

Assessment of Electroencephalographic Changes and Clinical Characteristics Among Patients with Substance-related Disorder

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Abstract

Background: Substance abuse is defined as the hazardous use of psychoactive substances such as alcohol and illegal narcotics. It is a significant global public health concern. Chronic relapsing diseases, defined by compulsive use of drugs despite negative health effects, were substantial contributors to the illness burden in the USA and all over the world. **Objective:** The objectives were as follows: (a) to determine the presence of electroencephalographic (EEG) changes and their types among patients with substance-related disorders and (b) to evaluate the sociodemographic and clinical characteristics of patients with substance-related disorder. **Materials and Methods:** It was a cross-sectional study conducted from September 1, 2021 to August 1, 2022. It was performed on 112 patients (104 males and 8 females) in the Neurophysiology Department of Al Imam Al Sadiq Teaching Hospital in Al-Hilla Governorate. The patients were diagnosed by psychiatrists, according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition. All patients were assessed by history, physical examination, and EEG test. **Results:** The study showed that the frequency of EEG changes was 57.1%, whereas those without any changes was 42.9%. Those with score 2 or moderate severity were 53.6%. Severe abnormalities were found in 3.5% of the patients. There was a significant association between the EEG change and the type of substance taken, with a *P*-value of 0.008. The study showed the association between the EEG change and duration of substance taken, with a *P*-value of 0.0001, which was significant. There was a significant association between the type of substance taken and age (*P* = 0.002). The association between the type of substance taken and gender, residence, and occupation was non-significant. **Conclusion:** The study concluded that the EEG changes were of high prevalence in patients with substance-related disorder. The most common abnormality was score 2 (moderate severity). The most common substance with an abnormal EEG change was amphetamine.

Keywords: APA, DSM-V, EEG, substance-related disorder

INTRODUCTION

Substance-related disorder is a maladaptive pattern of substance use leading to clinically significant impairment or distress in social and physical activity, manifested by the presence of at least 2 of 11 criteria in a 12-month period.^[1]

Drug use disorders have a lifetime prevalence of roughly 10% in the general American population, which corresponds to more than 23 million persons suffering with problematic drug use. Nearly one-third of American individuals will fit the criteria for alcohol use disorder at some point in their life, and other co-occurring drug use disorders are common.^[2]

An electroencephalogram (EEG) is an electronic device that records the electrical activity of the brain.^[3] It is a non-invasive neurophysiological test that uses electrodes put on the scalp to monitor brain activity.^[4]

EEG measurements are one of the most often utilized methods for diagnosing brain-related neurological

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irregularities. It has been widely utilized for the early detection of a wide range of brain illnesses, including epileptic seizures, attention-deficit/hyperactivity disorder, and so on.^[5] It is a valuable estimate for mental health in people with drug use disorder.^[6] EEG alterations are produced by drug addiction and a variety of other conditions, including psychotropic medication, notably atypical antipsychotics, neurological comorbidity, and a variety of other factors observed in the schizophrenic population.^[7]

The study aims to

- 1 Determine the presence of EEG changes and their types among patients with substance-related disorders.
- 2 Evaluate the sociodemographic and clinical characteristics of patients with substance-related disorder.

MATERIALS AND METHODS

Study design and subjects

This cross-sectional observational research was undertaken on people with drug use disorders. The study lasted from the beginning of September 2021 until the beginning of August 2022 at the Imam Al-Sadiq Teaching Hospital in Babylon Province's Department of Neurophysiology. The patient was identified as having a substance-related illness in the hospital's mental outpatient clinic and dependency ward. Patients are referred mostly by psychiatrists and our mental outpatient service. They were diagnosed with a substance-related disorder using DSM-V criteria.^[1]

Inclusion criteria

All patients who:

- Take substance for at least 12 months;
- Abstinence duration not more than 4 weeks;
- Diagnosed according to the DSM-V criteria for substance-related disorder.

Exclusion criteria

All patients with:

- Past medical history of neurological disease such as multiple sclerosis
- Patients with space-occupying lesions in the brain
- Patient with head trauma
- Patients having cerebrovascular accident, epilepsy, and diabetes mellitus
- Psychological disorders such as depression
- Patients on medication such as antipsychotic, antidepressant, antiepileptics, and so on.

Ethical approval

The study was conducted in accordance with the ethical principles that have their origin in the Declaration of

Helsinki. It was carried out with patients' verbal and analytical approval before the sample was taken. The study protocol and the subject information and consent form were reviewed and approved by a local Ethics Committee according to the document number 7266 (including the number and the date in 08/09/2021) to get this approval.

Psychological assessment and clinical examination

Subjects were carefully chosen to avoid the effects of patients' medical histories and medicines. All patients provided sociodemographic information such as their name, age, residence, marital status, educational level, employment, and a history of the type of the drug they used and the length of their problem, as well as a previous EEG record. They were all sent for CT scans to rule out any brain lesions. Patients who recruited for this study had been diagnosed with a substance-related illness using the DSM-V, which was accepted by the American Psychiatric Association (APA, 2013). After being informed of the aims and methods of electrographic examination, all volunteers were selected from the outpatient department and verbally consented.

Electrophysiological assessment

The patient was well prepared, and awake EEG recordings were made in accordance with the American Electroencephalographic Society standards, using a typical 10/20 electrode placement method, and bipolar montages were employed.^[8] The EEG was interpreted by special neurophysiologists. The EEG electrical activity recorded was as follows: 0 = no abnormality; 1 = mild abnormality (generalized or frontal symmetrical theta slowing); 2 = moderate abnormality (theta and delta slowing, increased delta/alpha frequency activity, that is, higher delta and lower alpha synchronization, decreased activity of alpha or beta, asymmetry increase activity of alpha or beta, increased activity of delta and theta, asymmetrical focal theta or delta), 3 = severe abnormalities (spike discharges or spike-and-wave activity, either alone or with the moderate abnormality).^[8,9]

Statistical analysis

The data were analyzed by using computerized SPSS (Statistical Package for Social Sciences) program, version 24. Categorical variables were addressed as percentages [no. (%)]. The χ^2 test was used to compare between the study groups, and a *P*-value of less than 0.05 was considered statistically significant.^[10]

RESULTS

The total number of participants in this study were 112 patients (104 males and 8 females). The age was most common in the groups 15–25 and 26–35, with a frequency of 41% for each category. The frequency of patients who were living in the urban area was 80.4%, whereas the

frequency of the study participants who were single was 50%. Most of the study participants were unemployed (87.5%). Secondary school was the most common educational level of the study participants (62.5%).

In this study, 44.6% of the participants used amphetamine. The duration of taking the substance for most of the patients was 2 and 3 years with a frequency of 33.9% for each one. Most of the study participants had an abstinence duration of 1 week (55.4%). The most common EEG change in this study was score 2, which means moderate changes (the frequency of the patients with moderate EEG change was 42.9%).

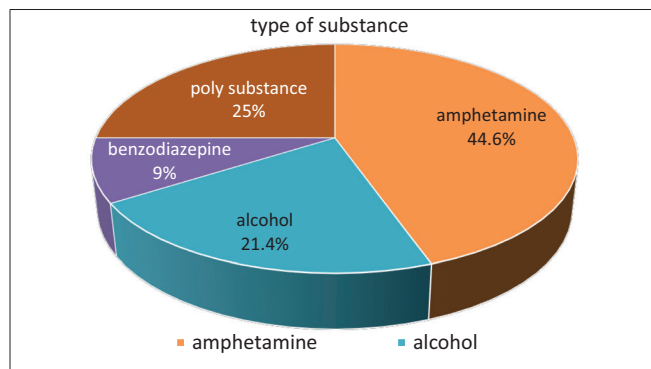


Figure 1: The distribution of the patients according to the type of substance

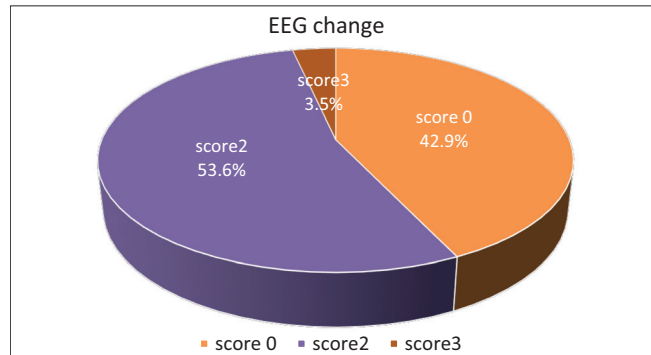


Figure 2: Distribution of the patients according to the EEG change

In this study, there were four types of the substance taken by the patients as identified in Figure 1 with their frequency.

The EEG changes were scored as shown in Figure 2:

Score 0 (normal): Among our study patients, 42.9% had normal EEG findings.

Score 1 (mild): 0% mild EEG changes.

Score 2 (moderate): Found in 53.6% of the patients.

Score 3 (severe): Found in 3.5% of the patients.

As in Table 1, there was a significant difference between the type of substance taking and age ($P = 0.002$).

Table 2 demonstrates the frequency of the patients according to the type of substance taking in correlation with gender. The study showed that there was no association between the type of substance and gender; P -value was 0.447 which was non-significant.

The study showed that there was a significant association between the type of substance taking and EEG change, with a P -value of 0.008.

DISCUSSION

The distribution of the patient according to the type of substance

The result showed that amphetamine was the most commonly used substance followed by multiple substances, then alcohol, and lastly benzodiazepine substance.

Our respondents' reasons for using psychoactive substances included relief from depression, increased alertness, staying awake at night, peer pressure, and improved sexual performance. These were similar to findings reported in previous studies for the initiation of substance use and included academic pressure, peer group temptation, stress relief, and increased pleasure during sex.^[11]

This is in agreement with Al-Wateefee,^[12] who studied the screening of addiction-associated drugs among suspected

Table 1: Distribution of patients according to the type of substance taking in correlation with age

Type of substance		Age group				
		15–25	26–35	36–45	More than 45	
Type	Alcohol	4	12	4	4	24
		16.7%	50.0%	16.7%	16.7%	100.0%
	Amphetamine	24	20	6	0	50
		48.0%	40.0%	12.0%	0%	100.0%
	Benzodiazepine	2	4	4	0	10
		20.0%	40.0%	40.0%	.0%	100.0%
	Multiple substances	16	10	2	0	28
		57.1%	35.7%	7.1%	.0%	100.0%
	Total	46	46	16	4	112
		41.1%	41.1%	14.3%	3.6%	100.0%

Table 2: The association between the type of substance and gender

Type of substance			Gender		Total	P-value
			Males	Females		
Type	Alcohol	Count	22	2	24	0.447
		%	91.7	8.3	100.0	
	Amphetamine	Count	48	2	50	
		%	96.0	4.0	100.0	
	Benzodiazepine	Count	8	2	10	
		%	80.0	20.0	100.0	
Multiple substances	Count	26	2	28	100.0	
	%	92.9	7.1	100.0		
Total	Count	104	8	112	100.0	
	%	92.9	7.1	100.0		

prisoners and mentioned that amphetamine (commercially called crystals) is hugely used among Babylon adduct. In Ibrahim's study, when compared with previous Saudi Arabian studies, polysubstance and amphetamine usage increased, but prescription drug misuse decreased. The use of drugs and alcohol was declining. The least often misused medicines were benzodiazepines and volatile inhalants.^[13]

The distribution of the patients according to the EEG changes

EEG changes found in this study were classified into four scores. Score 2 or moderate abnormality was the most common finding, followed by score 0 or no change and lastly score 3 or severe change. This may be explained by the fact that abnormal findings may be non-specific; for different drugs, it may affect the reward system, cognitive behavior, multiple neurotransmitters, and specific brain area. Normal EEG could be due to the abstinence period and EEG method was subjective and depends on the experience of neurophysiologists.

Substance addiction is a complicated group of illnesses characterized by common psychopathological comorbidities and a variety of EEG abnormalities.^[14] The effects of substances on the EEG vary and are typically dosage-dependent. The following effects on the EEG are generally predictable: no effect, accentuation of beta activity, background slowing with decreased amplitude and/or frequency of the alpha rhythm, intermixed theta and/or delta activity, decreased seizure activity, and lower seizure threshold with increased spike and wave discharges. The EEG may exhibit alpha/theta coma, burst suppression, or even a "flat" EEG pattern in situations of acute overdose.^[15] Long-term drug use such as alcohol, nicotine, cannabis, cocaine, opiates, heroin, and methamphetamine is linked with a wide variety of resting-state EEG abnormalities, the majority of which cannot be restored automatically after brief abstinence, according to the comprehensive review.^[16] The similarities and discrepancies in findings for various medicines might

be attributed to their common and varied effects on neurotransmitters and brain areas.

The distribution of patients according to the type of substance taking in correlation with age

The study demonstrated that there is a significant association between the type of substance and age; most of the amphetamine and multiple substance abusers were in the range 15–25 years, whereas alcohol and benzodiazepine abusers were in the range of 26–35 years.

Adolescence is characterized by a heightened desire in new experiences mixed with weak inhibitory control, which may promote impulsive acts and, as a result, increase the likelihood of experimenting with substances (for example, alcohol), making adolescents more prone to addiction.^[17]

Many studies supported our findings, such as those of Austic and Meier,^[18] who found that the greatest yearly incidence rates for non-medical use of prescription stimulants were recorded between the ages of 16 and 19 years. There is motivation to launch interventions during the early teenage years to prevent juveniles from beginning non-medical use of prescription stimulants, and ultimately a study by Degenhardt *et al.*^[19] demonstrated that young Australians consuming amphetamine at the age of 24 are extremely likely to be substantial polydrug users.

The distribution of patients according to the type of substance taking in correlation with gender

The study showed no association between the type of substance and gender; this reflects that substance-related disorder is a problem in both sexes and our results could be due to sample size (the larger the sample size, the greater the chance of a woman being present in our study). As mentioned previously, most of the females in our society did not seek help for treatment from abuse due to stigma, cultural religious customs, and traditions.

Recent clinical investigations in substance use disorder (SUD) that looks at sex differences indicate neurobiological

alterations that are influenced differently in common reward processing areas such the striatum, hippocampus, amygdala, insula, and corpus collosum.^[20]

According to the study by Lal *et al.*,^[21] although drug addiction is often regarded to be a male phenomenon, it exists among women and appears to be related with drug misuse tendencies comparable to those of males in modern metropolitan environments. Although drug use in women typically begins later or is introduced iatrogenically, it follows a more fast downhill trajectory, with quick advancement through the stages of dependency and increased psychological and physical morbidity. The stigma of being a “fallen angel” makes these ladies easy prey for society’s problems and prevents them from seeking treatment early in the illness’s course.

The distribution of patients according to the type of substance taking in correlation with EEG change

Table 3 showed that the association between the type of substance taking and EEG change was significant.

Most of the amphetamine participants had a score of 2 or moderate severity. We found that amphetamine could change the EEG result by causing an increase in the beta band activity; this agrees with Van Cott and Brenner^[22] who said that central nervous system stimulants such as cocaine, amphetamines, and methylphenidate as well as tricyclic antidepressants may evoke greater beta activity at low voltage.

Another observation was an increase in the delta and theta bands, which is consistent with one research. Newton *et al.*^[23] found that methamphetamine-dependent participants after 4 days of abstinence had increased EEG power in the delta and theta bands but not in the alpha and beta bands. The majority of the conventional EEGs were abnormal in the methamphetamine-dependent group (64%), compared with 18% in the non-methamphetamine-using group, indicating that methamphetamine consumption is linked with psychomotor slowing and

frontal executive impairments.^[24] The results of a study by Khajehpour *et al.*^[25] showed that the beta band waves are abnormally changed in methamphetamine-dependent individuals vs. normal controls.

In sum, the number of studies among substance-related disorders that converged on being abnormal in the beta band, however, is not significantly high, and there is high methodological variability in them (functional connectivity and power spectrum analysis with eye-close/eye-open resting-state EEG), and the beta band encompasses more significant differences of SUDs vs. healthy controls when compared with the other frequency bands. As a result, the beta band may have more potential than the other frequency bands to be a biomarker for SUDs, and it may be connected with inhibitory impairments in SUDs.

Alcoholic subjects in our study had a score of 2 or moderate severity (increased beta band activity, sluggish wave activity), whereas others got a score of 3 or severe EEG changes (spike and wave activity).

According to the study of Liu *et al.*,^[16] the most notable finding is the well-documented enhanced beta power, particularly in the frontal and central areas. Increased beta rhythms appeared to represent cerebral hyperexcitement or disinhibition.^[26] Neurophysiological similarities of these groups imply that binge drinking and risky alcohol use may be a precursor to addiction. According to the findings of the study,^[27] binge drinking in young people is related with dysregulation of the spontaneous EEG signal, as demonstrated by a slowing of the alpha peak and increased power in the theta and beta bands. This, together with evidence of greater beta power in patients with alcohol use disorder and their family, and the known genetic relationship between beta oscillations and GABA receptor markers, shows that beta power may be linked to sensitivity of alcoholism.

Acute alcohol withdrawal can cause bursts of spikes and polyspikes, especially as a photoparoxysmal reaction.^[22,28] This was consistent with our findings.

Table 3: The association between the type of substance taking and EEG change

		EEG changes			Total	P-value
		Normal	Moderate	Severe		
Alcohol	Count	8	12	4	24	0.008
	%	33.3	50.0	16.7	100.0	
Amphetamine	Count	22	28	0	50	
	%	44.0	56.0	0	100.0	
Benzodiazepine	Count	2	8	0	10	
	%	20.0	80.0	0	100.0	
Multiple substances	Count	16	12	0	28	
	%	57.1	42.9	0	100.0	
Total	Count	48	60	4	112	
	%	42.9	53.6	3.6	100.0	

The existence of an EEG drug effect is most typically indicated by beta activity; benzodiazepines are the most prominent generators of this effect.^[22,28]

CONCLUSION

1. The abnormal EEG changes were of high prevalence in patients with substance-related disorder.
2. The study showed that the most common abnormality was score 2 (moderate severity).
3. The most common substance with an abnormal EEG change was amphetamine.
4. The abnormal EEG changes are affected by the duration of the disorder (duration of taking the substance and abstinence period).
5. Most of the patients with substance-related disorder were single, at adolescence and early adulthood, and had secondary education, with no effect of gender, occupation, and residence.

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Conflicts of interest

None to declare.

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