Original Research

A Comparative Study of Architecture and Quality of Sleep among Juvenile Myoclonic Epilepsy Patients and Healthy Individuals Attending Tertiary Care Hospital in Central India

Ashwin Lathiya*, Dilip Maheshwari, Bharat Bhushan, Vijay Sardana, Vaibhav Somvanshi, Shubham Garg, Vinod Jatav

Department of Neurology, Government Medical College, Kota, Rajasthan, India

Received: 20 Apr. 2022 Accepted: 13 Jun. 2022

Abstract

Background and Objective: Primary sleep disorders are common in patients with epilepsy. Seizures, epileptiform discharges, and antiepileptic drugs alter the sleep architecture of patients with juvenile myoclonic epilepsy (JME). We evaluated sleep architecture and its quality in these patients.

Materials and Methods: Thirty patients with JME (11 men and 19 women with mean age of 21.10 ± 4.55 years) and 30 healthy controls underwent overnight polysomnography (PSG). Sleep quality and daytime sleepiness were assessed using Pittsburgh Sleep Quality Index (PSQI) and Epworth Sleepiness Scale (ESS), respectively.

Results: Myoclonus and generalized tonic-clonic seizures (GTCS) were present in all patients with JME, while absence seizures were in 13.3%. Sleep deprivation was the most frequent precipitating factor for seizures (56.6%) followed by fatigue, sound, and photic stimulation. Patients with JME reported a statistically significant drop in sleep efficiency (P<0.001) with prolonged sleep onset latency (P<0.001). There was prolongation in the N1 stage of non-rapid eye movement (NREM) sleep (P=0.002), and reduction in the N2 stage of NREM (P<0.001) and rapid eye movement (REM) sleep (P<0.001). The median PSQI score was higher in patients with JME, suggesting poor sleep quality (P<0.001), and the daytime sleepiness was not different as indicated by the similar median ESS score (P=0.033).

Conclusion: Our results suggest a significant alteration in the sleep architecture of patients with JME with reduced sleep efficiency and poor sleep quality. The possible role of the disease itself is suggested for these alterations as a similar trend was also observed in drug naïve patients.

Keywords: Sleep quality; Polysomnography; Juvenile myoclonic epilepsy

Citation: Lathiya A, Maheshwari D, Bhushan B, Sardana V, Somvanshi V, Garg S, et al. **A Comparative Study of Architecture and Quality of Sleep among Juvenile Myoclonic Epilepsy Patients and Healthy Individuals Attending Tertiary Care Hospital in Central India.** J Sleep Sci 2022; 7(3-4): 68-74.

Introduction

Patients with epilepsy frequently complain of sleeping problems. Sleep and epilepsy are generally considered uneasy bedfellows (1). Patients with epilepsy have primary sleep disorders a couple of times more common than the general population, including sleep-maintenance insomnia, excessive daytime sleepiness (EDS), and obstructive sleep apnea (OSA). In addition to poorly affecting the quality of life (QOL) of the general population (2), sleep disorders also adversely affect daytime performance, scholastic performance, cognitive function, and QOL in patients with epilepsy (3-5). Sleep architecture and quality appear to be affected by nocturnal and daytime seizures (6). Apart from that, various antiepileptic agents are also known to influence sleep architecture among patients with epilepsy (7-9).

First described by Herpin (10) and later known as impulsive petit mal (11), and after that by Lund et al. as Juvenile myoclonic epilepsy (JME) (12), is one of the most common forms of idiopathic

* ***Corresponding author****: A. Lathiya, Department of Neurology, Government Medical College, Kota, Rajasthan, India*
Tel/ Fax: +91 971215808
Email: ashwinlathiya55@gmail.com

generalized epilepsy. It represents 5-10 percent of idiopathic generalized epilepsy cases (13). Popularly known as awakening-related epilepsy, JME has specific age of onset with slight female predominance and a characteristic seizure profile of myoclonic jerks, generalized tonic-clonic seizures (GTCS), and absence seizures (14). Previous studies showed that in addition to seizures altering macro and micro-architecture of sleep (15), epileptiform discharges by acting as internal arousing stimuli led to poor sleep quality in patients with JME (16). This study aimed to evaluate sleep architecture and its quality and daytime sleepiness in patients with JME whether on treatment or drug naïve. Very few studies evaluated sleep architecture in drug naïve patients with JME. Moreover, this study analyzed any effect of antiepileptic drugs on sleep architecture and its quality in patients with JME.

Materials and Methods

This was a hospital-based single-center prospective observational case-control study conducted at the Department of Neurology in a tertiary care hospital setting from January to December 2021. The study commenced after obtaining ethical clearance from the institutional ethics committee. All patients with JME, diagnosed according to the International League Against Epilepsy (ILAE) criteria (17), attending neurology outdoor and indoor services fulfilling inclusion criteria were included in the study after taking written informed consent during the study period. Any male or female patient with a history of myoclonic jerks with GTCSs or absence seizures was included. The study size was limited because of the defined study period. Patients with myoclonic seizures secondary to hypoxic brain damage, metabolic disorders, or other structural brain disorders were excluded. Detailed history, including family and drug history, and clinical and neurological examinations, were performed among all patients by the first researcher. Previous electroencephalography (EEG) and brain magnetic resonance imaging (MRI) reports were reviewed. Thirty healthy age- and gender-matched controls who did not have a history of neurological or psychiatric disorders and were not on any medications were included. They were the attendants of the patients admitted for other ailments, neither of them was on any treatment nor had any family history of seizure disorder. Patients with JME were divided into two groups of drug naïve and those on treatment. Further subgrouping was done for patients on treatment into valproate monotherapy or polytherapy and valproate dose of ≤ 600 or > 600 mg/d.

Among the subjects, sleep quality and daytime sleepiness were assessed via Pittsburgh Sleep Quality Index (PSQI) (18) and Epworth Sleepiness Scale (ESS) (18), respectively. PSQI assesses sleep quality in the last month and includes 19 self-rated questions evaluating various factors influencing sleep quality, grouped into seven components scores, including: 1) sleep duration, 2) sleep disturbance, 3) sleep latency, 4) daytime dysfunction due to sleepiness, 5) sleep efficiency, 6) overall sleep quality, and 7) sleep medication use, each rating from 0 to 3 (0 = no difficulty, 1 = mild difficulty, 2 = moderate difficulty, 3 = severe difficulty) with total score ranging from 0 to 21. Subjects with PQSI > 5 were considered poor sleep quality (18). ESS assesses the daytime sleepiness of the individual, which includes the likelihood of falling asleep over eight situations, each rated from 0 to 3 (0 = would never doze, 1 = slight chance of dozing, 2 = moderate chance of dozing, 3 = high chance of dozing) with total score ranging from 0 to 24 (19). ESS $\geq$ 10 indicates EDS.

Sleep architecture was evaluated with overnight polysomnography (PSG), which was performed in the Department of Neurology having sixteen-channel EEG, chin and anterior tibialis surface electromyography (EMG), electrocardiography (ECG), electrooculography (EOG), chest and abdominal movement monitor, and pulse oximetry. Subjects were asked to have a relaxed day without daytime sleep. They were instructed to avoid strenuous exercise and caffeine in the afternoon or evening on the day of PSG. To avoid the first-night effect, subjects were asked and allowed to have a familiar sleep routine including pillow, pajamas, etc. during the PSG and they were allowed to go to sleep during their routine time. The temperature and darkness of the room were adequately maintained. All the eligible patients and healthy controls underwent overnight PSG. Various parameters were recorded, including total sleep time, sleep period time, sleep efficiency, sleep onset latency, rapid eye movement (REM) sleep latency, wake after sleep onset (WASO), and various stages of sleep. Scoring of the events was under the rules of the American Academy of

Sleep Medicine (AASM) (20). Recorded data were analyzed and compared among patients with JME, control group, and its subgroups.

Quantitative data were expressed as mean ± standard deviation (SD) and qualitative data were expressed as numbers and percentages. Median and interquartile ranges (IQRs) were used for continuous variables with a non-parametric distribution. The normality of the data was checked using the Shapiro-Wilk test. A comparison of PSG sleep parameters along with sleep quality and the likelihood of daytime sleepiness among patients with JME and the control group was done by the Mann-Whitney test. Sleep efficiency among patients with JME and controls as well as patients on valproate monotherapy and polytherapy was compared using a chi-square test. A P-value less than 0.05 was considered statistically significant. There was no missing data. Data were analyzed with Jamovi software (version 2.3).

Results

A total of 30 patients with JME fulfilling inclusion criteria were included in the analysis. The mean age of patients with JME was 21.10 ± 4.55 years, while that of control group was 23.13 ± 5.76 years (P = 0.19). Male/female ratio was 1:1.7 and 1:1.3 among patients with JME and controls, respectively (P = 0.79). Myoclonus and GTCS were present in all patients with JME, while absence seizures were in 13.3% of patients. The mean age of onset of myoclonus was 12.23 ± 1.67 years among all patients with JME, whereas it was 13.42 ± 1.58 and 8.71 ± 0.75 for GTCS and absence seizure, respectively. Seventy percent of all patients with JME reported seizure occurrence while awakening from sleep, and 10% of all patients with JME had nighttime seizures. Twenty percent of patients did not report any diurnal variation of seizure. Most patients reported sleep deprivation as a precipitating factor for seizure (n = 17, 56.6%) and other factors were fatigue (n = 8, 26%), sound (n = 4, 13.3%), and photic stimulation (n = 2, 6%) (Table 1).

While comparing PSG data among patients with JME and controls, median total recording time was higher in patients with JME but median sleep time was lower in these patients. Patients with JME reported a statistically significant drop in sleep efficiency [73.8 (52.1-87.8) vs. 84.5 (79.5-93.0), P < 0.001] compared to controls. Sleep onset latency was higher among patients with JME compared to controls [17.5 (3-31) vs. 4.5 (2-10), P < 0.001].

Table 1. Demographic profile of the study

Parameters	JME total patients (n = 30)	JME patients on treatment (n = 24)	Drug naïve JME patients (n = 6)
Age (year)	21.10 ± 4.55	21.79 ± 4.53	18.33 ± 3.72
Gender			
Men	11 (36.7)	10 (41.7)	1 (16.7)
Women	19 (63.3)	14 (58.3)	5 (83.3)
Seizure types			
Myoclonus	30 (100)	24 (100)	6 (100)
GTCS	30 (100)	24 (100)	6 (100)
Absence	4 (13.3)	3 (12.5)	1 (16.6)
Age of onset of the seizure (year)			
Myoclonus	12.23 ± 1.67	12.21 ± 1.72	12.33 ± 1.63
GTCS	13.42 ± 1.58	13.46 ± 1.59	13.16 ± 1.72
Absence	8.71 ± 0.75	8.50 ± 0.57	9.00 ± 1.00
Diurnal variation of seizure			
Seizure on awakening	21 (70.0)	18 (75.0)	3 (50.0)
Seizure during nighttime	3 (10.0)	2 (8.3)	1 (16.7)
No diurnal variation	6 (20.0)	4 (16.7)	2 (33.3)
Precipitating factors			
Sleep deprivation	17 (56.6)	13 (54.1)	4 (66.6)
Sound	4 (13.3)	3 (12.5)	1 (16.0)
Photic stimulation	2 (6.0)	2 (8.0)	0 (0)
Fatigue	8 (26.0)	6 (25.0)	2 (33.3)

Data are presented as mean ± standard deviation (SD) or number and percent
JME: Juvenile myoclonic epilepsy; GTCS: Generalized tonic-clonic seizure

Table 2. Polysomnographic (PSG) sleep parameters among patients with juvenile myoclonic epilepsy (JME) and controls

Parameters	JME group (n = 30)	Control group (n = 30)	Statistics*
SPT (minute)	423 (214-491)	404 (328-456)	U = 313.5, P = 0.044
TST (minute)	305 (170-421)	340 (260-400)	U = 286, P = 0.015
Sleep efficiency (%)	73.8 (52.1-87.8)	84.5 (79.5-93.0)	U = 106.5 , P < 0.001
Sleep latency (minute)	17.5 (3-31)	4.5 (2-10)	U = 133, P < 0.001
REM latency (minute)	103 (67-243)	106 (80-156)	U = 425, P = 0.717
Wake (%)	19 (12-25)	11.5 (6-22)	U = 109, P < 0.001
Stage N1 (%)	10.9 (5-19)	9 (7-10)	U = 238, P = 0.002
Stage N2 (%)	42 (23-52)	49 (41-56)	U = 168.5, P < 0.001
Stage N3 (%)	17.9 (10.4-34)	20 (13-25)	U = 367, P = 0.219
Stage R (%)	2.4 (0-11)	7 (5-12)	U = 51, P < 0.001
Respiratory index (AHI)	2 (0-5)	2 (0-4)	
PLM index	0 (0-50)	0 (0-7)	

Data are presented as median and interquartile range (IQR)
*Mann-Whitney U test
JME: Juvenile myoclonic epilepsy; REM: Rapid eye movement; N1: Non-rapid eye movement stage 1; N2: Non-rapid eye movement stage 2; N3: Non-rapid eye movement stage 3; SPT: Sleep period time; TST: Total sleep time; AHI: Apnea-hypopnea index; PLM: Periodic limb movement

However, the REM sleep latency of two groups was comparable. Patients with JME spent more time awake during PSG compared to controls [19 (12-25) vs. 11.5 (6-22), P < 0.001]. The distribution of sleep stages was significantly changed among patients with JME compared to controls with prolonged N1 stage [10.9 (5-19) vs. 9 (7-10), P = 0.002] and reduced N2 stage [42 (23-52) vs. 49 (41-56), P < 0.001] of non-REM (NREM) sleep. The N3 stage of NREM sleep was comparable among the two groups. REM sleep was reduced among patients with JME compared to controls [2.4 (0-11) vs. 7 (5-12), P < 0.001] (Table 2).

Subgroup analysis of patients with JME showed that the majority of patients with JME had sleep efficiency of less than 80%. It was also evident that the majority of patients with JME on valproate monotherapy or polytherapy had sleep efficiency of less than 80% (Tables 3 and 4).

Compared to control group, a greater number of patients with JME had PSQI score > 5 (n = 11, 36.7% vs. n = 2, 6.7%). Patients with JME had higher median PSQI scores than controls, suggesting poor sleep quality among patients with JME [4 (0-7) vs. 1 (0-8), P < 0.001]. The likelihood of daytime sleepiness was also reported higher among patients with JME.

Table 3. Sleep efficiency among patients with Juvenile myoclonic epilepsy (JME) and Controls

Sleep efficiency (%)	Group		Statistics*
	JME (n = 30)	Control (n = 30)	
≥ 80	5 (16.7)	23 (76.7)	X^2 = 21.7, P < 0.001
< 80	25 (83.3)	7 (23.3)	

Data are presented as number and percent
*Chi-square test
JME: Juvenile myoclonic epilepsy

The majority of the patients with JME and controls had ESS scores < 10 (n = 27, 90.0% and n = 29, 96.7%, respectively) (Table 5).

Table 4. Sleep efficiency among patients with juvenile myoclonic epilepsy (JME) on valproate monotherapy and polytherapy

Sleep efficiency (%)	Valproate monotherapy (n = 18)	Polytherapy (n = 12)	Statistics*
≥ 80	3 (16.7)	2 (16.7)	X^2 = 0.00, P > 0.999
< 80	15 (83.3)	10 (83.3)	

Data are presented as number and percent
*Chi-square test

Table 5. Sleep quality and the likelihood of daytime sleepiness among patients with juvenile myoclonic epilepsy (JME) and control group

Parameters	JME group (n = 30) [n (%)]	Control group (n = 30) [n (%)]	Statistics*
PSQI score	4 (0-7)	1 (0-8)	U = 188, P < 0.001
> 5	11 (36.7)	2 (6.7)	
≤ 5	19 (63.3)	28 (93.3)	
ESS score	2 (1-11)	2 (0-12)	U = 309, P = 0.033
≥ 10	3 (10.0)	1 (3.3)	
< 10	27 (90.0)	29 (96.7)	

*Mann-Whitney U test
PSQI: Pittsburgh Sleep Quality Index; ESS: Epworth Sleepiness Scale; JME: Juvenile myoclonic epilepsy

Discussion

JME, also known as awakening-related epilepsy, accounts for 5-10 percent of all cases of idiopathic generalized epilepsies (13, 14). Various epilepsy syndromes characteristically demonstrate nocturnal events suggesting a bidirectional relationship between seizure and sleep (21). A previous study on focal epilepsy has demonstrated markedly increased seizure discharges during sleep (22). While eyeing a paucity of studies evaluating sleep abnormalities in patients with idiopathic generalized epilepsies, especially JME, this study aimed to assess the sleep architecture of patients with JME, both drug-naïve and on treatment, as well as its quality evaluation with validated sleep scales. Patients with JME are considered perfect for studying the correlation between sleep and idiopathic generalized epilepsies due to all types of generalized seizures that occur characteristically after awakening, susceptibility to sleep deprivation, and polygenic inheritance (23).

This study's demographic and clinical profiles of patients with JME were comparable to previous studies with a slight female preponderance (24-26). All patients had myoclonic jerks and GTCS. Sleep deprivation was our study's most frequent precipitating factor for seizures (Tables 1 and 6), further supporting the vicious cycle theory (21).

Table 6. Comparison of demographic details with other studies

Parameters	Value
Age (year) (mean ± SD)	-0.09
Present study	21.1 ± 4.5
Ramachandraiah et al. (24)	20.8 ± 4.0
Krishnan et al. (25)	22.0 ± 6.3
Nayak et al. (26)	21.2 ± 4.0
Roshan et al. (27)	21.4 ± 7.9
Gender (male/female ratio)	
Present study	1:1.7
Krishnan et al. (25)	1.08:1
Roshan et al. (27)	1:2
Myoclonus, GTCS, absence seizure (%)	
Present study	100, 100, 13.3
Ramachandraiah et al. (24)	100, 100, 5.0
Krishnan et al. (25)	100, 100, 16.0
Roshan et al. (27)	100, 96.0, 9.1
Sleep deprivation as a precipitating factor for seizure (%)	
Present study	56.6
Dhanuka et al. (28)	73.3
Roshan et al. (27)	68.7

GTCS: Generalized tonic-clonic seizure; SD: Standard deviation

We found that patients with JME had a significant reduction in sleep efficiency, poor sleep quality, prolonged sleep onset latency, and increased wake percentage. While looking at the sleep macro architecture of patients with JME, sleep stage distribution was also significantly deranged with prolonged mean N1 stage, reduced mean N2 stage, and reduced mean REM stage of sleep (Table 2). This supports the results of previous studies done by Krishnan et al. (25), Roshan et al. (27), and Mekky et al. (29), and contradicts the result of the study by Nayak et al. (26). Our finding supports the hypothesis of the destabilizing effect of internal arousing stimuli on mechanisms of sleep.

The reduced REM stage of sleep in the present study may be due to a change in sleep architecture because of internal arousing stimuli in the form of epileptiform discharges, possibly replacing typically dominant REM sleep of later night sleep with abnormally prevalent lighter NREM sleep, which may be responsible for early morning seizures. This could have pathophysiological implications as JME, epilepsy with polygenic inheritance, has defective gamma-aminobutyric acid (GABA) receptors, leading to loss of inhibitory signals and increased cortical excitability. Apart from pontine circuitry, ventral medullary GABAergic neurons have been shown to initiate and maintain REM sleep (30). Here, defective GABA receptors may lead to difficulty initiating and maintaining REM sleep, leading to less desynchronized seizure protector sleep.

Subgroup analysis of patients with JME showed no difference in sleep parameters when a comparison was made between the groups of patients on valproate monotherapy or polytherapy, and the dose of sodium valproate ≤ 600 or > 600 mg/day for seizure. Besides, a comparison between drug naïve patients with JME with controls and patients on treatment with controls showed similar results for all patients with JME. These findings are comparable to the observations by Krishnan et al. (25), while contradictory to the one by Roshan et al. (27), which states that treatment with valproate leads to altered NREM sleep. Irreversible GABA receptor dysfunction secondary to genetic mutation may be responsible for these findings, as similar sleep architecture was found in both drug-naïve and JME patients on treatment.

In this study, a more significant number of patients with JME had a PSQI score > 5, and the median PSQI score was higher in patients with JME compared to controls, suggesting poor sleep quali-

ty. The majority of the studies have taken a cut-off value of 5 for the PSQI which suggests poor quality sleep (31). PSQI scores > 5 distinguish good sleepers from poor sleepers with a sensitivity of 89.6% and specificity of 86.5% (18). In our study, patients with JME and controls had comparable median ESS scores, suggesting no difference in EDS among the two groups (Table 5).

The positives of the study are that only a few studies have correlated sleep quality, daytime sleepiness with the validated questionnaire, and sleep architecture among patients with JME irrespective of treatment status in comparison to control group. This study has analyzed sleep architecture and its quality subjectively and objectively in patients with JME, both on treatment and drug naïve, and the possible role of antiepileptic drugs on sleep architecture in patients on treatment.

Alternatively, the study's limitations were few drug-naïve patients with JME and a single-center study with a limited sample size. Despite adequate instructions and arrangements, the first-night effect cannot be fully eliminated.

Patients with JME report alteration in sleep architecture and poor sleep quality, whether on treatment or drug naïve, suggesting a possible role of the disease itself in this alteration. Future studies focusing on its molecular pathophysiology with a larger sample size are recommended.

Conclusion

Sleep architecture is significantly altered in patients with JME with prolonged N1 stage and reduced N2 stage of sleep whether on treatment or drug naïve. REM sleep is also considerably reduced, with prolonged sleep onset latency among the patients. Sleep quality was poor in patients with JME.

Conflict of Interests

Authors have no conflict of interests.

Acknowledgments

The authors would like to thank the participants of this study for their kind contribution.

References

1. Grigg-Damberger MM, Foldvary-Schaefer N. Primary sleep disorders in people with epilepsy: Clinical questions and answers. Child Adolesc Psychiatr Clin N Am 2015; 24: 145-76.
2. Yang EH, Hla KM, McHorney CA, et al. Sleep apnea and quality of life. Sleep 2000; 23: 535-41.
3. Piperidou C, Karlovasitou A, Triantafyllou N, et al. Influence of sleep disturbance on quality of life of patients with epilepsy. Seizure 2008; 17: 588-94.
4. Gutter T, Callenbach PMC, Brouwer OF, et al. Prevalence of sleep disturbances in people with epilepsy and the impact on quality of life: A survey in secondary care. Seizure 2019; 69: 298-303.
5. Chan S, Baldeweg T, Cross JH. A role for sleep disruption in cognitive impairment in children with epilepsy. Epilepsy Behav 2011; 20: 435-40.
6. Kotagal P, Yardi N. The relationship between sleep and epilepsy. Semin Pediatr Neurol 2008; 15: 42-9.
7. Wolf P, Roder-Wanner UU, Brede M. Influence of therapeutic phenobarbital and phenytoin medication on the polygraphic sleep of patients with epilepsy. Epilepsia 1984; 25: 467-75.
8. Legros B, Bazil CW. Effects of antiepileptic drugs on sleep architecture: A pilot study. Sleep Med 2003; 4: 51-5.
9. Zhang H, Li Y, Li X, et al. Effect of sodium valproate on the sleep structures of epileptic patients. Exp Ther Med 2014; 7: 1227-32.
10. Pearce JM. Theodore Herpin: Neglected contributions in the understanding of epilepsy. Eur Neurol 2005; 54: 135-9.
11. Janz D. Epilepsy with impulsive petit mal (juvenile myoclonic epilepsy). Acta Neurol Scand 1985; 72: 449-59.
12. Lund M, Reintoft H, Simonsen N. A controlled social and psychological investigation of patients with juvenile myoclonic epilepsy [En kontrolleret social og psykologisk undersøgelse at patienter med juvenil myoklon epilepsi]. Ugeskr Laeger 1975; 137(41): 2415-8. [In Danish].
13. Jallon P, Latour P. Epidemiology of idiopathic generalized epilepsies. Epilepsia 2005; 46: 10-4.
14. Grigg-Damberger M, Foldvary-Schaefer N. Bidirectional relationships of sleep and epilepsy in adults with epilepsy. Epilepsy Behav 2021; 116: 107735.
15. Matos G, Andersen ML, do Valle AC, et al. The relationship between sleep and epilepsy: evidence from clinical trials and animal models. J Neurol Sci 2010; 295: 1-7.
16. Bonakis A, Koutroumanidis M. Epileptic discharges and phasic sleep phenomena in patients with juvenile myoclonic epilepsy. Epilepsia 2009; 50: 2434-45.
17. Proposal for revised classification of epilepsies and epileptic syndromes. Commission on classification and terminology of the international league against epilepsy. Epilepsia 1989; 30: 389-99.
18. Buysse DJ, Reynolds CF^{3rd}, Monk TH, et al. The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. Psychiatry Res 1989; 28: 193-213.

19. Johns MW. A new method for measuring daytime sleepiness: The Epworth sleepiness scale. Sleep 1991; 14: 540-5.
20. Berry RB, Quan SF, Abreu AR, et al. The AASM manual for the scoring of sleep and associated events: Rules, terminology and technical specifications, version 2.6. Darien, IL: American Academy of Sleep Medicine; 2020.
21. Gibbon FM, Maccormac E, Gringras P. Sleep and epilepsy: Unfortunate bedfellows. Arch Dis Child 2019; 104: 189-92.
22. Niedermeyer E, Rocca U. The diagnostic significance of sleep electroencephalograms in temporal lobe epilepsy. A comparison of scalp and depth tracings. Eur Neurol 1972; 7: 119-29.
23. Panayiotopoulos CP. Juvenile myoclonic epilepsy. In: Panayiotopoulos CP, editor. A clinical guide to epileptic syndromes and their treatment. London, UK: Springer; 2007. p. 336-43.
24. Ramachandraiah CT, Sinha S, Taly AB, et al. Interrelationship of sleep and juvenile myoclonic epilepsy (JME): A sleep questionnaire-, EEG-, and polysomnography (PSG)-based prospective case-control study. Epilepsy Behav 2012; 25: 391-6.
25. Krishnan P, Sinha S, Taly AB, et al. Altered polysomnographic profile in juvenile myoclonic epilepsy. Epilepsy Res 2014; 108: 459-67.
26. Nayak CS, Sinha S, Nagappa M, et al. Effect of valproate on the sleep microstructure of juvenile myoclonic epilepsy patients - a cross-sectional CAP based study. Sleep Med 2016; 17: 129-33.
27. Roshan S, Puri V, Chaudhry N, et al. Sleep abnormalities in juvenile myoclonic epilepsy-A sleep questionnaire and polysomnography based study. Seizure 2017; 50: 194-201.
28. Dhanuka AK, Jain BK, Daljit S, et al. Juvenile myoclonic epilepsy: A clinical and sleep EEG study. Seizure 2001; 10: 374-8.
29. Mekky JF, Elbhrawy SM, Boraey MF, et al. Sleep architecture in patients with Juvenile Myoclonic Epilepsy. Sleep Med 2017; 38: 116-21.
30. Weber F, Chung S, Beier KT, et al. Control of REM sleep by ventral medulla GABAergic neurons. Nature 2015; 526: 435-8.
31. Lin CY, Wu T, Chang CW, et al. Reduced sleep quality is related to poor quality of life in patients with juvenile myoclonic epilepsy, a case-control study. Life (Basel) 2022; 12: 434.