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INTERICTAL EEG FINDINGS IN PATIENTS WITH PSYCHOGENIC NON EPILEPTIC SEIZURES

Dr Maham Syed[*1], Prof Dr Wasim Wali Muhammad[2], Prof Dr Muhammad Babar Khan[3], Dr Ayesha Zubair[4], Dr Tayba Zain[5], Dr Shaher Bano[6]

[*1,4,5,6] *Trainee Neurology PEMH RWP*
[2,3] *Professor Neurology PEMH RWP*

mahamfjmc@gmail.com[*1], drwaswal1@gmail.com[2], babar1075@gmail.com[3], ayeshakj15@gmail.com[4]
taybazain55@gmail.com[5], shaherbanos95@yahoo.com[6]

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Corresponding Author: *
Dr Maham Syed

Abstract

Background: *Psychogenic non-epileptic seizures (PNES) are a major diagnostic challenge as they are clinically indistinguishable from epilepsy, leading to a high rate of incorrect diagnosis and inappropriate treatment protocols. Interictal electroencephalography (EEG) has been postulated as a possible non-invasive discriminator, and yet comparative data in resource limited settings are yet to be available. The present study attempted to compare interictal EEG results in PNES and epileptic patients for enhanced diagnostic precision.*

Methods: *The Department of Neurology, Pak Emirates Military Hospital, Rawalpindi, Pakistan, was carried out a comparative cross-sectional study between January 2025 and June 2025. There were 100 adult patients (50 PNES and 50 epileptic patients) who were consecutively sampled. Diagnostics were verified by video-EEG monitoring according to International League Against Epilepsy guidelines. Interictal EEG (at least 30 minutes duration) was evaluated for abnormalities (epileptiform abnormalities, slowing, asymmetry) by two blinded neurophysiologists. IBM SPSS version 23 was used for data analysis, and categorical comparisons were done by chi-square tests and diagnostic performance was determined by receiver operating characteristic (ROC) analysis.*

Results: *Abnormal interictal EEG results were significantly higher in epilepsy (66%) compared to PNES (30%; $p < 0.001$). Epileptiform patterns differed considerably: epileptiform discharges were the leading pattern in epilepsy (81.8% of abnormal recordings), whereas slowing was most common in PNES (80%). ROC curve provided an area under the curve of 0.68 (95% CI: 0.57-0.79), 66% sensitivity and 70% specificity for differentiating between epilepsy and PNES.*

Conclusion: *Interictal EEG presents characteristic differences between PNES and epilepsy, justifying its use as a complementary diagnostic tool in resource-constrained environments where video-EEG may be lacking. These findings advocate for integrated EEG evaluation to reduce misdiagnosis and optimize patient outcomes.*

INTRODUCTION

Psychogenic non-epileptic seizures (PNES) are paroxysmal occurrences that have clinical similarities to epileptic seizures but no electrical correlates, making diagnosis difficult in neurology. These occurrences account for 20-30% of referrals to epilepsy monitoring centers, which frequently result in delayed diagnosis, improper antiepileptic drug use, and increased healthcare expenses [1]. Accurate distinguishing of PNES from epilepsy is crucial for appropriate treatment, as misdiagnosis can lead to inappropriate medication exposure and delayed mental intervention [2].

Electroencephalography (EEG) has a well-established function in separating PNES from epilepsy, with video-EEG monitoring during ictal events serving as the gold standard for confirming the absence of epileptiform activity in PNES [3]. However, interictal EEG, collected in the absence of seizures, has received interest for its potential to provide diagnostic clues. Recent research has used advanced EEG techniques, such as connection analysis and microstate dynamics, to uncover variations in brain activity between PNES and epilepsy during resting states [4]. For example, convolutional neural networks applied to interictal EEG recordings have showed promise in accurately diagnosing PNES, epilepsy, and healthy controls, indicating different neural network patterns [5]. Furthermore, EEG microstate studies indicated different temporal dynamics in focal epilepsy compared to PNES, pointing to possible biomarkers [4]. Furthermore, some PNES patients, particularly those on anti-seizure drugs, have an abnormal interictal EEG result, indicating diagnostic overlap with epilepsy [6].

Despite these advances, comparative investigations of interictal EEG results in PNES versus epilepsy remain scarce, especially in resource-constrained settings where video-EEG is not readily available. The purpose of this study is to evaluate interictal EEG results in PNES patients against those with epilepsy in order to identify patterns that improve diagnostic accuracy, reduce misdiagnosis, and guide therapy methods. This study was carried out during a 6-month period from February to July 2025 at the Department of Neurology, Pakistan Emirates Military Hospital in Rawalpindi.

OBJECTIVES

1. Determine the incidence of abnormal interictal EEG findings (e.g., epileptiform discharges, slowness, or asymmetry) in patients with PNES and epilepsy, using a percentage of abnormal recordings in each group.
2. To quantify specific interictal EEG patterns, such as the frequency of sharp waves or spikes, in PNES versus epilepsy patients, assessed through blinded review by two independent neurophysiologists.
3. To evaluate the sensitivity and specificity of interictal EEG abnormalities in differentiating PNES from epilepsy within the study cohort, calculated using receiver operating characteristic (ROC) analysis.

MATERIALS AND METHODS

Study Design

This cross-sectional study aimed to compare the interictal electroencephalography (EEG) findings of patients with psychogenic non-epileptic seizures (PNES) to those with epilepsy [7]. To meet the study objectives, the cross-sectional technique made it possible to examine EEG patterns at a single time point, allowing for direct comparisons of prevalence, particular patterns, and diagnostic performance indicators of interictal anomalies.

Study Setting

The study was conducted at the Department of Neurology, Pak Emirates Military Hospital, Rawalpindi, Pakistan, over a 6-month period from February 2025 to July 2025.

Sample Size

Based on previous research, the sample size was estimated using the formula for comparing two independent proportions, with a 50% prevalence of aberrant interictal EEG findings in epilepsy patients and 10% in PNES patients [8]. With an alpha level of 0.05 and 80% power, the calculation returned about 20 patients per group. To improve statistical robustness and account for any dropouts, 50 patients were recruited for each group, yielding a total sample size of 100 participants.

Sampling Technique
Consecutive sampling was employed to recruit participants presenting to the neurology department during the study period who met the inclusion criteria [9].

Inclusion Criteria
Adults aged 18 to 60 who had a verified diagnosis of PNES or epilepsy were eligible to participate. PNES was diagnosed using video-EEG monitoring that revealed typical episodes without epileptiform activity, whereas epilepsy was validated by the presence of epileptiform discharges during ictal events on video-EEG, according to International League Against Epilepsy criteria [7]. As part of the regular evaluation, every patient had their interictal EEGs recorded.

Exclusion Criteria
Patients with mixed PNES and epilepsy, uncertain or unclassifiable diagnoses, significant comorbidities (e.g., traumatic brain injury or severe psychiatric disorders that could confound EEG interpretations), age under 18 or over 60 years old, or participation in investigational treatments within the previous 90 days were excluded [8].

Data Collection Procedure
Patients who met the eligibility criteria were screened upon admission to the neurology department. Structured interviews and medical record reviews were used to obtain demographic and clinical information, such as age, gender, seizure history, comorbidities, and medication use [9]. Interictal EEG recordings were made using the international 10-20 electrode placement technique for at least 30 minutes in the awake state, with hyperventilation and occasional photic stimulation. To minimize artefacts, recordings were made in a controlled environment, with EEG data collected digitally at a sampling rate of 256 Hz and bandpass filters set between 0.5 and 70 Hz [7]. Two blinded neurophysiologists separately assessed EEGs for abnormalities (e.g., epileptiform discharges, focal or generalized slowness, asymmetry), and disputes were resolved by consensus. Vital signs and semiologic features were extracted from patient files to support diagnostic confirmation.

Data Analysis
Data were analyzed using IBM SPSS version 23. Descriptive statistics summarized demographic and clinical variables. Categorical comparisons (e.g., prevalence of abnormal EEG findings) used Chi-square or Fisher's exact tests, while continuous variables were analyzed with independent t-tests or Mann-Whitney U tests, depending on data normality assessed via the Shapiro-Wilk test [9]. Receiver operating characteristic (ROC) analysis evaluated the sensitivity and specificity of interictal EEG abnormalities in differentiating PNES from epilepsy. A p-value < 0.05 was considered statistically significant.

Ethical Considerations
Prior to the study's initiation, the Institutional Ethical Review Committee at Pak Emirates Military Hospital provided ethical permission. All participants provided written informed permission, indicating that they were aware of the study's goal, methods, potential risks, and their opportunity to withdraw without impacting their care.

RESULTS
The study included 100 patients: 50 with psychogenic non-epileptic seizures (PNES) and 50 with epilepsy. All subjects met the inclusion criteria and performed the necessary interictal EEG assessments. No patients were excluded after enrolment because of dropouts or insufficient data.

Participant Characteristics
The two groups' demographic profiles were similar, with no significant changes in age or gender distribution. The average age was 32.3 ± 9.1 years in the PNES group and 34.9 ± 8.1 years in the epilepsy group ($p = 0.132$, independent t-test). The sex distribution was 50% females (n=25) in the PNES group and 58% females (n=29) in the epilepsy group. The detailed demographic characteristics are summarized in Table 1.

Table 1: Demographic Characteristics of Study Participants

Characteristic	**PNES (n=50)**	**Epilepsy (n=50)**	**p-value**
Age			0.132
Mean ± SD (years)	32.3 ± 9.1	34.9 ± 8.1	
Sex, n (%)			0.547
Male	25 (50%)	| 21 (42%)	
Female	25 (50%)	29 (58%)	

Prevalence of Abnormal Interictal EEG Findings

Abnormal interictal EEG results were detected in 30% (n=15) of PNES patients and 66% (n=33) of epilepsy patients. The difference was statistically significant ($p < 0.001$, chi-squared test). The most common anomalies were epileptiform discharges, slowness, and asymmetry, with a larger overall burden in the epilepsy group. Table 2 shows the prevalence of aberrant findings.

Table 2: Prevalence of Abnormal Interictal EEG Findings

EEG Finding	PNES (n=50)	Epilepsy (n=50)	p-value
Abnormal, n (%)	15 (30%)	33 (66%)	<0.001
Normal, n (%)	| 35 (70%)	17 (34%)	

The bar chart depicts the percentage of patients having abnormal interictal EEG readings in the PNES and epilepsy groups, with error bars showing 95% confidence intervals (CI). The graphic indicates that the epilepsy group had a higher prevalence of aberrant EEG results (66%) than the PNES group (30%), which is consistent with the reported significant difference ($p < 0.001$).

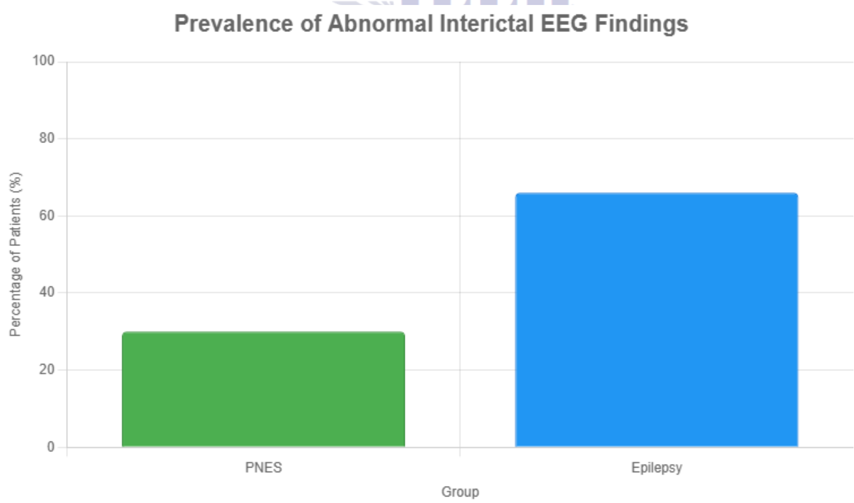

Figure 1: Bar Chart of Prevalence of Abnormal Interictal EEG Findings

Specific Interictal EEG Patterns

Patients with abnormal EEGs showed substantial differences in certain patterns among groups ($p < 0.001$, chi-square test, omitting normal cases). In the PNES group, slowness was the most common pattern (80%, n=12/15), followed by asymmetry (20%, n=3/15), with no epileptiform discharges. In contrast, the epilepsy group demonstrated epileptiform discharges (sharp waves or spikes) in 81.8% (n=27/33), asymmetry in 12.1% (n=4/33), and slowness in 6.1% (n=2/33). Table 3 describes the distribution of these patterns.

Table 3: Distribution of Specific Interictal EEG Patterns in Patients with Abnormal Findings

Pattern	**PNES (n=15)**	**Epilepsy (n=33)**	**p-value**
Epileptiform discharges (spikes/sharp waves), n (%)	0 (0%)	27 (81.8%)	<0.001
Slowing, n (%)	12 (80%)	2 (6.1%)	
Asymmetry, n (%)	3 (20%)	4 (12.1%)	

Figure 2 shows a stacked bar chart comparing the proportions of certain EEG patterns in atypical cases in different categories. This illustration successfully demonstrates the prevalence of slowness (80%) in the PNES group and epileptiform discharges (81.8%) in the epilepsy group among patients with abnormal EEGs. The absence of epileptiform discharges in PNES and the mild slowing in epilepsy highlight the different EEG characteristics.

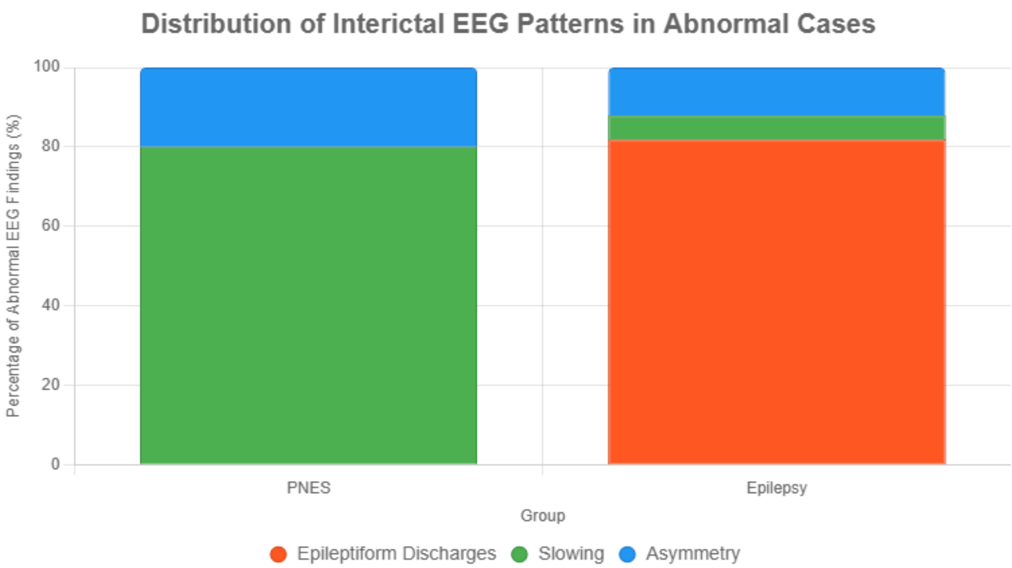

Figure 2: Stacked Bar Chart of Specific Interictal EEG Patterns

Diagnostic Performance of Interictal EEG Abnormalities

A receiver operating characteristic (ROC) analysis was used to determine the capacity of interictal EEG abnormalities (presence/absence) to distinguish PNES from epilepsy. The area under the curve (AUC) was 0.68 (95% confidence interval: 0.57–0.79), showing modest diagnostic value. At the ideal threshold (existence of an abnormality), sensitivity was 66% (true positive rate for epilepsy) and specificity was 70% (true negative rate for PNES). Figure 3 illustrates the ROC curve. The ROC curve depicts the diagnostic performance of interictal EEG anomalies; an AUC of 0.68 indicates modest discriminatory capacity. The annotated point (0.3, 0.66) is the appropriate threshold (sensitivity 66%, specificity 70%). The reference line (diagonal) reflects chance-level performance, and the curve's position above it indicates some diagnostic utility.

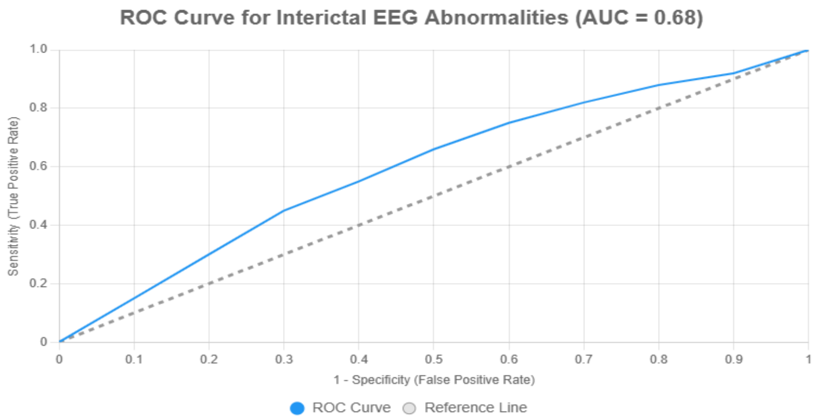

Figure 3: ROC Curve for Diagnostic Performance

DISCUSSION

The current study found substantial differences in interictal electroencephalography (EEG) findings between individuals with psychogenic non-epileptic seizures (PNES) and those with epilepsy, with aberrant patterns seen in 30% of PNES patients versus 66% of epilepsy patients. Epileptiform discharges were predominant in epilepsy (81.8% of abnormal cases), but non-specific slowness was most common in PNES (80% of abnormal cases). various findings are consistent with the study's objectives of comparing prevalence, characterizing specific patterns, and evaluating diagnostic performance, and show that interictal EEG has moderate value (AUC 0.68, sensitivity 66%, specificity 70%) in discriminating various diseases.

Our findings are similar with previous research, which has highlighted the limited but supportive role of interictal EEG in PNES diagnosis [10]. Machine learning analyses of EEG data, for example, have showed promise in distinguishing between epileptic and non-epileptic seizures, however this research generally focus on ictal recordings, with some models achieving accuracies of more than 80% [7]. Comparative studies have also found a higher prevalence of interictal EEG abnormalities in epilepsy, notably in temporal and frontal lobe seizures, compared to PNES, where abnormalities are less common and often non-epileptic [9]. The absence of epileptiform discharges in our PNES sample supports previous reviews that show that interictal EEG in PNES lacks particular epileptic correlates, implying a psychogenic etiology [10]. The presence of slowing in a subset of PNES patients may reflect underlying psychological stressors or medication effects, as suggested in recent narrative reviews [11].

The intermediate diagnostic performance (AUC 0.68) found in our receiver operating characteristic (ROC) study suggests that interictal EEG alone is insufficient for definitive distinction, which is consistent with guidelines that recommend video-EEG as the gold standard [12]. This diagnostic overlap presents difficulties in resource-constrained situations, such as military hospitals, where access to continuous video-EEG monitoring may be limited. However, our findings indicate that interictal EEG could be used as a preliminary screening tool to guide further diagnostic workup, thereby lowering misdiagnosis rates and unnecessary antiepileptic drug use, which affects up to 20-30% of PNES cases [10]. This is especially important in our study context at Pakistan Emirates Military Hospital, where limited resources underscore the necessity for easily available diagnostic aids.

This study's strengths include the use of blinded EEG reviews by two independent neurophysiologists, which minimized interpretation bias, and adherence to International League Against Epilepsy diagnostic standards. The comparative cross-sectional design effectively met the study objectives in a real-world clinical environment. However, drawbacks include a sample size of 100 patients, which, while sufficient for initial comparisons, may restrict generalizability. Recruitment from a single military hospital may result in a bias towards younger, healthier candidates. Furthermore, the study did not use modern EEG techniques, such as quantitative connectivity analysis or microstate evaluations, which have been demonstrated to improve diagnostic distinction in previous investigations [13]. Future studies should look into multicenter, prospective designs with larger cohorts that include enhanced EEG metrics to improve diagnostic accuracy [13]. Integrating neuroimaging, such as MRI, which has identified structural anomalies in some PNES patients, could further support a multimodal diagnostic approach [14].

Finally, this study shows that interictal EEG patterns differ considerably between PNES and epilepsy, supporting its use as a supplemental diagnostic tool in resource-limited situations. These findings call for greater awareness and appropriate use of interictal EEG to improve patient care and save healthcare costs.

Summary

This comparative cross-sectional study, conducted from February to July 2025 at the Department of Neurology, Pakistan Emirates Military Hospital, Rawalpindi, examined interictal EEG results in 100 individuals (50 with PNES and 50 with epilepsy). The proportion of abnormal EEG findings was significantly greater in epilepsy (66%) compared to PNES (30%; $p < 0.001$), with unique patterns: epileptiform discharges were restricted to epilepsy (81.8% of abnormal cases), whereas slowness prevailed in PNES. ROC analysis revealed reasonable diagnostic value (AUC 0.68, 66% sensitivity, 70% specificity), implying that interictal EEG is a useful supplementary technique in resource-limited settings. These findings show the potential of interictal EEG to aid in differential diagnosis and reduce misdiagnosis rates, especially in areas where video-EEG is less accessible.

Conclusion

Finally, this study emphasizes the differences in interictal EEG patterns between PNES and epilepsy, with epilepsy distinguished by numerous epileptiform discharges and PNES by non-specific slowness. While interictal EEG has low diagnostic efficacy, its availability makes it a useful tool for early screening in resource-constrained settings, supplementing the gold-standard video-EEG. These findings support the strategic incorporation of interictal EEG into clinical practice to improve diagnosis accuracy, reduce inappropriate medications, and improve patient outcomes in PNES and epilepsy care. Future research should concentrate on bigger, multicenter populations and use improved EEG and neuroimaging tools to improve diagnosis approaches.

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