



Original Article

EXPLORING SEIZURE CHARACTERISTICS: A COMPREHENSIVE ANALYSIS OF CLINICAL, RADIOLOGICAL AND ELECTROPHYSIOLOGICAL FINDINGS IN TERTIARY CARE TEACHING HOSPITAL

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ABSTRACT

Seizures are a heterogeneous clinical phenomenon with diverse etiologies, semiologies, and prognoses. Accurate phenotyping using clinical history, neuroimaging, and electrophysiology (EEG) is essential for diagnostic precision, etiologic classification, and targeted treatment (e.g., choice of antiseizure medication, surgery, or device therapy). Although many studies have described isolated aspects of seizures, integrated analyses combining clinical presentation, structural and functional neuroimaging, and EEG features in the same cohort are limited. This study aims to bridge that gap and identify reproducible patterns and correlations that could enhance diagnostic accuracy, predict outcomes, and inform individualized management strategies.

Methods: A prospective observational study of 157 patients with seizure disorders collected clinical, MRI, and EEG data to evaluate their characteristics. Statistical analysis revealed significant patterns and correlations among clinical features, radiological findings, and electrophysiological abnormalities.

Results: Generalized tonic-clonic seizures were the most common type (54.14%), followed by focal onset aware seizures (19.10%) and focal onset impaired awareness seizures (3.82%). MRI revealed structural abnormalities in 52.22% of patients, predominantly in non-lobular brain regions, while 47.77% showed lobular involvement. EEG abnormalities were found in 24.84% of participants, with 13.37% demonstrating concurrent MRI abnormalities.

Conclusion: The study emphasizes the importance of seizure semiology and its correlation with MRI and EEG findings, highlighting their value in improving diagnosis and management. Integrating these characteristics can support more personalized and effective treatment strategies for seizure disorders.

Keywords: Seizure characteristics, Semiology, Clinical analysis, Radiological findings, Electrophysiological analysis, Seizure disorders.

INTRODUCTION

Seizures are abrupt, transient episodes of dysregulated neuronal activity, resulting from excessive or hypersynchronous electrical discharges within the brain ^[1,2]. These disturbances can lead to profound alterations in motor control, sensory perception, autonomic function, and consciousness ^[3,4]. While epilepsy is a primary cause, seizures may also arise secondary to acute metabolic derangements, neuroinflammatory processes, structural brain anomalies, traumatic brain injury, or systemic conditions such as hyperthermia ^[5,6].

Seizures exhibit a heterogeneous spectrum of clinical manifestations, broadly categorized into generalized seizures, which involve bilateral cortical networks, and focal seizures, which originate within a discrete region of the brain [1,3]. Generalized seizures encompass tonic- clonic, absence, myoclonic, and atonic variants, each distinguished by specific electrophysiological and behavioral profiles [4,5]. Focal seizures, previously termed partial seizures, may be simple, wherein consciousness remains intact, or complex, wherein consciousness is impaired [2,6]. The ictal symptomatology ranges from involuntary muscle contractions and postural rigidity to sensory distortions, autonomic instability, and paroxysmal cognitive disturbances such as déjà vu or transient aphasia [7].

From a diagnostic standpoint, neuroimaging and electrophysiological assessment play critical roles in identifying seizure etiology and optimizing management strategies [8,9]. Magnetic Resonance Imaging (MRI) facilitates structural evaluations, detecting lesions such as focal cortical dysplasia, gliosis, or hippocampal sclerosis [10]. Concurrently, Electroencephalography (EEG) provides temporal resolution of aberrant electrical activity, revealing spike-and-wave discharges, polyspike bursts, or focal rhythmic slowing, aiding in seizure classification [11]. Semiology, a systematic analysis of seizure phenomenology, further enhances localization and characterization of ictal patterns, offering insights into underlying neurophysiological dysfunction [12,13].

A multidisciplinary approach integrating clinical, radiological, and electrophysiological data enables precise diagnosis and personalized therapeutic interventions [14,15]. The present study seeks to elucidate critical correlations between seizure presentations and their neurobiological substrates. By systematically examining ictal dynamics and biomarker patterns, researchers can refine classification paradigms, develop predictive modelling strategies, and enhance therapeutic efficacy, ultimately improving patient outcomes in seizure disorders.

OBJECTIVE

To comprehensively analyze the clinical, radiological, and electrophysiological characteristics of seizures, aiming to identify patterns and correlations that can enhance diagnosis and treatment.

METHODOLOGY

Study Design and Method

The present study was a prospective observational cohort design, incorporating patients diagnosed with seizures based on ILAE 2017 guidelines. Participants meeting the inclusion criteria were enrolled, and informed consent was obtained from each patient or their legal guardian. Clinical, radiological, and electrophysiological data were systematically collected and analyzed. To ensure rigorous data handling, statistical methods were employed for comparative evaluations, and the results were tabulated and graphically represented for interpretation.

Study Site and Ethical Approval

The present study was conducted at Government General Hospital, Guntur, a tertiary care teaching hospital. Ethical approval was obtained from the Institutional Ethics Committee under protocol number **GMC/IEC/064/2025**, ensuring compliance with Good Clinical Practice (GCP) and the Declaration of Helsinki.

Study Duration

This prospective study was conducted over six months, from September 2024 to February 2025.

Sample Size: A total of 157 patients were enrolled in the study.

Inclusion Criteria

Participants were included based on the following criteria:

- Patients of all age groups.
- Diagnosed with seizures, following ILAE 2017 guidelines.
- Underwent both Electroencephalography (EEG) and Magnetic Resonance Imaging (MRI).
- Provided written informed consent (patients or legal guardians).

Exclusion Criteria

Subjects were excluded if they met any of the following conditions:

- Did not undergo EEG or MRI.
- Had preexisting significant neurological or medical conditions that could confound seizure characterization.
- Had a history of brain surgery or significant trauma unrelated to epilepsy.

Data Collection and Analytical Methods

Data collection and analysis adhered to standardized methods, including obtaining informed consent, recording detailed clinical, radiological, and electrophysiological data, and conducting patient interviews and follow-ups to monitor disease

progression and treatment outcomes. Bias Minimization and Ethical Compliance

STATISTICAL ANALYSIS

Data obtained was entered into Microsoft excel spread sheet results were statistically analyzed, SPSS Software (version 28.0.1, Released in November 2021 by IBM, Armonk, New York, United States.). Descriptive statistics were reported as percentages. Descriptive statistics (mean, standard deviation, frequency distribution), inferential analyses (ANOVA, chi-square tests, regression models), and effect size calculations (Cohen's d, odds ratios).

RESULTS

Demographic Analysis and Age Distribution of Seizure Occurrence

The study enrolled 157 participants, with a nearly equal gender distribution (51% females, 49% males). Seizures were most prevalent among younger individuals, particularly in the 11–20 years age group (24.84%), followed by 21–30 years (24.20%) and 31–40 years (19.11%). Prevalence decreased steadily with advancing age, and no cases were reported between 71–80 years. Statistical evaluation of gender distribution across age groups reveals a higher male representation in the younger age brackets (1–20 years), while female prevalence increases in the 21–40 years range. Chi-square analysis revealed significant gender and age-related variations in seizure occurrence, suggesting non-random patterns and emphasizing the need to explore demographic and clinical factors influencing seizure susceptibility.

Age-Related Trends and Chronobiological Correlates of Seizure Onset, type and Frequency

Seizure onset occurred predominantly in childhood and adolescence, with 57% of cases seen in individuals under 20 years—most commonly in the 11–20 (30.57%) and 1–10 (26.75%) age groups. Incidence declined progressively with age, dropping to 2.55% in those aged 61–70 years and 0.64% in the 81–90 age group. Seizure occurrence varied throughout the day, with most cases reported in the morning (28%) and at night (26.8%). Afternoon and evening episodes each accounted for 9.6%, while 26.1% had no specific timing pattern. Seizure frequency in the study population was highest monthly (51.6%), followed by weekly (20.4%), daily (15.3%), yearly (7.6%), and less than monthly (5.1%)

Figure 1 depicts that Generalized tonic-clonic seizures were the most common (54.1%), followed by focal onset aware (17.8%) and breakthrough seizures (7.0%), while other seizure types occurred less frequently.

Figure 2 depicts that Generalized tonic-clonic seizures predominantly occurred at night (45%) and morning (35%), with higher frequencies (monthly or weekly) being more common.

A significant association was found between seizure type, frequency, and timing ($p \approx 0.002$), indicating that these seizures show a distinct nocturnal pattern and increased burden, highlighting the importance of considering temporal patterns in personalized treatment strategies.

Aura and Seizure Symptoms:

About 31.2% of participants experienced auras before seizures, most commonly sensory (32.7%) and visual or other types (24.5% each). During seizures, 51% showed both jerking and stiffening, 24.2% only jerking, and 22.9% only stiffening. Non-motor symptoms were dominated by loss of consciousness (73.9%), followed by autonomic (40.8%) and sensory disturbances (25.5%), with 2.5% reporting none. Seizure Aura and Associated Signs.

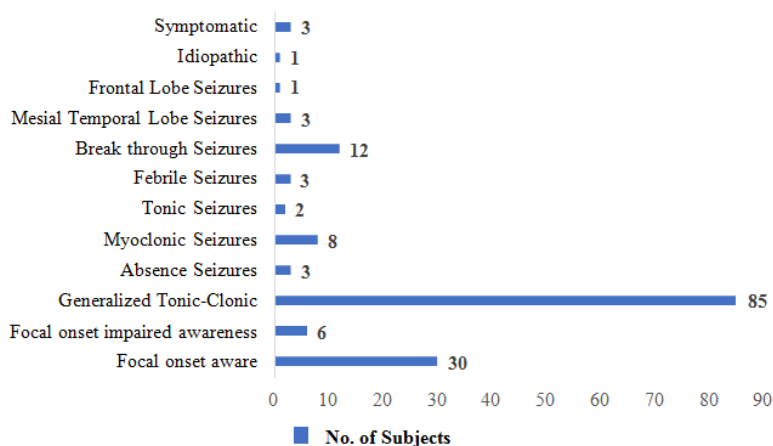
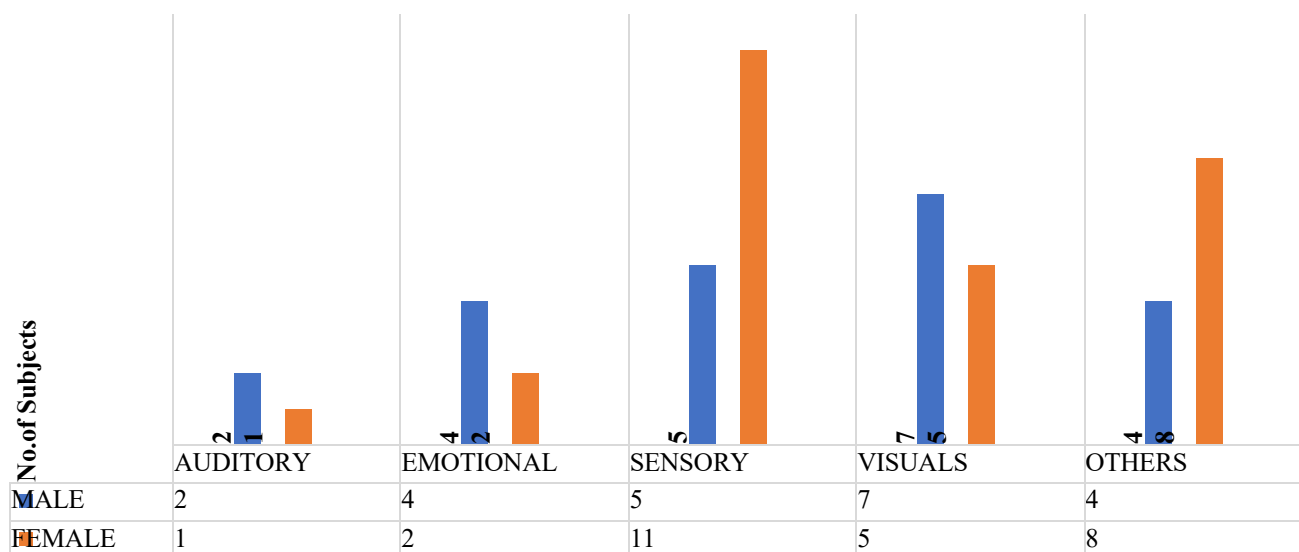


Fig.01: Types of Seizures



Type of Aura

Fig.02: Seizure Aura and Associated Signs Seizure-Related Actions and Duration

Figure 3 depicts that the most common seizure-related actions were tongue biting (45.9%) and upward eye rotation (44.6%), while 29.9% had no symptoms. Other actions included urination (15.3%) and ictal hypersalivation (11.5%). Seizure duration was typically 2–5 minutes (40.1%), with 35% lasting over 5 minutes and 24.8% lasting 1–2 minutes.

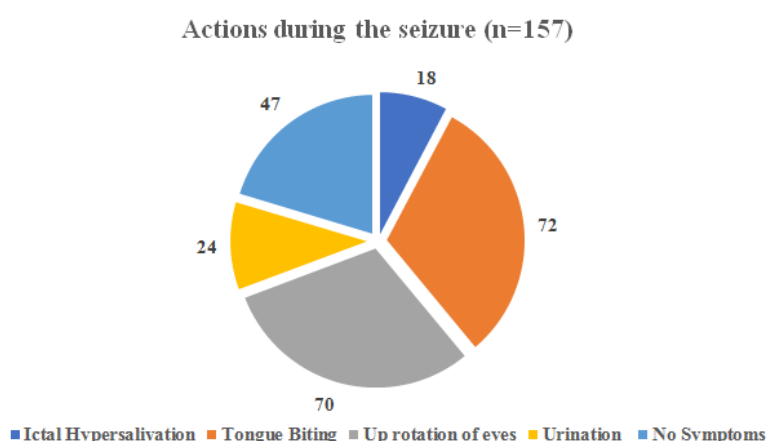


Fig.03: Actions during Seizures

Correlation between Seizure Duration and Clinical Features (Pearson Correlation Test): Pearson correlation analysis showed that seizures with motor symptoms strongly correlated with longer duration ($r = 0.703$, $p < 0.001$), while non-motor symptoms were weakly associated with shorter duration ($r = -0.179$, $p = 0.032$). Tongue biting ($r = 0.254$, $p = 0.001$) and urinary incontinence ($r = 0.203$, $p = 0.011$) were weakly but significantly linked to longer seizures.

Scientific Analysis of Aura Presence and Seizure Duration

Analysis showed that aura presence had no significant effect on seizure duration ($p = 1.00$) or seizure type ($p = 0.77$), indicating it does not influence seizure length or classification. One-way ANOVA showed seizure duration differed significantly by seizure type ($p = 0.011$), with post hoc tests revealing that generalized onset motor seizures lasted longer than both focal onset aware ($p = 0.021$) and focal to bilateral tonic-clonic seizures ($p = 0.033$). Aura presence did not affect duration or type.

Awareness During Seizures and Postictal Symptoms

Figure 4 depicts that during seizures, 67.5% of participants were unaware, 19.1% fully aware, and 13.4% partially aware. Postictal symptoms were mainly drowsiness (56.4%) and headache (33.7%), with muscle soreness (18%) and confusion (11%) less common; 2.9% reported other symptoms, and 1.2% had none.

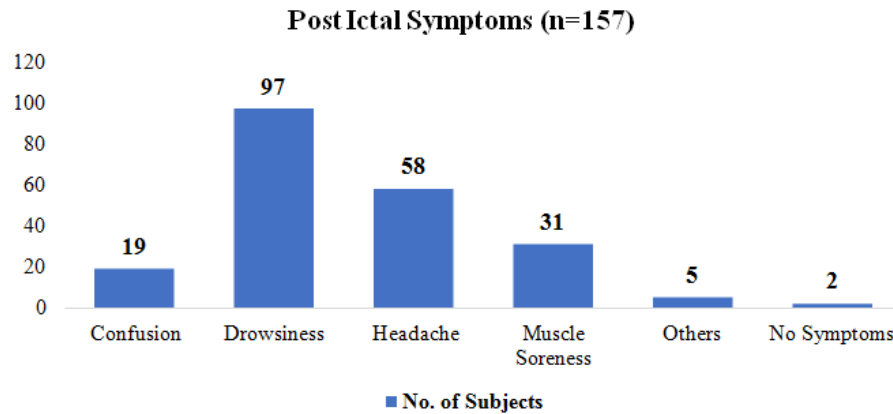


Fig.04: Post Ictal Symptoms

Seizure Triggers

Figure 5 depicts that the most common seizure triggers were stress and overthinking (60.5%) and lack of sleep (31.8%), with less frequent triggers including headache, alcohol, and food-related factors. Seizures were often linked to specific activities (63.7%), certain settings (22.3%), or times of day (7.6%), while 10.8% reported no identifiable triggers. Triggering factors for Seizures (n=157)

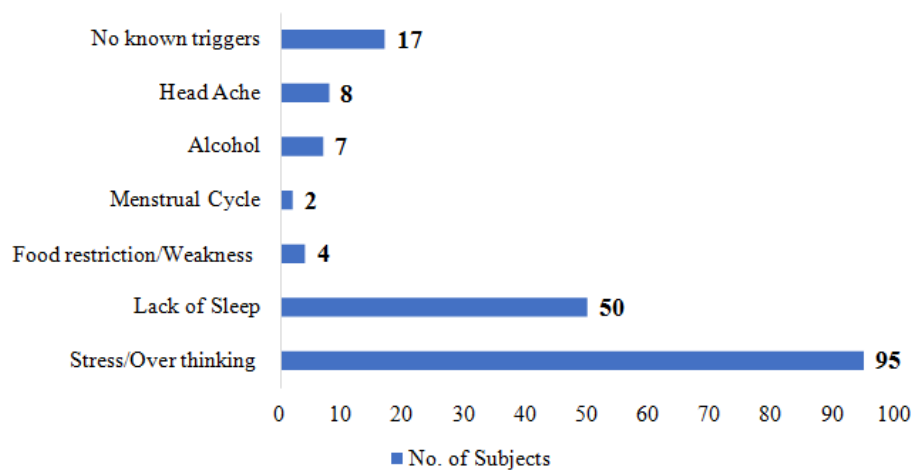


Fig.05: Triggering Factors for Seizures

Seizure Pattern Distribution

Seizures were most commonly linked to specific activities (63.7%), followed by particular settings (22.3%) and certain times of day (7.6%). A minority (6.4%) reported no identifiable seizure pattern.

Interpretation of MRI and EEG Findings in Seizure Diagnosis

Figure 6 depicts that on Analysis of 157 seizure patients showed that abnormal MRI with normal EEG was most common (42%), highlighting MRI's sensitivity for structural lesions, while EEG abnormalities with normal MRI occurred in 13.4%, reflecting detection of functional disturbances. Both modalities were normal in 34.4%, and only 10.2% had abnormalities on both. EEG abnormalities were more likely with multifocal or extensive lobar involvement, whereas MRI reliably detected structural lesions regardless of location. These findings emphasize that MRI and EEG are complementary, with combined use improving diagnostic accuracy and guiding individualized management.

Abnormal Findings in MRI & EEG

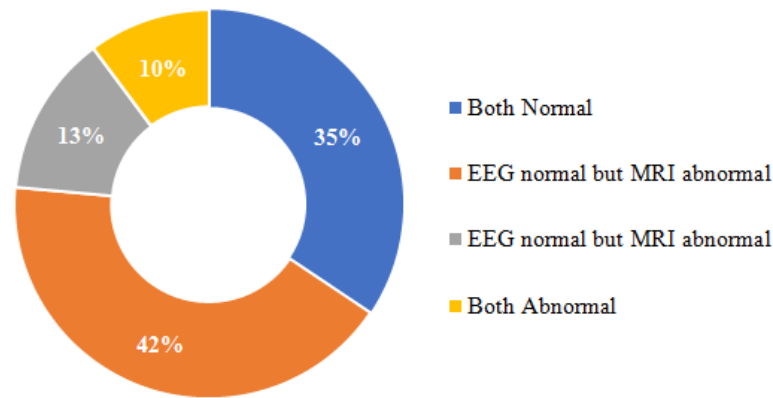


Fig.06: Abnormal Findings in MRI & EEG

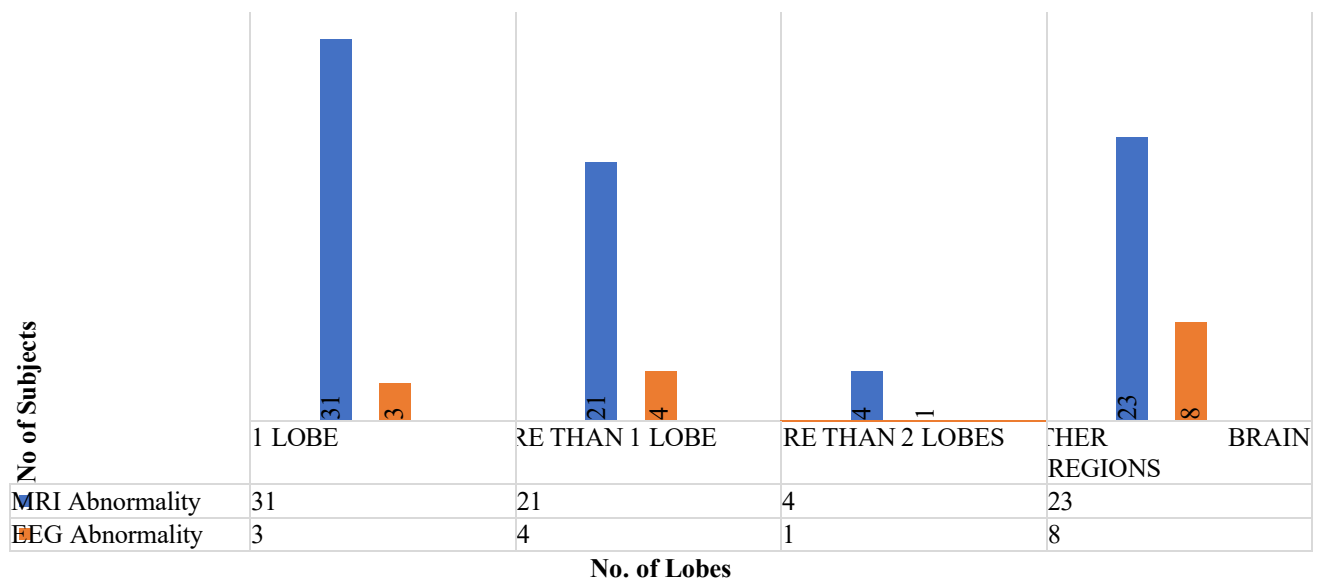


Fig.07: Lobular Involvement in Relation to MRI & EEG Findings

Seizures were more common in younger individuals, with generalized tonic-clonic seizures predominating. Circadian patterns suggest links to neurophysiological rhythms, while frequent postictal drowsiness and headache highlight the need for targeted management. Key triggers included stress, sleep deprivation, and specific activities, underscoring lifestyle modifications. MRI and EEG findings reveal challenges in correlating structural and functional abnormalities, supporting the use of comprehensive neurophysiological assessment.

DISCUSSION

Demographics and Age Distribution

The study observed a near-equal gender distribution with slight male predominance, consistent with prior research done by Elwan et al. ^[16], Betting et al. ^[17]. Seizure onset occurred mostly before age 30, peaking at 11–20 years, highlighting the need for early detection. New-onset seizures declined sharply after age 50, underscoring the importance of age-specific management strategies.

Frequency and Impact of Seizures

The study found high seizure frequency, with 51.6% experiencing monthly episodes and 35.7% weekly or daily, underscoring the need for effective management. Azab et al. ^[18] similarly emphasized the debilitating effects of frequent seizures, particularly in childhood epilepsy, and the importance of effective treatment strategies. Frequent seizures significantly impact daily life, highlighting the importance of interventions that control seizures and support cognitive and emotional well-being.

Identifying Seizure Triggers

Stress and overthinking were the most common seizure triggers, alongside lack of sleep, food restrictions, alcohol, and menstrual cycles, highlighting the multifactorial nature of triggers. These findings underscore the importance of addressing both psychological and environmental factors in personalized epilepsy management. These findings align with Srinivasan et al. [19], Vulliemoz et al. [20]

Aura and Seizure Types

Seizure auras were reported in 32% of participants, serving as important markers for predicting and localizing seizures. Additionally, 51% experienced jerking and stiffening movements, highlighting the need for strategies to manage motor symptoms. This is consistent with Beniczky et al. [21] and Srinivasan et al. [19].

Non-Motor Symptoms

Non-motor symptoms, including loss of consciousness (58%) and autonomic signs (32%), were common and complicate diagnosis and treatment. These results align with Krakow et al. [22] and Vulliemoz et al. [20]. These findings emphasize the need for comprehensive, personalized management addressing both motor and non-motor aspects of seizures.

Awareness Levels During Seizures

The study found that 67.5% of participants experienced reduced awareness during seizures, emphasizing the need to differentiate seizure types, as awareness levels influence management and help localize the epileptic focus. Hirsch et al. [23] and Atmaca et al. [24] highlighted the importance of differentiating seizure types and assessing awareness are crucial for guiding treatment and localizing the epileptic focus.

Postictal Symptoms and Recovery

Postictal symptoms, mainly drowsiness (56.4%) and headache (33.7%), significantly impact quality of life, highlighting the need for tailored management addressing both physical and cognitive recovery. These findings are consistent with Muayqil et al. [25], Beniczky et al. [21] who reported similar recovery patterns.

MRI and EEG Abnormalities

The study found MRI abnormalities in 52.2% and EEG abnormalities in 24.8% of participants, highlighting the complementary roles of MRI for structural and EEG for functional assessment. Combining both modalities enhances epilepsy diagnosis and treatment. Studies by Kuzniecky et al. [26] and Jin et al. [27], Elmi et al. [28] reveal that MRI identifies structural abnormalities, EEG provides functional insights, and combining both improves understanding of epilepsy.

CONCLUSION

Seizures were more common in younger individuals, predominantly generalized tonic-clonic, often following circadian patterns. Frequent postictal drowsiness and headache highlight the need for targeted management, while stress, sleep deprivation, and specific activities were key triggers, underscoring the role of lifestyle modifications. MRI and EEG findings emphasize the importance of comprehensive neurophysiological assessment due to challenges in correlating structural and functional abnormalities.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest related to this study.

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