

## INTERICTAL ELECTROENCEPHALOGRAM CHANGES IN PATIENTS WITH IDIOPATHIC GENERALIZED EPILEPSY

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### Abstract

**OBJECTIVE:** To determine the interictal electroencephalogram (EEG) changes in patients presenting with idiopathic generalized epilepsy.

**METHODOLOGY:** The cross-sectional study was conducted from September 2024 to February 2025 at Dr. Ruth K.M. Pfau Civil Hospital Karachi on non-probability consecutive sampling techniques. Subjects who were 1-30 years old and diagnosed with idiopathic generalized epilepsy were included in the study. Interictal electroencephalogram (EEG) was carefully evaluated for specific epileptiform abnormalities focusing attention in particular on interictal epileptiform discharges. Regular bilateral generalized spike-and-wave discharges in the absence of epilepsy (sometimes) were also detected at analysis. Data analysis was conducted using SPSS version 26, and  $p \leq 0.05$  was considered statistically significant.

**RESULTS:** A sample of 97 patients who had been diagnosed with idiopathic generalized epilepsy (mean age:  $12.00 \pm 7.66$  years, 37.1% male and 62.9% female) was studied. The most common type of electrophysiological abnormality observed was the "spike and wave" pattern in 74 (76.3%) of the patients, followed by the "sharp and wave" in 10 (10.3%) patients, "poly spikes" 8 (8.2%), and the "slow waves" 5 (5.2%) patients, and there was no significant association between gender and the spike and wave pattern ( $p=0.996$ ;  $OR=0.953$ ).

**CONCLUSION:** This investigation underscores that interictal electroencephalogram (EEG) alterations, particularly the spike-and-wave configuration, represent the most salient electrophysiological indicators in individuals diagnosed with IGE. These distinctive EEG manifestations, identified in a predominant segment of the studied population, are crucial for the precise diagnosis and therapeutic management of IGE. The lack of significant gender disparities further substantiates the generalized nature of these observations. Nevertheless, the execution of extensive, multicenter investigations is advised to corroborate these findings and enhance diagnostic accuracy.

## INTRODUCTION

Seizures are the most common neurological disorders, with clear references from even in the ancient literature, and very common in the clinical practice; up to 10% of the general populations (even asymptomatic populations) will have one or more seizures during their life, and the response of seizures in both early life and later life present with peak times of incidence. In contrast to seizures in childhood, the majority of seizures occurring in adults are associated with a cause already established and therefore deserve separate attention with respect to their etiology, however in the young adults, the majority of seizures that present are idiopathic [1]. Furthermore, the underlying cause and clinical aspects of seizures in adults provide distinct rationale for the start and stop of pharmacotherapy compared to children [2,3]. Idiopathic generalized epilepsy (IGE) is a unique and ancient group of presumed genetic seizure disorders. This group makes up 15–20% of the overall cases of chronic seizure disorders [4].

Primary seizures were determined in 58% and secondary seizures in 42% of the cases as reported by Jawaid W, et al. [5]. In an additional study of Ullah S, et al. 57.9% of the patients had generalized tonic-clonic seizures [6]. Idiopathic generalized epilepsy is characterized by different combinations of generalized seizure types including absence, myoclonic, and generalized tonic-clonic seizures, and generalized epileptiform discharges on EEG [7]. Patients with idiopathic (genetic) generalized epilepsy are defined as having no structural brain anomaly according to magnetic resonance imaging (MRI) in addition to the absence of interictal symptoms and signs, which eliminates most etiological categories [8-9]. Genetic predisposition has been suggested to be the genesis from twin studies showing higher concordance rates in mono- to dizygotic twins [10-11].

The electroencephalogram (EEG) is the most sensitive diagnostic method for diagnosis and verification of idiopathic generalized epilepsy. The EEG shows generalized discharges that are marked by spikes, polyspikes, or spike/polyspike-wave complexes and that can appear ictally or interictally. These discharges are commonly provoked by hyperventilation, sleep deprivation, and intermittent photic stimulation. Well-established clinical symptoms are subtle and video-EEG monitoring and hyperventilation with

breath counting are required to reveal them. The EEG may be normal in untreated patients, which also is important to note. If there is a concern about idiopathic generalized epilepsy and a normal routine awake EEG, it is recommended to have an awake and sleep EEG in this population.

We conducted a pilot study in 30 patients with idiopathic generalised epilepsy. In 30 interictal EEG recordings recorded from clinically diagnosed patients of idiopathic generalized epilepsy, normal findings were observed in 11 (36.66%) and 19 (63.33%) revealed abnormal findings. Regarding the morphology of the epileptiform discharges, 73.6% [14] were of spike and wave patterns, 10.5% [2] of sharp waves, 10.5% [2] of polyspikes and an insignificant 5.2% [1] for slow waves. Current literature focuses mainly on EEG data from generalized seizures, as they are more commonly experienced in the epileptic population. Our study will provide increasing evidence and help neurophysicians to diagnose and have more effective treatments for individuals who have idiopathic generalized epilepsy.

## METHODOLOGY

This cross-sectional study was carried out between from September 2024 to February 2025 at the Department of Neurology, Dr. Ruth K.M. Pfau Civil Hospital, Karachi. The sample size of ninety-seven patients were recruited by a non-probability consecutive sampling method. Inclusion criteria males and females between the ages of 1–30 years with a diagnosis of idiopathic generalized epilepsy (IGE) were considered for inclusion.

Idiopathic generalized epilepsy was defined as two or more unprovoked seizures in a patient for whom no cause was evident in acting history, neurological examination and relevant investigation, including neuroimaging and laboratory studies. Patients with the evidence of previous structural brain lesions, head trauma, or epileptic seizures occurring over 30 days prior to the EEG were not recruited for our study.

An interictal electroencephalogram (EEG) was conducted in all participants up to one month after their latest seizure. The interictal period is commonly defined as the period between seizures, when

abnormal cerebral activity can still be evident on the EEG.

Recordings were conducted using a modern digital equipment throughout 20–30 min, and positions of electrodes were carried out according to the 10-20 system, widely accepted in the world. Data acquisition was performed identified while awake and sleeping. Provocative measures, hyperventilation and photic stimulation for 3 minutes each, were performed to increase diagnostic sensitivity.

EEG readings were performed by a consultant neurologist specialized in electrophysiological evaluation. The interictal EEG findings were analyzed for specific epileptiform abnormalities, and special attention was paid to IEDs. These apart the abnormalities occurred in the form of spikes of short duration (20–70 ms), spiky deflected discharges and sharp waves of longer duration (70–200 ms) an epileptic hallmark. Regular symmetric, generalized spike-and-wave discharges (especially common in absence epilepsy) were also identified and recorded. Generalized or focal epileptiform activity was distinguished. The background rhythm was described in terms of normal (coherent and symmetrical) or abnormal (coherent and asymmetrical). Slow wave bursts or paroxysmal discharges as spike-wave, sharp wave and polyspike were noted for their presence and distribution.

Statistical evaluations were performed employing SPSS software version 26. Descriptive statistics encompassed the computation of means and standard deviations for continuous variables, alongside frequencies and percentages for categorical variables. Interrelations among categorical variables were scrutinized utilizing the Chi-square test, with statistical significance established at a p-value of less than 0.05.

## RESULTS

A total of 97 subjects were incorporated into the investigation, exhibiting a mean age of  $12.00 \pm 7.66$  years. A significant proportion of the cohort (52.6%) fell within the age bracket of 1 to 10 years, whereas 47.4% were classified as being older than 10 years. The sample was predominantly characterized by females (62.9%), with males constituting 37.1%. Regarding residential status, 66.0% of the participants resided in urban environments, while 34.0%

originated from rural backgrounds, as illustrated in TABLE I.

Interictal electroencephalographic alterations observed during the examination of the subjects revealed the "spike and wave" configuration as the predominant anomaly, identified in 74 (76.3%) of the participants. Subsequently, "sharp and wave" patterns were present in 10 (10.3%) of the subjects, "poly spikes" were recorded in 8 (8.2%), and "slow waves" were detected in 5 (5.2%). This observation indicates that the spike and wave configuration represent the most salient electroencephalographic characteristic within this cohort as shown in FIGURE I.

The interictal electroencephalogram (EEG) findings were subjected to analysis in relation to gender among the cohort of 97 subjects. The spike and wave pattern emerged as the predominant finding, observed in 75.0% of male participants and 77.0% of female participants. No statistically significant associations were detected between the spike and wave pattern and gender ( $p = 0.996$ ; odds ratio: 0.953 [95% CI: 0.589–1.543]). Likewise, other EEG patterns, including sharp and wave (11.1% in males and 9.8% in females), poly spikes (8.3% and 8.2%), and slow waves (5.6% and 4.9%), did not exhibit any significant gender disparities, as delineated in TABLE II.

## DISCUSSION

Interictal electroencephalography is a valuable diagnostic tool in the evaluation of idiopathic generalized epilepsy (IGE), especially for recognition of characteristic paroxysmal abnormalities. The "spike and wave" pattern was the most common EEG finding in our study and was present in 74 (76.3%) of patients. This was followed by "sharp and wave" in 10 (10.3%), "poly spikes" in 8 (8.2%) and "slow waves" in 5 (5.2%) of the cases. There is no significant association between gender and spike and wave pattern ( $p = 0.996$ ; OR = 0.953), which means that the quintessential EEG pattern is evenly distributed among males and females. The results are in agreement with the previous literature and support the importance of spike and wave complexes in the interictal EEG of IGE patients.

Chowdhury et al. similarly reported a high prevalence of the spike and wave pattern in 74% of their cohort, while "sharp and wave" discharges were present in 11%, "poly spikes" were present in 6%, and "slow

waves” were present in 2% [16]. This strong concordance with our results, enhances the evidence supporting the spike and wave pattern as the most reliable interictal EEG characteristic of IGE. Also, the slight difference in the frequency of polyspikes and slow waves can be attributed to differences in patient population or diagnostic criteria.

However, Dahiam et al. showed a lower spike-wave prevalence (observed in only 20.9% of the subjects), sharp waves (19.1%), spikes (11.8%), and poly spikes (10.9%) in a descending order [17]. This difference could be due to a more heterogenous patient group, with possibly partial epilepsy or structural abnormalities, which are known to have different EEG patterns compared to IGE syndromes. Secondly, the wider subclassification and potential differences of interpretation criteria on EEG could also explain the discrepancy in findings.

The degree of diagnostic accuracy of interictal EEG is also improving on account of advances in technology shown most clearly by the studies of Clarke et al, which have demonstrated the ability of computer-assisted EEG diagnostic review systems to improve diagnostic yield in idiopathic generalized epilepsy (IGE) [18]. The benefits of such methodologies are that subtle patterns are consistently recognized and the inter-observer variability is reduced, with that addressing some of the disparities between different studies than can arise. The application of deep learning to EEG diagnostics can improve the detection of typical anomalies (spike and wave discharges) in borderline or ambiguous cases.

While supporting better characterization of IGE, Koren et al. emphasized the value of a systematic approach in the assessment of focal EEG abnormalities and semiology, even in the case of patients with idiopathic generalized epilepsies [19]. Their study, conducted in a highly controlled epilepsy monitoring unit (EMU) environment, underscored the possibility of focal EEG features which could exist concomitantly with generalized patterns and highlighted the need for a nuanced interpretative approach. Although the current study focused only on interictal aspects of IGE, it is crucial to consider the full clinical and EEG range, particularly in unusual cases.

The study has a number of important strengths but is also subject to important limitations and weaknesses

that require careful attention in the interpretation of the findings. One of the major positive points is the use of clear inclusion and exclusion criteria, resulting in a homogenous sample of patients who are securely diagnosed with IGE. This methodological strictness allowed to exclude confounding factors which could have been responsible for a structural etiology of epilepsy such as structural cerebral lesions, a history of head injury or secondary causes of epilepsy. Besides, the study used standardized EEG procedures, which includes the internationally recognized 10–20 system for electrode placement and the combination of awake and sleep states with activation procedures (hyperventilation, photic stimulation). These methodologic refinements greatly increased the diagnostic yield as well as the reliability of interictal findings. Moreover, the application of rigorous statistical methods such as the normality test and sparing use of the Chi-square or Fisher’s Exact testing further reinforces the validity of the study results.

In spite of the above strengths, the study has several limitations. The unique institutional setting limits the generalizability of the results, and the findings from the Dr. Ruth K.M. Pfau Civil Hospital may not reflect the EEG patterns from a larger or more diverse population. There is also considerable selection bias and consequent lack of generalizability of the study sample attributable to the use of non-probability consecutive sampling design. The cross-sectional nature of the study only provides a snapshot of interictal EEG changes, and the development of these phenomena over time or the possible response to treatment cannot be determined.

The investigation also exposes a number of methodological shortcomings. The lack of a control group (i.e. otherwise healthy unaffected controls or controls with focal epilepsy) limits the comparative analysis and ability to identify EEG traits that are specific for IGE. The inclusion of patients in the study was limited to those between 1 and 30 years, which restricts the extrapolation of its results to any patients older than 30 years, who could present other specific electrophysiological profile.

Based on these caveats, we offer a few suggestions on how future studies might be improved. Use of probability sampling methods would reduce bias and increase representativeness. To promote generalizability, analysis and contextualization at an

older age and comparing it with a control or reference group was needed.

Variable	n (%)
<b>Age (Mean ± SD) = 12.00 ± 7.66</b>	
1 - 10 years	51 (52.6)
>10 years	46 (47.4)
<b>Gender</b>	
Male	36 (37.1)
Female	61 (62.9)
<b>Residential Status</b>	
Urban	64 (66.0)
Rural	33 (34.0)

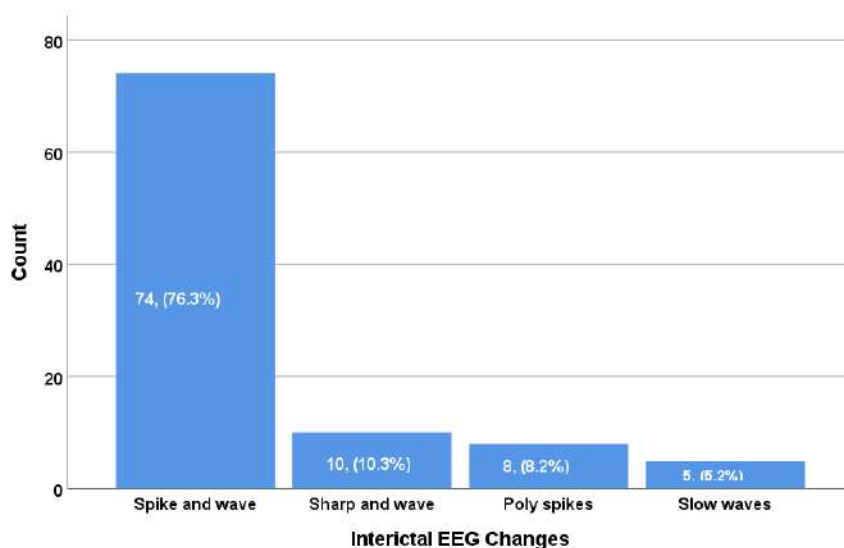


Figure I

Interictal EEG Changes	Gender		ODD RATIO (95% C.I)	P-Value
	Male	Female		
Spike and wave, n (%)	27 (75.0)	47 (77.0)	0.953 (0.589-1.543)	0.996
Sharp and wave, n (%)	4 (11.1)	6 (9.8)		
Poly spikes, n (%)	3 (8.3)	5 (8.2)		
Slow waves, n (%)	2 (5.6)	3 (4.9)		

**CONCLUSION**

This investigation underscores that interictal electroencephalogram (EEG) alterations, particularly the spike-and-wave configuration, represent the most salient electrophysiological indicators in individuals diagnosed with IGE. These distinctive EEG

manifestations, identified in a predominant segment of the studied population, are crucial for the precise diagnosis and therapeutic management of IGE. The lack of significant gender disparities further substantiates the generalized nature of these observations. Nevertheless, the execution of extensive,

multicenter investigations is advised to corroborate these findings and enhance diagnostic accuracy.

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