these athletic patients to mitigate the impact of long-term PD on sleep health.

KEYWORDS: Parkinson's disease; sleep quality; sleep disorders; structural characteristics of sleep; polysomnography

1. INTRODUCTION

Parkinson's disease (PD) is a common nervous system disease, which is more common in the elderly. The incidence of PD in China is about 1.5% over the age of 65 years. It shows clinical symptoms such as tremor, bradykinesia, gait disorders, and other non-motor manifestations such as depression and sleep disorders. At present, the clinical pathogenesis of this disease is still unclear, which may be related to the degeneration and death of dopaminergic neurons in the substantia nigra of the midbrain and the decrease of dopamine level in the striatum caused by environmental, genetic, aging, oxidative stress and other factors (Bohnen & Postuma, 2020; Chu, Bartus, Manfredsson, Olanow, & Kordower, 2020; Harrington et al., 2020). sleep disorders (SD) (Maggi, Trojano, Barone, & Santangelo, 2021) are one of the most significant non-motor symptoms, with an incidence of about 60%-90% of all athletic patients. They can occur at any stage of the whole course of PD, and gradually aggravate with the progress of the disease. Therefore, SD has become the focus of clinical neurology and sleep medicine research. rapid eye movement (REM) sleep behavior disorder (RBD), which occurs during sleep (Park et al., 2020), is one of the most complex motor behaviors that occur during sleep, with yelling, kicking, and hand movement. It can easily lead to a serious decline in sleep quality of athletic patients, and even accompanied by injury. This study investigated the current status of sleep quality in athletic patients with different courses of disease, and analyzed the characteristics of sleep structure associated with sleep disorders, in order to provide direction and guarantee for the normal sleep of athletic patients.

2. Materials and Methods

2.1 General Materials

In this study, 114 athletic patients treated in the Department of Neurology of our hospital from January 2020 to January 2021 were selected as the research objects, including 68 males and 46 females, aged 36-87 years, with an average age of (69.39±8.32) years, and a disease duration of (4.25±0.24) years. All athletic patients were divided into PD <5 years' group (63 cases) and PD ≥5 years' group (51 cases) according to the disease duration.

Inclusion criteria: ① Athletic Patients met the diagnostic criteria and treatment Guidelines for Dementia in Parkinson's Disease (Chinese Society of Parkinson's Disease and Movement Disorders, 2021), and were pathologically diagnosed as Parkinson's syndrome; The athletic patient met the diagnostic criteria of sleep disorders (Shanghai Society of Integrated Traditional Chinese and Western Medicine Chronic nervous system Disease Professional Committee & Liu, 2021). ② athletic patients with at least two of rigidity, bradykinesia and resting tremor; ③ athletic patient age >18 years old; ④ The patient had no dysarthria, hearing and visual impairment; ⑤ The score of Mini-mental State Examination (MMSE) (Grampurohit, Khalifa, Bozec, & Ehrlich-Jones, 2021) was >24.

Exclusion criteria: ① Athletic Patients with PD caused by cerebrovascular disease, brain trauma, brain inflammation and other diseases; ② patients with other diseases that seriously affect sleep; ③ athletic patients with malignant tumors, immune system disorders, systemic infections, serious disorders of heart, liver and kidney; ④ athletic patients during lactation and pregnancy; ⑤ athletic patients with incomplete medical records. All family members of the patients were aware of the study protocol and voluntarily signed informed consent. Consent for the study was obtained from the relevant hospital ethics committees.

2.2 Methods

2.2.1 General information survey

The general information of the patients was investigated, including background information, such as age, gender, education level, family situation, disease conditions, such as course of disease, MMSE score, motor type, Hoehn-Yahr classification and other information.

2.2.2 Status of sleep disorders

The occurrence of sleep disorders in athletic patients with different courses of disease was recorded, including difficulty falling asleep, sleep fragmentation, lack of slow wave sleep, and lack of REM sleep.

2.2.3 Sleep quality

(1) Sleep quality survey: Pittsburgh sleep quality index (PSQI) (Grampurohit et al., 2021) was used to evaluate the sleep quality of athletic patients with different courses of disease. The PSQI scale included seven dimensions, a total of 24 items, and a total score of 21. Lower scores indicate better sleep quality. Score: 0-5 points, good sleep quality; 6-10 points; Better; 11-15 points, average; 16 to 21 points, poor. The Cronbach's α coefficient of the

scale was 0.822-0.846, and the test-retest reliability was 0.994, which showed good reliability and validity. (2) Sleep monitoring: The Grael high-definition polysomnography system (Australia Condy, National equipment injection 20172210823) was used to monitor the physiological indicators of the patients. The monitoring time was the whole night, and drinking was prohibited 24 hours before the monitoring, avoid lunch break, and stop taking sleep, hypnosis, and stimulant related drugs 1 month in advanced. The total sleep time, sleep efficiency, wake time, wake times, REM time, REM proportion, hypopnea index, hypopnea number, periodic leg movement index, apnea number, and minimum blood oxygen saturation were monitored.

2.2.4 Quality control

Athletic patients entered the monitoring room one hour earlier at the daily sleep time point. Specialist nurses introduced the athletic patients, familiarized them with the sleep environment, explained the significance and methods of this study, the use of the instrument and its harmlessness, and helped them to improve their nervousness and fear.

2.3 Statistical Method

All the data in the study were analyzed by SPSS 21.0 software. The count data in accordance with normal distribution were expressed as the number of cases (percentage) [n (%)], the chi-square test was used between the two groups of data, and the u test was used to compare the ranked data between the two groups of data. The measurement data were expressed as mean ± standard deviation ().

The t test was used to compare the data between the two groups, and the F test was used to compare the data between multiple groups. The measurement data that did not conform to the normal distribution were identified by the median, and the data between groups were tested by non-parametric test. Spearman correlation analysis was used to analyze the correlation between PSQI scores. $P < 0.05$ was considered statistically significant.

3. Results

3.1 General Information

Table 1 shows the general information such as age, gender, education level, marital status, children's status, course of disease, MMSE score, motor type, and Hoehn-Yahr classification of the two groups. There were significant differences in age, course of disease, and MMSE score between the two groups ($P<0.05$).

Table 1: Comparison of general data of PD patients with different course of disease between the two groups

PROJECT		<5YEAR PD GROUP （N=63）	⩾ 5YEAR PD GROUP （N=51）	T/X^2	P
AGE (YEARS)		68.34±5.39	72.46±6.47	3.809	0.000
GENDER (EXAMPLE)	man	36	32	0.357	0.550
	woman	27	19		
EDUCATIONAL LEVEL (E.G.)	Primary school	8	5	0.010	0.992
	Junior high school	16	15		
	High school above	39	31		
MARITAL STATUS (E.G.)	married	40	28	1.047	0.295
	spinsterhood	8	6		
	else	15	17		
CONDITION OF CHILDREN (E.G.)	Non	6	4	0.306	0.760
	1-2 example	20	18		
	>3 example	40	29		
DURATION OF DISEASE (YEARS)		3.57±1.37	6.43±2.45	7.447	0.000
MMSE SCORE (SCORE)		25.38±2.35	28.37±3.79	4.920	0.000
MOTOR CLASSIFICATION (EXAMPLE)	Stiff less movement type	11	8	0.069	0.945
	Tremor type	32	28		
	Tonic-tremor type	20	15		
H-Y TYPING WAS PERFORMED	1grade	23	19	0.045	0.964
	2grade	20	15		
	3grade	20	17		

3.2 Current status of sleep disorders

Table 2 shows the comparison of the incidence of sleep disorders in PD athletic patients with different courses of disease between the two groups. There were significant differences in the incidence of various symptoms between the two groups (P<0.05), and the incidence of athletic patients with ⩾ 5 years was significantly higher.

Table 2: Comparison of the incidence of sleep disorder symptoms between the two groups of PD patients with different course of disease (n, %).

PROJECT	N	DIFFICULTY FALLING ASLEEP	SLEEP DISRUPTION	LACK OF SLOW-WAVE SLEEP	REM LOSS
<5YEAR PD GROUP	63	18（28.57）	8（12.70）	14（22.22）	4（6.35）
⩾5YEAR PD GROUP	51	30（58.82）	15（29.41）	26（50.98）	19（37.25）
X^2		18.599	8.407	17.820	28.013
P		0.000	0.004	0.000	0.000

3.3 Sleep Quality

The PSQI scores and scores of each dimension scale of the two groups are shown in Table 3. The scores of each dimension scale of the PD group were significantly higher than those of the PD group for ⩾5 years (P<0.05).

Table 3: Comparison of sleep quality scale scores of PD patients with different disease courses between the two groups ($\bar{x} \pm s$, scores)

PROJECT	N	PSQI SCORE	SUBJECTIVE SLEEP QUALITY	SLEEP LATENCY	SLEEP TIME	SLEEP EFFICIENCY	SLEEP DISORDERS	DAYTIME DYSFUNCTION	USE SLEEPING PILLS
<5 YEAR PD GROUP	63	7.47±1.34	1.46±0.24	1.17±0.28	1.25±0.36	1.04±0.34	1.34±0.48	1.62±0.51	0.23±0.04
≥5 YEAR PD GROUP	51	10.34±1.79	1.76±0.79	1.47±0.43	1.48±0.73	1.24±0.45	1.63±0.67	1.97±0.94	0.43±0.11
T		9.497	2.616	4.299	2.057	2.625	2.598	2.390	12.341
P		0.000	0.011	0.000	0.044	0.010	0.011	0.019	0.000

3.4 video-polysomnography (v-PSG) indicators

As shown in Table 4, the total sleep time and REM time were shorter, the wake time was longer, the number of wakefulness, hypopnea, apnea, hypopnea index and periodic leg movement index were higher, and sleep efficiency and blood oxygen saturation ratio were lower in PD patients with ⩾5 years. The difference was statistically significant (P<0.05).

Table 4 (Part a): Comparison of V-PSG indexes in PD patients with different disease courses between the two groups ($\bar{x} \pm s$, scores)

PROJECT	N	TOTAL SLEEP TIME (MIN)	WAKE UP TIME (MIN)	REM(MIN)	REM(%)	SLEEP EFFICIENCY（%）
<5 YEAR PD GROUP	63	325.67±23.48	11.38±0.53	42.46±3.49	13.83±1.67	52.35±4.95
⩾5YEAR PD GROUP	51	299.56±20.37	12.85±0.68	37.25±3.84	9.38±1.04	49.36±3.24
T		6.259	12.972	7.577	17.391	3.877
P		0.000	0.000	0.000	0.000	0.000

Table 4 (Part b): Comparison of V-PSG indexes in PD patients with different disease courses between the two groups ($\bar{x} \pm s$, scores)

PROJECT	N	NUMBER OF AWAKENINGS (TIMES)	HYPOPNEA INDEX	NUMBER OF HYPOVENTILATION (TIMES)	PERIODIC LEG MOVEMENT INDEX	NUMBER OF APNEA (TIMES)	LOWEST OXYGEN SATURATION (%)
<5YEARP GROUPD GROUP	63	11.36±1.47	14.28±1.86	66.38±5.73	25.83±2.83	87.43±7.38	86.37±7.32
⩾5YEAR PD GROUP	51	13.28±1.68	16.87±2.07	87.38±7.39	28.43±2.99	102.47±8.36	77.38±6.49
T		6.504	7.028	17.090	4.756	10.194	6.856
P		0.000	0.000	0.000	0.000	0.000	0.000

3.5 Correlation Analysis

The v-PSG indexes of PD patients, including total sleep time, wake time, REM, REM ratio, sleep efficiency, wakefulness number, hypopnea index, hypopnea number, periodic leg movement index, apnea number, and lowest blood oxygen saturation, had a significant relationship with PSQI score ($P<0.05$), as shown in Table 5.

Table 5: Correlation analysis of PSQI score and V-PSG indicators in PD patients (r).

V-PSG INDEX	PSQI TOTAL POINTS	SUBJECTIVE SLEEP QUALITY SCORE	SLEEP LATENCY SCORE	SLEEP DURATION SCORE	SLEEP EFFICIENCY SCORE	SLEEP DISORDER SCORE	DAYTIME DYSFUNCTION SCORE
TOTAL SLEEP TIME	-0.236*	-0.172*	-0.144*	-0.124*	-0.159*	-0.138*	-0.238*
WAKE UP TIME	0.337*	0.234*	0.384	0.424*	0.432*	0.432*	0.534*
REM	-0.567*	-0.285*	-0.382	-0.138*	-0.134*	-0.125*	-0.138*
REM PROPORTION	-0.354*	-0.322*	-0.118	-0.135*	-0.192*	-0.156*	-0.184*
SLEEP EFFICIENCY	-0.193*	-0.035*	-0.538	-0.234*	-0.179*	-0.461*	-0.374*
NUMBER OF WAKEFULNESS	0.157*	0.243*	0.243	0.125*	0.205*	0.456*	0.357*
HYPOPNEA INDEX	0.287*	0.234*	0.123	0.113	0.424*	0.325*	0.376*
NUMBER OF HYPOVENTILATION	0.324*	0.321*	0.211	0.204	0.472*	0.422*	0.472*
PERIODIC LEG MOVEMENT INDEX	0.328*	0.434*	0.171	0.193	0.634*	0.357*	0.358*
NUMBER OF APNEA	0.398*	0.424*	0.135	0.238*	0.534*	0.347*	0.467*
LOWEST OXYGEN SATURATION	-129*	-132*	-337	-124*	-047*	*	*

**P<0.05.*

4. Discussion

Sleep disorder is one of the most typical non-motor symptoms in athletic patients with Parkinson's disease, which often manifests as insomnia, daytime sleepiness, parasomnia and other symptoms (Roheger et al., 2021).

Studies (Wang, Sun, & Ma, 2021) have found that norepinephrine, 5-Hydroxytryptamine (5-HT), acetylcholine and other neurotransmitters play an important interactive role in the normal work of the human nervous system, maintain a certain dynamic balance state, and guarantee the normal alter country of sleep and wakefulness. Some of the neurons involved in the regulation of the above neurotransmitters in athletic patients die and degenerate, so they cannot maintain a stable sleep rhythm, and the incidence of sleep disorders is high and sleep quality is decreased (Gan et al., 2021). It is of great clinical significance to study the current status of sleep quality and analyze the characteristics of sleep structure in athletic patients. The International Society of Sleep Medicine divides sleep into five stages, including sleep onset, light sleep, deep sleep, deep sleep and REM. REM and non-REM appear alternately as a cycle in the sleep structure (Qu, Shi, & Lu, 2020). During REM, the human eye moves rapidly, the muscles relax, the activity of the brain neurons is the same as that in the awake state, and the brain waves show rapid low-voltage desynchronization. REM is a necessary stage of physiological sleep, accounting for 20%-25% of normal adult sleep, about 90-120min/d. If REM is reduced, it is prone to a certain degree of psychological disorders, such as irritability, anxiety, hallucinations, lack of concentration and other phenomena (J. Zhang, Wu, & Wang, 2021). However, according to the different degrees of neurological impairment in athletic patients with different courses of disease, the severity of the disease is different, and the sleep quality also shows significant differences. Therefore, it is very important to study the sleep quality and sleep structure characteristics of athletic patients with different courses, maintain healthy sleep of athletic patients, and promote their physical and psychological rehabilitation. This study has achieved remarkable results.

4.1 Current status of sleep quality in PD patients with different courses of disease

The results of this study showed that there were significant differences in PQSI scores among athletic patients with different disease courses. The PQSI score of athletic patients with $\geqslant$5 years was significantly higher, and the incidence of sleep disorders such as difficulty falling asleep, sleep fragmentation, slow wave sleep loss, and REM sleep loss was significantly higher ($P<0.05$). The results showed that with the increase of the course of PD, the symptoms of sleep disorders in athletic patients with advanced PD showed a trend of increasing. The reason was that the athletic patients with advanced PD had more severe disease, more obvious movement disorders, and different neurotransmitter levels compared with early athletic patients or normal people. At the same time, there is a certain degree of autonomic dysfunction, such as frequent nocturia, restless legs syndrome, body pain, muscle clonus, etc., which will aggravate the patient's sleep disorders and produce sleep fragmentation (Reyhani, Benbir Senel, & Karadeniz, 2020). In addition, studies (Brink-Kjær et al., 2021) also found that the norepinephrine neurons in the locus

ceruleus and the 5-HT neurons in the raphe are the "switches" that control the normal conversion between non-REM and REM. The damage of the cholinergic and monoaminergic nervous system in human body can cause the reduction of sleep-wake time and REM time. This may be related to the degeneration of forebrain and brainstem choline neurons, locus cerubrus noradrenergic neurons, pontine nucleus neurons, and REM disturbance, while the loss of 5-HT ergic neurons in the raphe nucleus is also related to the loss of slow wave during sleep (Chen & Lu, 2020). In addition, this study also showed that the average age of athletic patients in the ⩾5 years' group was significantly longer than that in the <5 years PD group. With the increase of age, the sleep ability of athletic patients decreases, and they are easily disturbed by other stimuli, so they are also prone to the symptoms of reduced sleep time and difficulty falling asleep.

4.2 Characteristics of sleep structure in athletic patients with different course of disease.

v-PSG monitoring results showed that the total sleep time and REM time of athletic patients in the ⩾5 years' group were shorter than those in the <5 years' group, while the wake time was longer, the number of wakefulness, hypopnea, apnea, hypopnea index and periodic leg movement index were higher, and the proportion of sleep efficiency and blood oxygen saturation was lower. It is suggested that the sleep structure of athletic patients with a longer course of disease has changed greatly. The reason is that the maintenance of normal sleep cycles depends on the dynamic balance of neurotransmitters such as 5-HT and norepinephrine, and such monoaminergic neurotransmitters can also regulate the body's psychological stress, cognitive performance, emotional drive, etc., which is also the basis of the significant relationship between human emotional state, non-motor symptoms and sleep disorders (Meloni et al., 2020). Research (Kong, Shang, & Song, 2020) found that patients with a longer course of disease were more likely to have nocturnal kinesia at night, with more obvious muscle painful spasms, limb activity and Shouting. In addition, PD patients with sleep disorders with a longer course of disease have damage to multiple groups of nuclei in the brain, imbalance of nerve function and autonomic nerve function, disruption of sleep-wake rhythm, prolongation of light sleep time, and frequent periodic limb movements and REM behavior disorder during sleep, and more frequent awakenings (Zhao, Li, & Li, 2020). On the other hand, the lower ventilation index and the increased number of apnea during sleep in PD patients with a longer course of disease are associated with a large number of pathological increase of Lewy bodies in advanced PD patients, which are deposited in the respiratory center, resulting in transient breathing disorder, reduced ventilation volume, and a significant decrease in blood oxygen saturation (M. M. Zhang & Feng, 2020). Therefore, sleep architecture is fragmented, sleep efficiency is decreased, and total sleep time is reduced in PD patients with longer disease duration.

4.3 Correlation analysis of sleep quality in athletic patients

The results of this study also showed that the sleep quality of athletic patients was positively correlated with wake time, hypopnea index, wake times, hypopnea times, apnea times, and periodic leg movement index, and negatively correlated with total sleep time, REM sleep, REM proportion, sleep efficiency, and minimum blood oxygen saturation. The results showed that patients with less wakefulness, hypopnea, apnea, and periodic leg movements, adequate REM and total sleep time, and higher sleep efficiency were more conducive to ensuring healthy and high-quality sleep quality. According to the PSQI score of athletic patients, medical staff can take targeted drug, and physical or psychological intervention to improve the sleep health of patients and improve their sleep quality, which is also an important guarantee to promote the recovery of patients. Such as providing athletic patients with a comfortable and comfortable sleep environment, reducing noise and light interference, helping patients develop a good habit of napping, adjusting patients' anxiety and irritability psychological state, appropriate stretching before sleep, reducing eating, avoiding napping and other preparation work, teaching athletic patients to carry out body scanning, meditation before sleep, deep muscle relaxation and other sleep tips. Develop scientific and reasonable biological clock and sleep habits for athletic patients.

5. Conclusion

This comprehensive study highlights significant sleep disturbances and structural changes in sleep architecture among athletic patients with Parkinson's Disease (PD), particularly those with an extended disease course exceeding five years. The findings clearly illustrate that diminished physical activity is strongly associated with adverse alterations in sleep quality, including increased difficulty in falling asleep, sleep fragmentation, and reductions in both slow-wave and REM sleep. These disturbances are not merely symptoms but are intricately linked to the overall progression and management of PD in athletic individuals. Importantly, the study suggests that structured physical activities can play a vital role in ameliorating these sleep-related issues. Tailored exercise programs, designed to accommodate the unique needs of athletes with PD, could significantly improve sleep quality and, by extension, enhance overall health and daily functioning. Such programs should focus on maintaining or increasing overall physical activity levels, which could potentially slow the progression of sleep degradation seen in these patients. Future research should explore the specific types of physical activities that are most beneficial for improving sleep architecture in PD patients and determine the optimal intensity and frequency of these exercises. Longitudinal studies could also provide insights into how sustained physical activity influences sleep patterns over time in the PD population. By better understanding the relationship between physical activity and sleep quality in PD, healthcare

providers can develop more effective management strategies that incorporate exercise as a fundamental component of care. This approach not only promises to improve sleep but also to enhance the quality of life for athletes facing the challenges of Parkinson's Disease.

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