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RESEARCH

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Sleep, cognitive functions, behavioral, and emotional disturbance in self-limited focal childhood epilepsies

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Abstract

Background Self-limited focal epilepsies of childhood, including self-limited epilepsy with centrotemporal spikes (SeLECTS), idiopathic childhood occipital epilepsy of Gastaut (ICOE-G), and self-limited epilepsy with autonomic seizures (SeLEAS), were considered benign conditions. However, recent research assumed potential adverse impacts on sleep, cognition, behavior, and emotional well-being. Our aim was to investigate the effects of self-limited focal epilepsies on sleep architecture, cognitive functions, behavior, and emotional disturbances in drug naive children. A cross-sectional study was conducted on 46 newly diagnosed children (ages 6–12) with SeLECTS (n = 22), ICOE-G (n = 12), SeLEAS (n = 12), and 20 healthy controls. Overnight polysomnography was performed. Cognitive assessments included intelligence scales, executive function tests, verbal fluency, visuospatial abilities, and memory. Behavioral and emotional problems were evaluated using standardized questionnaires and psychiatric interviews.

Results Children with epilepsy exhibited significant disturbances in sleep architecture, impairments in cognitive domains (executive functions, verbal fluency, visuospatial skills, and memory), and higher rates of internalizing/externalizing problems, social issues, attention deficit hyperactive disorder, depression, and anxiety compared to controls. No significant differences were found among the three epilepsy subtypes.

Conclusion Self-limited focal epilepsies in childhood are associated with sleep disruption, cognitive deficits, behavioral issues, and psychiatric comorbidities, challenging their traditional "benign" perception. Comprehensive management approaches addressing these multidimensional impacts are warranted.

Keywords Self-limited focal epilepsies of childhood, Polysomnogram, Cognition, Behavior

Introduction

Self-limited focal epilepsies of childhood are electroclinical syndromes of unknown or genetic cause that occur in developmentally and neurologically normal children and have a benign course, remitting prior to adulthood [1].

The best described syndromes are self-limited epilepsy with centrotemporal spikes (SeLECTS) previously known as benign childhood epilepsy with centrotemporal spikes, idiopathic childhood occipital epilepsy of Gastaut (ICOE-G), and self-limited epilepsy with autonomic seizures (SeLEAS) formyl known as Panayiotopoulos syndrome [2].

Sleep disorders are common and may coexist with a variety of neurological diseases, including epilepsy [3]. On the other hand, one-third of patients with epilepsy have seizures during sleep [4]. The relationship between epilepsy and sleep is both complex and bidirectional. While sleep states modulate the expression of epileptic seizures and interictal epileptiform discharges, epileptic discharges alter sleep regulation and provoke sleep disruption [5].

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Despite of abundant literatures addressing the sleep and epilepsy, the relation between benign focal epilepsies of childhood and sleep disturbance is unclear, as few studies investigated the effect of SeLECTS on sleep [6].

Traditionally, SeLECTS was thought to cause no neurological or cognitive deficits, with seizures stopping spontaneously after puberty. However, recent research challenges this benign view, finding evidence of cognitive impairment, especially in speech and executive functions, as well as higher rates of behavioral, social problems, and psychiatric comorbidities like psychosis. The severity of these deficits appears to be correlated with the frequency and duration of epileptiform discharges during non-rapid eye movement (NREM) sleep [7].

Unfortunately, most previous studies focused on SeLECTS and ignoring other type of self-limited focal childhood epilepsy. In our study, we tried to study the possible effect of epilepsy on sleep architecture, cognitive functions, behavior, and emotional disturbance in non-medicated children with self-limited focal epilepsies.

Methods

The current study is a cross-sectional one that was conducted on 46 newly diagnosed epileptic children (self-limited focal epilepsies) aged from 6 to 12 years of both genders over a period of 12 months from attending the outpatient clinic in the department of Neuropsychiatry. After taking informed written consent from the patients' parent, patients were classified into 3 subgroups as follows:

Group I A: included 22 patients with SeLECTS, diagnosed on clinical and EEG basis according to International League against Epilepsy, all of them were newly diagnosed and drug naive. Group IB: included 12 patients with ICOE-G, diagnosed on clinical and EEG basis according to International League against Epilepsy, all of them were newly diagnosed and drug naïve. Group IC: included 12 patients with SeLEAS diagnosed on clinical and EEG basis according to International League against Epilepsy, all of them were newly diagnosed and drug naïve.

Another 20 healthy age- and sex-matched children sex matched healthy were recruited from complex school's compound who severed as a control group (group II).

Magnetic resonance imaging of the brain (in suspected secondary epileptic cases). Routine laboratory tests were done, such as fasting and post prandial blood sugar level, and liver and kidney function tests to exclude diabetic patients or patients with liver or kidney diseases.

Patients with endocrinal, cardiac, renal, hepatic problems, symptomatic epilepsy, patients on antiepileptic drugs or medications influencing sleep such as benzodiazepines, patients with psychiatric illness, and body mass index > 30 were excluded from the study.

All patients were subjected to: Thorough neurological examination and clinical assessment of epilepsy severity was done using Hague seizure severity scale (HASS) [8]

All participants were subjected to one night polysomnography (PSG), and PSG parameters were scored using Somon Medics GmbH (Am SonnenstuhL63, D-97236 Rander Sacker, Type: SOMNO screen TM plus, SN: 4259, kw45: 2014, Germany). The PSG parameters were scored according to The American Academy of Sleep Medicine Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications, version 2.4 [9]. Measure for the quantification of epileptiform activity was done using spike frequency method consists in counting the total number of spikes per unit of time [10].

All participants in the study were evaluated by cognitive, psychological, and behavioral battery including the following:

The child behavior checklist (CBCL) [11], a widely employed standardized tool designed to assess emotional, behavioral, and social problems in children and adolescents. The CBCL is a comprehensive questionnaire completed by parents or caregivers, providing a detailed profile of the child's functioning across various domains. It encompasses numerous items that evaluate a range of behavioral and emotional problems, including internalizing issues such as anxiety, depression, and somatic complaints, as well as externalizing problems like aggressive behavior and rule-breaking. Additionally, the CBCL assesses competencies in activities, social relationships, and school performance.

The controlled oral word association test (COWAT) [12, 13] is a neuropsychological test that evaluates verbal fluency and executive functioning. It requires patients to orally produce as many words as possible that begin with a given letter within a fixed time limit (usually 60 s). The test measures the spontaneous production of words under restricted search conditions. Performance requires cognitive flexibility, initiation, attention, and speed of verbal output. Impaired performance may indicate dysfunction in frontal systems that regulate executive functions like fluency, working memory, inhibition, and set shifting. The test has high utility in neuropsychological batteries evaluating executive dyscontrol and verbal function.

The Rey–Osterrieth complex figure (ROCF) [14] test is a neuropsychological assessment that evaluates visuospatial constructional ability and visual memory. It involves copying a complex geometric figure composed of multiple shapes and details. The accuracy and approach to copying the figure provides information on visuospatial

and constructional skills. After a delay (often 30 min), the examinee is asked to redraw the figure from memory. This assesses visual and nonverbal memory ability. Impaired performance can indicate problems with visuospatial skills, nonverbal memory, executive functions like organization, and planning.

The Kiddie Schedule for Affective Disorders and Schizophrenia (K-SADS) [15] is a semi-structured psychiatric interview used to assess psychopathology in children and adolescents. It screens for a broad range of disorders including depression, anxiety, attention deficit hyperactive disorder (ADHD), conduct disorder, substance abuse, eating disorders, psychosis, and Oppositional defiant disorder (ODD).

The Wechsler intelligence scale for children (WISC-III-R) was utilized to measure intelligence quotient (IQ), providing scores for verbal IQ, performance IQ, and a combined full-scale IQ. This widely used test evaluates various aspects of intelligence in school-aged children and adolescents [16]. The Wisconsin card sorting test (WCST), a computerized version, was administered to evaluate executive functions such as set shifting, working memory, conceptual problem-solving ability, the use of feedback, the ability to modify incorrect strategies, flexibility, and the inhibition of prepotent but incorrect responses [17].

The Trail Making Test consisted of two parts. Part A measured visual search by requiring participants to draw lines in ascending order from 1 to 25 on a standard test sheet. The score was based on the number of seconds taken by the participant to solve the problem, with errors not corrected but the time continuing to run during corrections. Part B was similar but involved alternating between numbers (1 to 13) and letters (A to L) in ascending order. This part assessed distracted attention and set-shifting components of executive functions, with scoring done in the same manner as Part A. Additionally, the Digit Span (DS) subtest from the Wechsler scales was administered, comprising digits forward (DF) and digits backward (DB) components. DF assesses short-term auditory memory, sequencing, and simple verbal expression, while DB is more sensitive to deficits in verbal working memory. The DS scaled score, the longest digits forward raw score, and the longest digits backward raw score were analyzed in this study [17].

The reading disabilities were evaluated by test of reading disabilities which is composed of 80 sentences and each correct answer is given one degree. The child was considered to have reading disorder when the result of the test was below 85% of the total score [18, 19].

All cognitive assessments were conducted on participants in the interictal period, with a minimum duration of 1 week since their last seizure episode prior to participation in the current study. Participation was on a voluntary basis, and comprehensive information regarding the research objectives was provided to the parents of all prospective participants. Informed written consent was obtained from parents prior to the commencement of study procedures. The study protocol obtained ethical approval from the institutional review board at our university (approval code: 36049/11/22).

Statistical analysis of the collected data was performed using SPSS Prism version 20, 2013 (developed by IBM, Armonk, NY, USA). The Chi-square test was employed for categorical data, while the t test was utilized for numerical data. One-way analysis of variance (ANOVA) was conducted to compare the means across the four groups. Post hoc Tukey tests were subsequently applied for pairwise comparisons of group means. The F test was used to evaluate the regression model. A significance level of $p < 0.05$ was adopted as the threshold for interpreting the results of the tests of significance.

Results

The present study employed a cross-sectional design and involved a cohort of 46 participants recently diagnosed with self-limited focal epilepsy, ranging in age from 6 to 12 years, encompassing both genders and 20 healthy children. As depicted in Tables 1 and 2, the distribution of age and sex did not exhibit statistically significant differences between the epilepsy patient group and the non-epileptic control group.

The polysomnogram parameters analyzed in the present study encompassed total sleep time, sleep latency, rapid eye movement (REM) latency, wake after sleep onset, sleep efficiency, sleep fragmentation, sleep stage transition index, arousal index, apnea–hypopnea index, periodic limb movement index, and the percentages of different sleep stages (N1, N2, N3, and REM) relative to total sleep time, as well as the REM sleep without atonia (RSWA) index. The F-test results revealed statistically significant differences among the groups for most of these measures, apart from the apnea–hypopnea index and the percentage of N1 sleep. Subsequent post hoc analyses were employed to delineate the specific group differences for each parameter, unveiling significant disparities between the epileptic children and their healthy counterparts across various domains, including total sleep time, sleep latency, REM latency, wake after sleep onset, sleep efficiency, sleep fragmentation, sleep stage transition index, arousal index, periodic limb movement index, and the percentages of N2, N3, and REM sleep relative to total sleep time, as well as the RSWA index. Notably, no significant differences were observed among the three epileptic groups (Table 3).

Table 1 Comparison of age distribution between studied groups

		Mean ± S. D	F test	P value	Post hoc test			
Age	Group 1A	8.35 ± 1.29	2.882	0.072	P1	0.078	P4	0.867
	Group 1B	7.17 ± 1.40			P2	0.115	P5	0.079
	Group 1C	7.33 ± 2.64			P3	0.490	P6	0.080
	Group II	7.22 ± 2.79						

P1: Group 1A and Group 1B—P2: Group 1A and Group 1C- P3: Group 1A and Group II—P4: Group 1B and Group 1C- P4: Group 1B and Group II—P6: Group 1C and Group II

Table 2 Comparison of sex distribution between studied groups

Group 1A	Group 1B	Group 1C	Group II		Total	Chi-square	
						X^2	P value
Male							
n	12	7	6	15	40	0.380	0.944
%	54.5%	58.3%	50.0%	60.0%	56.3%		
Female							
n	10	5	6	10	31	0.380	0.944
%	45.5%	41.7%	50.0%	40.0%	43.7%		
Total							
n	22	12	12	25	71	0.380	0.944
%	100.0%	100.0%	100.0%	100.0%	100.0%		

P1: Group 1A and Group 1B—P2: Group 1A and Group 1C- P3: Group 1A and Group II—P4: Group 1B and Group 1C- P4: Group 1B and Group II—P6: Group 1C and Group II

The mean epilepsy durations are similar across the three groups, ranging from 0.95 to 1.16 years without significant difference between them. The post hoc tests further confirm that there are no significant pairwise differences between the groups. The HASS score, which assesses the severity of epilepsy, shows a statistically significant difference among the groups, as indicated by the F-test p value of 0.03. The post hoc tests reveal that Group 1B has a significantly higher mean HASS score compared to Group 1A and 1C. The inter-ictal discharge load, which measures the frequency of epileptiform discharges between seizures, does not show a statistically significant difference among the three groups, as indicated by the F-test p value of 0.878. The post hoc tests further confirm that there are no significant pairwise differences in inter-ictal discharge load between the groups (Table 4).

Regarding the results of CBCL, there were significant differences in both internalizing problems including (anxious/depressed, withdrawn/depressed, somatic complaint) and externalizing problems including (rule breaking, aggressive behavior) between the epileptic groups and the control group where the epileptic groups were worse than the control group. Also, there were significant increases in the social problems, thought problems, and attention problem in the epileptic groups compared to control group. Regarding sluggish cognitive tempo, there were significant difference between the epileptic groups and the control group where the control group showed better results than the epileptic group. There was significant difference between the epileptic groups and the control group regarding the total competence in Favor to the control group. (Table 5).

There was no significant difference between the studied groups regarding IQ. Regarding the DF and the digit DB tests, there were significant differences between the epileptic groups and the control group where the control group showed better results than the epileptic groups. There were significant differences in both the TMTA (time and errors) and the TMTB (time and error) between the epileptic groups and the control group where the epileptic groups showed worse results than the control group.

There was a significant difference in the WCST correct response between the epileptic groups and the control group in favor to the control group. Regarding the COWAT, there were significant differences between the epileptic groups and the control group to the advantage of the control group (Table 6).

Regarding the ROCF test including copy, immediate recall, and late recall, there were significant differences between the epileptic groups and the control group where the control group showed better results than the epileptic groups. According to reading test, there were significant difference between the epileptic groups and the control group where the epileptic groups showed worse results than the control group.

According to the K-SADS assessment, a higher number of children in the epileptic groups experienced psychiatric disorders compared to the control group. In Group 1A, 11 children (50%) suffered from depression, while in Group 1B, 4 children (33.3%), and in Group 1C, 5 children (41.7%) experienced depression, in contrast to only 2 children (8%) in the control group. Furthermore, anxiety was reported in 11 children (50%) in Group 1A, 3 children (25%) in Group 1B, and 4 children (33.3%) in Group 1C, compared to 2 children (8%) in the control group. ADHD was more prevalent in the epileptic groups, with 13 children (59.1%) in Group 1A, 7 children (58.3%) in Group 1B, and 6 children (50%) in Group 1C suffering from ADHD, while only 2 children (8%) in the control group had ADHD. ODD was also more common

Table 3 Results of one night polysomnography results between the studied groups

		Mean	±	S. D	F test	p value	Post hoc test			
Total sleep time	Group 1A	437.82	±	11.01	43.436	0.001	P1	0.886	P4	0.571
	Group 1B	438.64	±	20.16			P2	0.670	P5	0.01
	Group 1C	440.50	±	14.26			P3	0.001	P6	0.008
	Group II	484.44	±	17.66						
sleep latency	Group 1A	19.73	±	4.45	18.790	0.001	P1	0.460	P4	0.160
	Group 1B	20.00	±	2.41			P2	0.801	P5	0.001
	Group 1C	19.00	±	2.95			P3	0.031	P6	0.001
	Group II	12.60	±	2.52						
REM latency	Group 1A	103.95	±	10.43	10.647	0.001	P1	0.280	P4	0.736
	Group 1B	103.75	±	3.41			P2	0.171	P5	0.001
	Group 1C	104.92	±	3.80			P3	0.001	P6	0.001
	Group II	90.72	±	7.21						
Wake after sleep onset	Group 1A	33.73	±	3.61	17.650	0.001	P1	0.643	P4	0.120
	Group 1B	34.33	±	2.96			P2	0.190	P5	0.001
	Group 1C	32.00	±	2.30			P3	0.001	P6	0.001
	Group II	27.04	±	4.35						
Sleep efficiency	Group 1A	81.91	±	2.54	17.655	0.001	P1	0.886	P4	0.599
	Group 1B	82.07	±	2.84			P2	0.648	P5	0.001
	Group 1C	81.39	±	2.09			P3	0.001	P6	0.001
	Group II	87.52	±	4.07						
Sleep fragmentation	Group 1A	10.32	±	1.21	44.032	0.001	P1	0.535	P4	0.098
	Group 1B	10.08	±	0.67			P2	0.016	P5	0.001
	Group 1C	11.25	±	1.06			P3	0.001	P6	0.001
	Group II	7.60	±	1.04						
Sleep stage transition index	Group 1A	14.82	±	3.28	28.922	0.001	P1	0.602	P4	0.252
	Group 1B	15.25	±	2.05			P2	0.070	P5	0.001
	Group 1C	16.33	±	1.72			P3	0.001	P6	0.001
	Group II	10.12	±	1.42						
Arousal index	Group 1A	11.99	±	1.47	44.478	0.001	P1	0.181	P4	0.413
	Group 1B	11.38	±	1.04			P2	0.025	P5	0.001
	Group 1C	10.95	±	1.50			P3	0.001	P6	0.001
	Group II	7.99	±	1.05						
Apnea–hypopnea index	Group 1A	5.09	±	1.74	1.816	0.153	P1	0.258	P4	0.471
	Group 1B	5.68	±	0.48			P2	0.752	P5	0.030
	Group 1C	5.25	±	1.18			P3	0.211	P6	0.174
	Group II	4.55	±	1.58						
Periodic limb index	Group 1A	9.57	±	2.23	73.244	0.001	P1	0.001	P4	0.133
	Group 1B	11.76	±	1.62			P2	0.062	P5	0.001
	Group 1C	10.72	±	1.82			P3	0.001	P6	0.001
	Group II	4.44	±	0.90						
N1%Total Sleep Time	Group 1A	7.68	±	1.73	1.101	0.355	P1	0.464	P4	0.899
	Group 1B	8.22	±	2.59			P2	0.381	P5	0.452
	Group 1C	8.32	±	1.35			P3	0.074	P6	0.546
	Group II	8.75	±	2.19						
N2% Total Sleep Time	Group 1A	40.02	±	2.34	4.976	0.004	P1	0.292	P4	0.061
	Group 1B	40.88	±	2.13			P2	0.059	P5	0.034
	Group 1C	41.52	±	2.37			P3	0.040	P6	0.001
	Group II	38.68	±	1.97						

Table 3 (continued)

		Mean	±	S. D	F test	p value	Post hoc test			
N3% Total Sleep Time	Group 1A	33.38	±	2.29	33.030	0.001	P1	0.503	P4	0.948
	Group 1B	32.45	±	3.84			P2	0.551	P5	0.001
	Group 1C	32.55	±	2.86			P3	0.001	P6	0.001
	Group II	23.39	±	5.16						
REM% Total Sleep Time	Group 1A	15.78	±	2.30	26.549	0.001	P1	0.450	P4	0.830
	Group 1B	14.88	±	3.61			P2	0.608	P5	0.001
	Group 1C	15.17	±	1.87			P3	0.001	P6	0.001
	Group II	22.72	±	4.31						
RSWA index	Group 1A	13.77	±	2.03	103.708	0.001	P1	0.154	P4	0.953
	Group 1B	12.36	±	3.54			P2	0.203	P5	0.001
	Group 1C	12.41	±	2.08			P3	0.001	P6	0.001
	Group II	4.77	±	2.23						

P1: Group 1A and Group 1B—P2: Group 1A and Group 1C- P3: Group 1A and Group II—P4: Group 1B and Group 1C- P4: Group 1B and Group II—P6: Group 1C and Group II REM: rapid eye movement. RSWA: REM sleep without atonia

Table 4 Comparison of epilepsy duration, severity, and inter-ictal discharge load in patients' groups

		Mean	±	S. D	F test	P value		
Epilepsy duration	Group 1A	0.920	±	0.33	0.084	0.920	P1	0.736
	Group 1B	0.96	±	0.30			P2	0.925
	Group 1C	1.15	±	0.37			P3	0.704
HASS	Group 1A	27.05	±	4.57	3.820	0.030	P1	0.034*
	Group 1B	30.58	±	5.12			P2	0.427
	Group 1C	25.75	±	3.60			P3	0.012*
Inter ictal discharge load	Group 1A	1.69	±	0.79	0.130	0.878	P1	0.613
	Group 1B	1.55	±	0.76			P2	0.858
	Group 1C	1.64	±	0.73			P3	0.773

P1: Group 1A and Group 1B- P2: Group 1A and Group 1C—P3: Group 1B and Group 1C- HASS: Hague seizure severity scale

in the epileptic groups, with 5 children (22.7%) in Group 1A, 3 children (25%) in Group 1B, and 1 child (8.3%) in Group 1C exhibiting ODD, compared to 1 child (4%) in the control group. Lastly, Conduct Disorder was observed in 3 children (13.6%) in Group 1A, 5 children (41.7%) in Group 1B, and 2 children (16.7%) in Group 1C, while only 1 child (4%) in the control group suffered from Conduct Disorder (Table 7).

Discussion

The present study explored the complex relationship between self-limited focal epilepsies of childhood and their potential impact on sleep architecture, cognitive functions, behavioral patterns, and emotional well-being. The findings revealed significant differences in polysomnographic parameters between children with benign focal epilepsies and their healthy counterparts.

Children with epilepsy had a shorter total sleep time, prolonged sleep latency, increased wake after sleep onset, decreased sleep efficiency, increased sleep fragmentation, and an increased sleep stage transition index. These disturbances in sleep architecture underscore the profound influence of epileptic discharges on the natural sleep patterns in these children.

Epilepsy is a complex, multidimensional condition that extends beyond the occurrence of seizures alone. It is associated with alterations in both the macrostructure and microstructure of sleep. These changes are multifactorial, arising from the underlying pathology, comorbid neuropsychiatric and sleep disorders, as well as the effects of pharmacological and non-pharmacological treatments. Accumulating evidence suggests that epileptic activity exerts a direct impact on sleep architecture, sleep continuity, and sleep oscillations [20].

The study conducted by Bruni and colleagues [21] included SeLECTS drug naïve children and healthy control. They reported that compared to controls, children with SeLECTS epilepsy showed shorter total sleep

Table 5 Comparison of child behavior check list and sluggish cognitive tempo between studied groups

		Mean	±	S. D	F. test	p. value	Post Hock test			
Anxiety–depression	Group 1A	62.14	±	9.52	5.839	0.001	P1	0.024	P4	0.187
	Group 1B	55.00	±	6.98			P2	0.425	P5	0.356
	Group 1C	59.67	±	10.67			P3	0.000	P6	0.016
	Group II	52.20	±	7.19						
Withdrawn–depression	Group 1A	59.73	±	8.60	4.360	0.007	P1	0.079	P4	1.000
	Group 1B	55.00	±	7.65			P2	0.079	P5	0.245
	Group 1C	55.00	±	6.58			P3	0.001	P6	0.245
	Group II	51.96	±	6.37						
Somatic	Group 1A	58.64	±	5.76	16.578	0.001	P1	0.007	P4	0.469
	Group 1B	63.42	±	2.91			P2	0.053	P5	0.000
	Group 1C	62.00	±	6.94			P3	0.000	P6	0.000
	Group II	53.20	±	2.89						
Social	Group 1A	65.64	±	9.06	13.490	0.001	P1	0.195	P4	0.564
	Group 1B	62.17	±	8.35			P2	0.053	P5	0.000
	Group 1C	60.42	±	6.24			P3	0.000	P6	0.003
	Group II	52.32	±	5.56						
Thought	Group 1A	66.95	±	2.68	152.934	0.001	P1	0.968	P4	0.000
	Group 1B	67.00	±	3.05			P2	0.000	P5	0.000
	Group 1C	52.58	±	6.22			P3	0.000	P6	0.026
	Group II	50.04	±	0.20						
Attention	Group 1A	72.82	±	11.44	21.540	0.001	P1	0.026	P4	0.674
	Group 1B	65.33	±	10.01			P2	0.078	P5	0.000
	Group 1C	66.92	±	9.86			P3	0.000	P6	0.000
	Group II	51.92	±	5.46						
Rule break	Group 1A	54.36	±	8.92	1.678	0.180	P1	0.187	P4	0.173
	Group 1B	58.33	±	10.44			P2	0.816	P5	0.059
	Group 1C	53.67	±	8.34			P3	0.302	P6	0.533
	Group II	51.84	±	6.37						
Aggressive	Group 1A	58.86	±	12.13	1.840	0.148	P1	0.811	P4	0.297
	Group 1B	59.75	±	10.95			P2	0.342	P5	0.063
	Group 1C	55.33	±	9.25			P3	0.052	P6	0.506
	Group II	52.92	±	8.52						
Internalizing problems	Group 1A	60.55	±	10.50	12.999	0.001	P1	0.396	P4	0.811
	Group 1B	57.42	±	7.46			P2	0.563	P5	0.000
	Group 1C	58.42	±	11.84			P3	0.000	P6	0.000
	Group II	43.52	±	10.20						
Externalizing problems	Group 1A	53.59	±	12.83	2.908	0.041	P1	0.585	P4	0.297
	Group 1B	56.00	±	15.05			P2	0.520	P5	0.013
	Group 1C	50.75	±	11.58			P3	0.020	P6	0.192
	Group II	45.08	±	10.46						
Total problems	Group 1A	63.68	±	8.41	30.756	0.001	P1	0.894	P4	0.157
	Group 1B	63.25	±	8.05			P2	0.083	P5	0.000
	Group 1C	58.00	±	8.45			P3	0.000	P6	0.000
	Group II	41.04	±	10.05						
Total competence	Group 1A	17.77	±	3.77	113.483	0.001	P1	0.342	P4	0.100
	Group 1B	19.83	±	6.34			P2	0.006	P5	0.000
	Group 1C	23.92	±	2.84			P3	0.000	P6	0.000
	Control	47.08	±	8.12						
Sluggish cognitive tempo	Group 1A	65.09	±	9.79	15.023	0.001	P1	0.022	P4	0.367
	Group 1B	58.67	±	10.45			P2	0.195	P5	0.004
	Group 1C	61.50	±	7.62			P3	0.000	P6	0.000
	Group II	50.56	±	1.69						

Table 5 (continued)

P1: Group 1A and Group 1B—P2: Group 1A and Group 1C- P3: Group 1A and Group II—P4: Group 1B and Group 1C- P4: Group 1B and Group II—P6: Group 1C and Group II

Table 6 Comparison on cognitive function tests between studied groups

		Mean	±	S. D	F test	P value	Post hoc test			
Intelligence quotient	Group 1A	95.36	±	4.15	1.476	0.229	P1	0.557	P4	0.181
	Group 1B	94.50	±	3.97			P2	0.347	P5	0.072
	Group 1C	96.75	±	3.28			P3	0.145	P6	0.797
	Group II	97.12	±	4.39						
Digit span forward	Group 1A	3.50	±	0.51	74.411	0.001	P1	0.104	P4	0.024
	Group 1B	3.92	±	0.79			P2	0.000	P5	0.000
	Group 1C	4.58	±	0.51			P3	0.000	P6	0.000
	Group II	6.40	±	0.87						
Digit span backward	Group 1A	2.50	±	0.51	122.300	0.001	P1	0.000	P4	0.158
	Group 1B	3.50	±	0.52			P2	0.000	P5	0.000
	Group 1C	3.83	±	0.83			P3	0.000	P6	0.000
	Group II	5.64	±	0.49						
Trail making test A time	Group 1A	191.00	±	36.47	102.200	0.001	P1	0.404	P4	0.004
	Group 1B	200.92	±	40.90			P2	0.013	P5	0.000
	Group 1C	160.83	±	32.32			P3	0.000	P6	0.000
	Group II	44.92	±	24.75						
Trail making test A error	Group 1A	4.59	±	1.18	87.011	0.001	P1	0.234	P4	0.000
	Group 1B	4.25	±	0.75			P2	0.000	P5	0.000
	Group 1C	2.42	±	0.51			P3	0.000	P6	0.000
	Group II	1.16	±	0.37						
Trail making test B time	Group 1A	363.32	±	47.46	224.243	0.001	P1	0.014	P4	0.000
	Group 1B	328.67	±	52.30			P2	0.000	P5	0.000
	Group 1C	235.42	±	11.37			P3	0.000	P6	0.000
	Group II	91.32	±	28.11						
Trail making test b error	Group 1A	7.05	±	1.65	80.460	0.001	P1	0.008	P4	0.000
	Group 1B	5.92	±	1.51			P2	0.000	P5	0.000
	Group 1C	3.42	±	0.51			P3	0.000	P6	0.003
	Group II	2.16	±	0.37						
Wisconsin card sorting test	Group 1A	38.00	±	4.89	71.044	0.001	P1	0.221	P4	0.120
	Group 1B	39.67	±	3.37			P2	0.004	P5	0.000
	Group 1C	42.08	±	3.82			P3	0.000	P6	0.000
	Group II	52.84	±	2.58						
Controlled oral word association test	Group 1A	16.05	±	1.53	147.361	0.001	P1	0.011	P4	0.919
	Group 1B	17.92	±	1.44			P2	0.015	P5	0.000
	Group 1C	17.83	±	1.59			P3	0.000	P6	0.000
	Group II	27.36	±	2.66						

P1: Group 1A and Group 1B—P2: Group 1A and Group 1C- P3: Group 1A and Group II—P4: Group 1B and Group 1C- P4: Group 1B and Group II—P6: Group 1C and Group II

time, longer REM sleep latency, lower sleep efficiency, and lower percentage of REM sleep. Additionally, Clemens and colleagues [22] evaluated 11 children with SeLECTS and healthy control. These children were free from medication or taking a single low-dose drug. The epileptic children had an average sleep duration that was 34 min shorter compared to the control group, although this difference was not statistically significant the epileptic children experienced a longer wake after sleep onset duration.

The previous study results by Gogou and colleagues [23] indicated that epilepsy affects sleep quality, as

Table 7 Rey–Osterrieth complex figure test and reading test between studied groups

		Mean	±	S. D	F test	P value	Post hoc test			
ROCF copy	Group 1A	22.05	±	5.14	7.706	0.001	P1	0.421	P4	0.051
	Group 1B	20.58	±	5.20			P2	0.151	P5	0.000
	Group 1C	24.67	±	5.42			P3	0.000	P6	0.081
	Group II	27.80	±	4.66						
ROCF immediate recall	Group 1A	14.68	±	6.27	10.236	0.001	P1	0.574	P4	0.238
	Group 1B	13.50	±	6.02			P2	0.433	P5	0.000
	Group 1C	16.33	±	4.79			P3	0.000	P6	0.003
	Group II	22.64	±	5.77						
ROCF late recall	Group 1A	14.05	±	6.14	9.540	0.001	P1	0.108	P4	0.152
	Group 1B	10.92	±	4.25			P2	0.984	P5	0.000
	Group 1C	14.08	±	3.78			P3	0.000	P6	0.003
	Group II	19.96	±	5.66						
Reading test	Group 1A	37.82	±	11.50	104.668	0.001	P1	0.329	P4	0.000
	Group 1B	40.50	±	8.54			P2	0.000	P5	0.000
	Group 1C	69.08	±	2.07			P3	0.000	P6	0.380
	Group II	71.44	±	3.18						

P1: Group 1A and Group 1B—P2: Group 1A and Group 1C- P3: Group 1A and Group II—P4: Group 1B and Group 1C- P4: Group 1B and Group II—P6: Group 1C and Group II. ROCF: Rey–Osterrieth complex figure

almost all parameters of sleep architecture were worse in the epilepsy group. The observed abnormalities in sleep architecture included an increase in the percentage of N1 and N2 sleep stages, an increase in the arousal index, an increase in the periodic limb movement index, an increase in sleep onset latency, as well as a reduction in the percentage of REM sleep and sleep efficiency. A meta-analysis revealed that a longer sleep latency and greater latency of REM were the most significant finding among patients with SeLECTS [24]. The underlying mechanisms behind sleep disturbances in children with SeLECTS are not fully understood, but several hypotheses have been proposed. One theory suggests that the epileptic discharges themselves, particularly those occurring during sleep, may contribute to sleep fragmentation and alterations in sleep architecture. Additionally, the presence of subclinical seizures or interictal epileptiform discharges during sleep may disrupt normal sleep patterns [20].

The present study uncovered significant deficits in cognitive domains among children with benign focal epilepsies. Impairments were observed in verbal fluency, visuospatial abilities, non-verbal memory, executive functions, and reading proficiency. These findings challenge the traditional notion of these epilepsies being truly "benign," as they appear to have a detrimental effect on various cognitive processes. The observed deficits in executive functions, such as cognitive flexibility, set shifting, and inhibition, align with previous research linking epileptiform discharges during NREM sleep to impairments in these domains [17].

In the stud by Li and colleagues [7], the researchers aimed to explore the relationship between neural network changes and cognitive impairment in newly diagnosed children with SeLECTS. The results showed that SeLECTS patients had significantly lower WISC scores compared to controls, and their functional connectivity network patterns were significantly altered particularly in the functional connections between the posterior cingulate cortex and frontal lobe. Quantified by graph theory analysis revealed increased connection strength, decreased path length, and decreased clustering coefficient in SeLECTS patients across various frequency bands. Correlation analysis demonstrated positive associations between full-scale IQ, verbal comprehension index, perceptual reasoning index, and specific network measures, suggesting that the trend of cognitive impairment in early SeLECTS children may be related to changes in their functional connectivity network patterns [7].

Zhang and colleagues [25] found that SeLECTS patients who experienced a higher frequency of epileptic discharges during the first cycle of NREM sleep performed significantly worse on tests measuring arithmetic skills, executive functioning, attention, and memory compared to those with a lower discharge frequency. Patients who exhibited high-frequency oscillations demonstrated poorer performance across various cognitive domains, including arithmetic,

executive function, vocabulary, visual perception, auditory perception, spatial memory, and response ability. Their findings suggest that a higher burden of epileptic discharges during NREM sleep can have a detrimental impact on various cognitive functions, including arithmetic, executive functioning, attention, memory, perception, and processing speed. Also, Currie and colleagues [26] reported that children with SeLECTS exhibited significantly poorer performance compared to typically developing children on measures of word reading, reading comprehension, and non-verbal IQ.

A previous study conducted on 93 children with SeLEAS reported that on neuropsychological testing, their IQ and subtest scores on the WISC-R were within normal limits. However, some minor statistically significant differences were found compared to controls in the arithmetic, comprehension, and picture arrangement subtests· [27] Another study found that children with SeLEAS exhibited a mean full-scale IQ score within the normal range but significantly lower than the normative mean. Their verbal IQ and processing speed did not differ significantly from the normative data. However, these children demonstrated significant deficits compared to norms in areas such as simple auditory/visual reaction times, visual attention, visual-motor integration, and verbal memory. While their overall IQ fell in the normal range, specific cognitive domains involving speed, attention, visual-motor abilities, and memory were impacted in this syndrome [28].

A study investigated language deficits in SeLECTS and ICOE-G. Surprisingly, both patient groups exhibited significant language deficits compared to controls. ICOE-G patients performed worse than SeLECTS patients on tests of semantic functions. However, no associations were found between the severity of language impairment and clinical parameters of the epilepsies. The findings suggest that language dysfunction can occur across different self-limited focal epilepsy types, reflecting the distributed representation of language networks in the brain. Furthermore, recent epileptic activity did not impact the degree of language deficits in these patients [29].

Another study examined cognitive and behavioral profiles across patient groups with ICOE-G and SeLEAS compared to healthy controls. Patients with SeLEAS exhibited lower scores across all intelligence domains, with performance IQ significantly lower than both the ICOE-G group and controls. Both patient groups demonstrated verbal memory impairments and psychomotor slowing. However, only the SeLEAS group showed deficits in visual memory and reading abilities. Writing and arithmetic skills were compromised in both groups [30].

Previous studies showed that children with SeLECTS suffer heterogeneous cognitive deficits correlated to NREM epileptiform discharges. It was found that centrotemporal spikes may be associated with widespread adverse effects on attentional networks. Also, other studies had shown that a high frequency of IEDs could be correlated with lower executive functions [31].

The current study shed light on the elevated prevalence of behavioral and emotional disturbances among children with benign focal epilepsies. Increased rates of internalizing problems (anxiety, depression, and somatic complaints), externalizing problems (rule-breaking, aggressive behavior), social problems, thought problems, and attention deficits were observed in these children compared to their healthy counterparts. Moreover, the study revealed a higher incidence of psychiatric comorbidities, including depression, anxiety, ADHD, ODD, and conduct disorder, among children with benign focal epilepsies.

Our result is going with the study of Samaitienė and colleagues [32] who found that treated patients with SeLECTS exhibited significantly higher scores across multiple behavioral domains compared to patients with peripheral nervous system disorders. Specifically, they had more issues with social problems, anxiety/depression, aggressive behavior, and attentional problems. Earlier age of first seizure was linked to more delinquent behavior, and longer epilepsy duration was positively related to withdrawn behavior and delinquency.

Previous work of Sousa and colleagues [33] revealed that most patients with SeLECTS had mild-to-severe impairments in executive functioning areas. A significant percentage of cases had emotional and behavioral dysregulation scores that fell into the abnormal category. The significance of thorough screening processes covering cognitive, behavioral, and affective domains for all patients diagnosed with SeLECTS is highlighted by these findings.

There is increasing evidence suggesting a bidirectional relationship between epilepsy and certain psychiatric comorbidities, especially depression and ADHD. Depression may precede the onset of seizures. Likewise, ADHD occurs more frequently in children with epilepsy compared to controls, while epilepsy is also more common in children with ADHD. The brain regions implicated in temporal lobe and frontal lobe epilepsy have been linked to the neurobiology of depression and anxiety disorders. While further research is needed to firmly establish this bidirectionality [34].

The findings of this study emphasize the need for a more comprehensive understanding and management approach for self-limited focal epilepsies of childhood. These conditions were traditionally considered relatively

benign, the observed impact on sleep, cognitive functioning, behavior, and emotional well-being challenges in this perception. Early identification and interventions targeting these associated impairments could potentially mitigate the long-term consequences and improve overall outcomes for children with benign focal epilepsies [35].

It is important to note that the study did not find significant differences among the three subtypes of benign focal epilepsies in terms of polysomnographic parameters, cognitive deficits, or behavioral/emotional disturbances. This suggests that the impact of these epilepsies may share common underlying mechanisms, irrespective of their specific clinical presentations.

While the study provides useful insights, it is essential to acknowledge its limitations. The cross-sectional design limits the ability to establish causal connections between epilepsy and the observed impairments. Longitudinal studies are warranted to elucidate the temporal dynamics and potential bidirectional interactions between epileptic discharges, sleep disturbances, cognitive deficits, and behavioral/emotional problems. Additionally, the study focused on drug-naive children, and the potential consequences of antiepileptic medications on these domains remain unexplored.

Conclusion

The findings of this study challenge the traditional perception of benign focal epilepsies of childhood as truly benign conditions. The observed disturbances in sleep architecture, cognitive impairments, and elevated rates of behavioral and emotional problems highlight the need for a more comprehensive and multidisciplinary approach to the management of these epilepsies. Early identification and targeted interventions addressing sleep, cognitive, and psychosocial aspects could potentially improve overall outcomes and quality of life for children with benign focal epilepsies.

Abbreviations

ADHD	Attention deficit hyperactivity disorder
CBCL	Child behavior checklist
COWAT	Controlled oral word association test
DB	Digit backward
DF	Digit forward
DS	Digit span
HASS	Hague seizure severity scale
ICOE-G	Idiopathic childhood occipital epilepsy of Gastaut
IEDs	Interictal epileptic discharges
IQ	Intelligence quotient
K-SADS	Kiddie schedule for affective disorders and schizophrenia
NREM	Non-rapid eye movement
ODD	Oppositional defiant disorder
REM	Rapid eye movement
ROCF	Rey–Osterrieth complex figure
RSWA	REM sleep without atonia
SeLEAS	Self-limited epilepsy with autonomic seizures
SeLECTS	Self-limited epilepsy with centrotemporal spikes
TMTA	Trail making test A
TMTB	Trail making test B
WCST	Wisconsin card sorting test
WISC	Wechsler intelligence scale for children

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Author contributions

All authors have participated inn in designing the study, acquisition of data, data interpretation, and revising. OR recruited the patient and carried out clinical, neurological evaluation, cognitive evaluation, and polysomnogram interpretation participated in interpretation of the study results and editing the manuscript. FE recruited the patient and carried out clinical, psychiatric evaluation, and cognitive evaluation and participated in interpretation of the study results and editing the manuscript. AB recruited the patient and carried out clinical, neurological evaluation, cognitive evaluation, and polysomnogram interpretation participated in interpretation of the study results and editing the manuscript. AA recruited the patient and carried out clinical, neurological evaluation, cognitive evaluation, and polysomnogram interpretation participated in interpretation of the study results and editing the manuscript**.** All authors have read and approved the manuscript.

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Availability of data and materials

All raw data will be available on the editor request.

Declarations

Ethics approval and consent for participation

The study protocol was approved by the ethical committee in Tanta University, Egypt, under the code number (36049/11/22). Participation was voluntary and all contributors' parents received detailed information about the aims of this research work and an informed written consent was obtained prior to the commencement of the study.

Consent for publication

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Competing interests

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