Biological and Psychosocial Study of Self Harm in Borderline Personality Disorder

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Abstract

Background: Borderline personality disorder (BPD) results in severe impairment and distress and is linked to various co-morbid conditions. Self-injurious behavior (SIB) presents therapeutic challenges in the treatment of individuals with BPD.

Objectives: to assess the socio-demographic profile of individuals with BPD associated with self-injurious behavior and to explore the potential biological abnormalities that might characterize these patients in electroencephalogram (EEG) and evoked potential P300.

Patients and methods: A comparative case-control study was conducted on 40 adults (≥18 years) diagnosed with BPD with a history of self-harm and 20 healthy controls. Participants were assessed using the Borderline Personality Features Scale (BPFS) and the Deliberate Self-Harm Inventory (DSHI), along with resting EEG and P300 measurements.

Results: No significant socio-demographic differences were found between the groups, except for impaired occupational functioning in BPD patients (P = 0.003). These patients exhibited frontal theta activity, significantly delayed P300 latency (P<0.001), and reduced P300 amplitude (P<0.001). A positive correlation was observed between P300 tone latency and both age (P= 0.873) and DSHI scores (P = 0.857), as well as between P300 tone amplitude and the age of self-harm onset (P = 0.211). Similarly, P300 speech latency correlated positively with age (P = 0.582), BPFS (P = 0.015) and DSHI scores (P = 0.246), and self-harm duration (P = 0.483), while P300 speech amplitude was positively associated with the age of self-harm onset (P = 0.111).

Conclusion: No specific socio-demographic criteria can be specified for BPD with SIB, but specific biological aberrations can be detected.

Keywords: Biology; Self Harm; Borderline Personality Disorder; EEG;P300.

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Introduction

The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) describes borderline personality disorder (BPD) as a pervasive pattern of instability in social relations, self-image, emotional responses, and impulsive behavior **(Bandyopadhyay et al., 2014)**. The lifetime prevalence of BPD in the public is believed to be between 1% and 2% **(Coid et al., 2003)**. Extensive epidemiological studies released in 2007 and 2008 assessed the point prevalence of BPD in the general public at 1.6%, with an overall prevalence of 5.9%. **(Hersh, 2024)**. BPD results in considerable dysfunction and suffering and is linked to several physical and psychiatric comorbidities. Surveys reported that the prevalence of BPD is 1.6% in the public and 20% among psychiatric inpatients. **(Ellison et al., 2018)**.

Self-injurious behavior, boundary violations, and recurrent suicidal threats represent significant therapeutic obstacles in the management of patients with BPD. Elevated incidence of concomitant substance misuse may complicate and challenge the management of people with BPD **(Hersh, 2024)**. Self-injurious behavior, either suicide or non-suicidal self-harm (NSSH), is a worrying issue in people with BPD, with around 65–80% of persons have one or more episodes of NSSH **(Jørgensen et al., 2024)**.

In medical research, there is an advancement in employing neurobiological markers (biomarkers) to facilitate personalized care, as they serve as "objective biological measures that can forecast clinical outcomes." **(Abi-Dargham and Horga, 2016)**. In recent decades, electrophysiology has significantly enhanced the comprehension of both normal brain functioning and aberrations in brain function associated with psychopathological diseases. Electrophysiological technology is noninvasive and considered not overpriced to a great extent, facilitating the comprehension of the pathophysiology of BPD **(Shankar et al., 2019)**.

Several previous studies highlighted an elevated prevalence of electrophysiological alterations in electroencephalogram (EEG) and diminution of P300 amplitude in evoked potential studies in BPD. **(Boland et al., 2021)**.

We hypothesized that patients diagnosed with BPD who engage in self-harm behavior have special psychosocial characteristics and biological abnormalities expressed in the EEG and P300. This research aimed to investigate the demographic and psychosocial profile of individuals with BPD associated with self-injurious behavior and to explore the potential biological abnormalities that might characterize these patients in EEG and P300.

Patients and methods

This comparative case-control research was performed on 60 participants aged ≥ 18 years old. Forty participants were diagnosed with BPD depending on criteria of the DSM 5th edition and had recent or previous history of self-harm, they were categorized as a patient group. The remaining twenty participants were healthy subjects with ages like those of the recruited patients and were categorized as the control group. The research was conducted from October 2020 to October 2023 following approval from the Ethics Committee with approval code 34130/9/20, Tanta University Hospitals, Tanta, Egypt. A well-informed written consent has been obtained from all subjects.

Criteria for exclusion were schizophrenia, major depressive disorder, or other mental illness such as intellectual disability, substance use disorder, patients with hearing loss or middle ear problem, and patients diagnosed with any neurological disorder or other general health problem.

Subjects were categorized into two groups: Patients group (n=40): diagnosed

with BPD depending on criteria of the DSM 5th edition. They must have a recent or previous history of self-harm. And the control group (n=20): consisted of twenty healthy control subjects of the same age group and were recruited from multiple sources such as hospital workers, faculty students older than the age specified in the study, friends of some patients included in the study who volunteered to participate in the research, for comparison of the findings.

Each participant had been exposed to complete history taking, physical examinations and resting EEG and P300 assessment.

Application of Borderline Personality Features Scale -24 Arabic version(Crick et al., 2005): This 24-item self-report measure was developed from the Personality Assessment Inventory, based on theoretical frameworks, diagnostic conceptualizations, empirical research, and psychometric evaluations **(Jackson and Trull, 2001)**Four subscales measure the BPD features of affective instability, identity disturbance, negative relationships, and impulsive Self-Harm; each comprises six items. Responses to items are evaluated on a 5-point Likert scale, with 1 indicating "not true at all" and 5 signifying "always true." The translated version of the test had an estimated reliability value of 0. 85 and validity of 0.50.

Application of Deliberate Self Harm Inventory Arabic version (Gratz, 2001): The scale was translated by Professor Hala El-Boraey in 2022. DSHI is a 17-item self-report questionnaire using a yes/no format, designed to evaluate intentional self-harm. The assessment is behaviorally focused and evaluates dimensions of intentional self-harm, including frequency, severity, duration, and kind of self-injurious behavior. The items are prefaced by the statement: 'have you ever consciously, or on purpose...' to guarantee the exclusion of unintentional self-harm. Each affirmative response contributes to the cumulative sum of behaviors, with scores of five or more deemed indicative of psychopathology and strongly connected with BPD in clinical settings, as evidenced by previous studies such as a study conducted by Sansone et al in 2001 on borderline personality disorder patients **(Sansone et al., 2001).** The translated version of the test had estimated reliability value of 0.8 and validity of 0.40.

Resting electroencephalogram

Digital EEG was recorded with a neurofax EEG machine, the product of the Japanese NIHON KOHDEN company. The International 10–20 Electrode Placement System was employed with conventional activation methods. Participants were instructed to close their eyes. Eye movement and muscular artefacts were eliminated manually and by Independent Component Analysis. An EEG wave represents the variations in electrical potential between an electrode positioned on the scalp and a reference electrode located elsewhere on the head.

The EEG was analyzed by neurologists who were uninformed of the study's context. Upon discovery of irregularities, they were described based on location, wave shape, and frequency. Only clear abnormalities were classified as abnormal. If there was a high suspicion of abnormality but the resting EEG appears normal, activation methods were used to enhance the likelihood of capturing abnormal patterns. Intense hyperventilation and photic stimulus (activation of the visual cortex through light) were the predominant activation techniques utilized.

P300 measurement

First, we performed an otoscopic examination to verify a patent external auditory canal, the absence of occlusive wax, and a normal tympanic membrane. Basic audiological assessment was done for all participants to exclude any patients with hearing loss through [pure tone audiometry along the frequency range of 250- 8000 Hz, speech audiometry: using

both speech reception thresholds (SRTs) and speech discrimination score (SD %) and immittancemetry: to exclude participants with middle ear problems, including using single component low probe tone 226 Hz tympanometry and ipsilateral acoustic reflexes.

P300 component of event related potentials in response to tonal stimulation [ERPs were recorded in a quiet room, the skin at the electrode sites was rubbed with a piece of gauze using abrasive gel, electrode montage was active in Fz, ground in Fpz, and reference in ipsilateral mastoid electrode sites, depending on the International 10-20 System, The impedance was maintained at 5 KΩ or below, standard disposable electrodes were employed, and secured with electrode paste and adhesive layer following skin abrasion, trials in which EOG activity exceeded +80 μV were automatically rejected, P300 was detected in the oddball paradigm in response to two stimulus types (tone and speech) given in two paradigms. Participants were told to maintain a mental count of all "target" tones. The stimulus and procedures employed evoked P300 through an auditory oddball paradigm. Administered through inserted phones, in the initial paradigm, 1000 Hz served as the standard stimulus, whereas 2000 Hz functioned as the deviant stimulus. The tone bursts exhibited varying frequencies of occurrence: one was a frequent background tone at 1000 Hz, while the other represented an infrequent and unpredictable target tone at 2000 Hz. In the second paradigm, /da/ served as the standard stimulus and /ga/ as the deviant stimulus, the two given at a repetition rate of 1/s, with a 15% probability of deviance and at 50 dBSL (relative to the PTA average at 500, 1000, 2000, and 4000 Hz) monaurally presented to each ear and P300 waveform analysis. P300 was identified as the highest positive peak that appeared around 300 msec following N1-P2 complex after stimulus presentation. Latency values were obtained from the onset of stimulus to the point of maximum peak and amplitude was measured from P300 maximum peak to the following trough.

Statistical analysis

Statistical analysis had been conducted employing SPSS v27 (IBM©, Chicago, IL, USA). The Shapiro-Wilks test and histograms had been utilized to assess the data distribution normality. Quantitative parametric data had been displayed as mean and standard deviation (SD) and had been analyzed by ANOVA (F) test with post hoc test (Tukey). Quantitative non-parametric data had been displayed as median and interquartile range (IQR) and had been analyzed by Kruskal-Wallis test with Mann Whitney-test to contrast each group. Qualitative parameters had been displayed as frequencies and percentages (%) and had been analyzed employing the Chi-square test. Correlation between different parameters had been done employing Pearson moment correlation equation. A two tailed P value < 0.05 was considered statistically significant.

Results

Age, sex, marital status, residence, social standard and level of intelligence were statistically matched among the two groups. Occupation was significantly less in the case group in comparison to control group ($P<0.05$). Depending on the clinical application of the borderline personality features scale (BPFS), all patients included had a score above the cut-off value (60) with a mean of 84 ± 12.23. Most of them scored > 75 (higher severity). Based on the clinical application of the deliberate self harm inventory (DSHI), all BPD patients included in the study had a score with a mean of 12.65 +/- 7.71. Regarding age at which the patients started to harm themselves, majority of them started this behaviour during the adolescence and continued to harm themselves for 1-5 years or more. Regarding forms of self-harm committed by the patients, 35 of the 40 patients (87.5%) committed more than

one form of self-harm. The most recorded form was cutting followed by overdosing and body hitting. Among the included patients, only eleven out of the forty patients were admitted to mental hospitals for different causes. (**Table.1).**

Table 1. Comparison between the two studied groups according to demographic data, social standard, level of intelligence and total score of BPFS, DSHI score, age of first time of self-harm and duration of this behaviour, form of self-harm and history of mental hospital admission and cause of admission in case group

Variables		Cases (n= 40)	Control (n= 20)	P
Age (years)		27.18±9.29	27.30±7.80	0.718
Sex	**Male**	7(17.5%)	5(25.0%)	$^{FE}p=$ 0.511
	Female	33(82.5%)	15(75.0%)	
Marital status	**Single**	15(37.5%)	9(45.0%)	$^{MC}p=$ 0.854
	Married	21(52.5%)	9(45.0%)	
	Divorced	4(10.0%)	2(10.0%)	
Occupation	**Student**	16(40.0%)	0(0.0%)	**0.003***
	Employed	11(27.5%)	11(55.0%)	
	Unemployed	13(32.5%)	9(45.0%)	
Residence	**Urban**	21(52.5%)	9(45.0%)	0.860
	Suburban	7(17.5%)	4(20.0%)	
	Rural	12(30.0%)	7(35.0%)	
Social standard	**Low**	7(17.5%)	3(15.0%)	0.283
	Middle	20(50.0%)	14(70.0%)	
	High	13(32.5%)	3(15.0%)	
Level of intelligence	**Subaverage**	7(17.5%)	1(5.0%)	0.249
	Average	33(82.5%)	19(95.0%)	
BPFS total score		84.60±12.23	--	--
60 – 75		11(27.5%)	--	
>75		29(72.5%)	--	
DSHI score		11.50(6.50 – 17.50)	--	--
Age of 1st self-harm (years)		17.23 ± 3.31	--	--
10 – 18		26(65.0%)	--	
>18		14(35.0%)	--	
Duration of self-harm (years)		2.75 (1.50 – 4.75)	--	--
<1		2(5.0%)	--	
1 – 5		32(80.0%)	--	
>5		6(15.0%)	--	
Form of self-harm				
Cutting		33(82.5%)	--	--
Overdosing		21(52.5%)	--	
Inhalation of toxic gases		4(10.0%)	--	
Jumping from height		922.5%)	--	
Body hitting		18(45.0%)	--	
Ingestion of poisonous substances		11(27.5%)	--	
Self-burning with fire		6(15.0%)	--	
Hanging, self-strangulation		7(17.5%)	--	
Number of forms of self-harm	**One form**	5(12.5%)	--	
	Two forms	18(45.0%)	--	
	> Two forms	17(42.5%)	--	

History of mental hospital admission		11(27.5%)	--	--
Cause	**BPD features**	1(2.5%)	--	--
	Self-harm	6(15.0%)	--	
	Other causes	4(10.0%)	--	
	No hospital admission	29(72.5%)	--	

Data are presented as mean ± SD, frequency (%) or median (IQR). * Significant p value <0.05, MC: Monte Carlo test, FE: Fisher Exact test, BPFS: Borderline Personality Features Scale, DSHI: deliberate self-harm inventory.

The recorded scores of the four subscales of Borderline personality features scale BPFS were significantly different among each other. (**Table.2)** as it was noticed that the scores of the affective instability, identity problems and negative relations subscales were significantly higher than that of the self harm subscale**.**

Table 2.Descriptive analysis of the studied cases according to subscales of BPFS

Variables	**Affective instability**	**Identity problems**	**Negative relations**	**Self-harm**	**F**	**P**
BPFS	22.08±3.85	21.70±3.37	21.25±3.71	19.60±2.85	26.583*	**<0.001***
Sig. bet. scores	P_1=1.000, P_2=0.111, **P_3<0.001*,** P_4=1.000, **P_5<0.001***, **P_6<0.001***					

Data are presented as mean ± SD. * Significant p value <0.05, Fr: Friedman test, P1: p value for comparing Affective instability and identity problems. P2: p value for comparing Affective instability and negative relations, P3: p value for comparing Affective instability and self-harm, P4: p value for comparing between Identity problems and negative relations, P5: p value for comparing between Identity problems and self-harm, P6: p value for comparing between Negative relations and self-harm, BPFS: Borderline Personality Features Score.

Among the patients of both groups, no significant differences existed regarding the sociodemographic characteristics, intelligence level and EEG recordings. The latency of P300 wave response to both tone and speech was significantly delayed, and its amplitude was significantly decreased in BPD patients when put in comparison with P300 wave response to tone and speech recorded in normal individuals (**Table .3).**

Table 3. Comparison between total scores of BPFS and sociodemographic characteristics and intelligence level of studied BPD patients, predominant EEG wave and P300 (Speech) in each brain area in the two studied group

Variables		**N**	**BPFS total score**		**χ^2**	**P**
			60 – 75 (n = 11)	**>75 (n = 29)**		
Age	**18 – <30**	**28**	11(91.7%)	17(60.7%)	3.300	^{MC}p= 0.208
	30 – 40	**8**	1(8.3%)	7(25.0%)		
	>40	**4**	0(0.0%)	4(14.3%)		
Sex	**Male**	**7**	2(16.7%)	5(17.9%)	0.008	^{FE}p= 1.000
	Female	**33**	10(83.3%)	23(82.1%)		
Marital status	**Single**	**15**	4(33.3%)	11(39.3%)	0.345	^{MC}p= 0.886
	Married	**21**	7(58.3%)	14(50.0%)		
	Divorced	**4**	1(8.3%)	3(10.7%)		
Occupation	**Student**	**16**	6(50.0%)	10(35.7%)	0.786	^{MC}p= 0.688
	Employed	**11**	3(25.0%)	8(28.6%)		
	Unemployed	**13**	3(25.0%)	10(35.7%)		
Social standard	**Low**	**7**	2(16.7%)	5(17.9%)	5.233	^{MC}p= 0.064
	Middle	**20**	9(75.0%)	11(39.3%)		
	High	**13**	1(8.3%)	12(42.9%)		
Level of	**Sub average**	**7**	2(16.7%)	5(17.9%)	0.008	^{FE}p=

intelligence	**Average**	**33**	10(83.3%)	23(82.1%)		1.000
EEG wave						
			Cases (n= 40)	**Control (n= 20)**		
Frontal	**Alpha**		34(85.0%)	18(90.0%)	0.332	$^{MC}p=$ 1.000
	Theta		3(7.5%)	1(5.0%)		
	Beta		3(7.5%)	1(5.0%)		
Temporal	**Alpha**		38(95.0%)	20(100.0%)	1.034	$^{FE}p=$ 0.548
	Theta		2(5.0%)	0(0.0%)		
	Beta		0(0.0%)	0(0.0%)		
Parietal	**Alpha**		40(100.0%)	20(100.0%)	--	--
	Theta		0(0.0%)	0(0.0%)		
	Beta		0(0.0%)	0(0.0%)		
Occipital	**Alpha**		40(100.0%)	20(100.0%)	--	--
	Theta		0(0.0%)	0(0.0%)		
	Beta		0(0.0%)	0(0.0%)		
P300 (Tone)						
			Cases (n= 80)	**Control (n= 40)**		
Latency			344,8± 27,48	306.33 ± 6.31	U=295.50*	**<0.001***
Amplitude			4.99± 3.43	9,24 ±3.18	U= 369.0*	**<0.001***
P300 (Speech)						
			Cases (n= 80)	**Control (n= 40)**		
Latency			346.4 ± 27.49	305.07 ± 5.0	U=125.0*	**<0.001***
Amplitude			2.97±5.11	9.55 ± 2.63	U=270.0*	**<0.001***

Data is presented as frequency (%). $\chi 2$: Chi-square test, MC: Monte Carlo, FE: Fisher Exact, BPFS: Borderline personality features score.

No significant correlation existed between(socio-demographic characteristics and intelligence level with the scores of DSHI). Also, no significant correlation had been recorded between (level of intelligence and the BPFS and the EEG findings), while there was a significant result in relating frontal EEG wave findings to DSHI scores **(Table. 4).**

Table 4. Relation between (DSHI score and socio-demographic characteristics and intelligence level), (level of intelligence, BPFS and EEG findings) of studied BPD patients

Variables		**N**	**DSHI score**		χ^2	**P**
			2 - 10 (n = 17)	**>10 – 36(n = 23)**		
Demographic data						
Age	**18 – <30**	**28**	14(50.0%)	14(50.0%)	1.999	$^{MC}p=$ 0.415
	30 – 40	**8**	2(25.0%)	6(75.0%)		
	>40	**4**	1(25.0%)	3(75.0%)		
Sex	**Male**	**7**	2(28.6%)	5(71.4%)	0.674	$^{FE}p=$ 0.677
	Female	**33**	15(45.5%)	18(54.5%)		
Marital status	**Single**	**15**	7(46.7%)	8(53.3%)	0.541	$^{MC}p=$ 0.902
	Married	**21**	8(38.1%)	13(61.9%)		
	Divorced	**4**	2(50.0%)	2(50.0%)		
Occupation	**Student**	**16**	9(56.3%)	7(43.8%)	2.368	0.306
	Employed	**11**	3(27.3%)	8(72.7%)		
	Unemployed	**13**	5(38.5%)	8(61.5%)		

Social standard	**Low**	**7**	3(42.9%)	4(57.1%)	1.234	$^{MC}p=$ 0.538
	Middle	**20**	10(50.0%)	10(50.0%)		
	High	**13**	4(30.8%)	9(69.2%)		
Intelligence level	**Sub average**	**7**	2(28.6%)	5(71.4%)	0.674	$^{FE}p=$ 0.677
	Average	**33**	15(45.5%)	18(54.5%)		
EEG wave						
Frontal	**Alpha**	**34**	14(41.2%)	20(58.8%)	5.417*	$^{MC}p=$ 0.034*
	Theta	**3**	0(0.0%)	3(100.0%)		
	Beta	**3**	3(100.0%)	0(0.0%)		
Temporal	**Alpha**	**38**	17(44.7%)	21(55.3%)	1.556	$^{FE}p=$ 0.499
	Theta	**2**	0(0.0%)	2(100.0%)		
	Beta	**0**	0(0.0%)	0(0.0%)		
Parietal	**Alpha**	**40**	17(42.5%)	23(57.5%)	--	--
	Theta	**0**	0(0.0%)	0(0.0%)		
	Beta	**0**	0(0.0%)	0(0.0%)		
Occipital	**Alpha**	**40**	17(42.5%)	23(57.5%)	--	--
	Theta	**0**	0(0.0%)	0(0.0%)		
	Beta	**0**	0(0.0%)	0(0.0%)		
			Level of intelligence			
			Subaverage (n =7)	**Average (n=33)**		
Frontal	**Alpha**	**34**	5(71.4%)	29(87.9%)	2.175	$^{MC}p=$ 0.288
	Theta	**3**	1(14.3%)	2(6.1%)		
	Beta	**3**	1(14.3%)	2(6.1%)		
Temporal	**Alpha**	**38**	7(100.0%)	31(93.9%)	0.447	$^{FE}p=$ 1.000
	Theta	**2**	0(0.0%)	2(6.1%)		
	Beta	**0**	0(0.0%)	0(0.0%)		
Parietal	**Alpha**	**40**	7(100.0%)	33(100.0%)	--	--
	Theta	**0**	0(0.0%)	0(0.0%)		
	Beta	**0**	0(0.0%)	0(0.0%)		
Occipital	**Alpha**	**40**	7(100.0%)	33(100.0%)	--	--
	Theta	**0**	0(0.0%)	0(0.0%)		
	Beta	**0**	0(0.0%)	0(0.0%)		
			BPFS total score			
			60 - 75 (n = 12)	**> 75 (n = 28)**		
Frontal	**Alpha**	**34**	10(83.3%)	24(85.7%)	0.520	$^{MC}p=$ 1.000
	Theta	**3**	1(8.3%)	2(7.1%)		
	Beta	**3**	1(8.3%)	2(7.1%)		
Temporal	**Alpha**	**38**	12(100.0%)	26(92.9%)	0.902	$^{FE}p=$ 1.000
	Theta	**2**	0(0.0%)	2(7.1%)		
	Beta	**0**	0(0.0%)	0(0.0%)		
Parietal	**Alpha**	**40**	12(100.0%)	28(100.0%)	--	--
	Theta	**0**	0(0.0%)	0(0.0%)		
	Beta	**0**	0(0.0%)	0(0.0%)		
Occipital	**Alpha**	**40**	12(100.0%)	28(100.0%)	--	--
	Theta	**0**	0(0.0%)	0(0.0%)		
	Beta	**0**	0(0.0%)	0(0.0%)		

Data is presented as frequency (%). $\chi 2$: Chi square test, MC: Monte Carlo, FE: Fisher Exact, BPFS: Borderline personality features score, DSHI: deliberate self-harm inventory.

There was no significant sex difference regarding forms of self-harm except for "jumping from height" which was more committed by males. Regarding the relation between age and forms of self harm, there was no significant difference between different age groups except for body hitting that was done by patients older than 40 years. There were no significant relations between (the number of self-harm forms committed by the BPD patients and their EEG findings) and between (history of hospital admission and EEG findings) (**Table.5).**

Table 5. Relation between (sex and age and different forms of self-harm) and between number of forms of self-harm, mental hospital admission of studied BPFS and their EEG findings

Variables		N	Sex		χ^2	P
			Male (n = 7)	Female (n = 33)		
Cutting		33	6(85.7%)	27(81.8%)	0.061	^{FE}p=1.000
Overdosing		21	3(42.9%)	18(54.5%)	0.316	^{FE}p=0.689
Inhalation of toxic gases		4	0(0.0%)	4(12.1%)	0.943	^{FE}p=1.000
Jumping from height		9	4(57.1%)	5(15.2%)	5.840*	**^{FE}p=0.034***
Body hitting		18	3(42.9%)	15(45.5%)	0.016	^{FE}p=1.000
Ingestion of poisonous substances		11	1(14.3%)	10(30.3%)	0.743	^{FE}p=0.650
Self-burning with fire		6	1(14.3%)	5(15.2%)	0.003	^{FE}p=1.000
Hanging, self-strangulation		7	1(14.3%)	6(18.2%)	0.061	^{FE}p=1.000
Number of forms of self-harm	One form	5	1(14.3%)	4(12.1%)	0.361	^{MC}p=1.000
	Two forms	18	3(42.9%)	15(45.5%)		
	>two forms	17	3(42.9%)	14(42.4%)		
			Mental hospital admission			
			No (n = 29)	Yes (n = 11)		
Frontal	Alpha	34	24(82.8%)	10(90.9%)	1.057	^{MC}p=0.798
	Theta	3	2(6.9%)	1(9.1%)		
	Beta	3	3(10.3%)	0(0.0%)		
Temporal	Alpha	38	28(96.6%)	10(90.9%)	0.535	^{FE}p=0.479
	Theta	2	1(3.4%)	1(9.1%)		
	Beta	0	0(0.0%)	0(0.0%)		
Parietal	Alpha	40	29(100.0%)	11(100.0%)	--	--
	Theta	0	0(0.0%)	0(0.0%)		
	Beta	0	0(0.0%)	0(0.0%)		
Occipital	Alpha	40	29(100.0%)	11(100.0%)	--	--
	Theta	0	0(0.0%)	0(0.0%)		
	Beta	0	0(0.0%)	0(0.0%)		
			Age			
			18 - <30 (n = 28)	30 – 40 (n = 8)	>40 (n = 4)		
Cutting		33	22(78.6%)	8(100.0%)	3(75.0%)	2.117	0.398
Overdosing		21	13(46.4%)	6(75.0%)	2(50.0%)	2.069	0.355
Inhalation of toxic gases		4	2(7.1%)	1(12.5%)	1(25.0%)	2.076	0.344
Jumping from height		9	6(21.4%)	2(25.0%)	1(25.0%)	0.061	1.000
Body hitting		18	14(50.0%)	0(0.0%)	4(100.0%)	11.901*	**0.001***
Ingestion of poisonous substances		11	8(28.6%)	1(12.5%)	2(50.0%)	1.921	0.398
Self-burning with fire		6	5(17.9%)	0(0.0%)	1(25.0%)	1.892	0.480

Hanging, self-strangulation		**7**	5(17.9%)	2(25.0%)	0(0.0%)	0.912	0.669
Number of forms of self-harm	**One form**	**5**	4(14.3%)	1(12.5%)	0(0.0%)	2.668	0.643
	Two forms	**18**	12(42.9%)	5(62.5%)	1(25.0%)		
	>two forms	**17**	12(42.9%)	2(25.0%)	3(75.0%)		
			Form of Self harm				
			1 (n = 5)	**2 (n = 18)**	**>2 (n = 17)**		
Frontal	**Alpha**	**34**	5(100.0%)	16(88.9%)	13(76.5%)	3.976	0.392
	Theta	**3**	0(0.0%)	0(0.0%)	3(17.6%)		
	Beta	**3**	0(0.0%)	2(11.1%)	1(5.9%)		
Temporal	**Alpha**	**38**	5(100.0%)	18(100.0%)	15(88.2%)	2.267	0.419
	Theta	**2**	0(0.0%)	0(0.0%)	2(11.8%)		
	Beta	**0**	0(0.0%)	0(0.0%)	0(0.0%)		
Parietal	**Alpha**	**40**	5(100.0%)	18(100.0%)	17(100.0%)	--	--
	Theta	**0**	0(0.0%)	0(0.0%)	0(0.0%)		
	Beta	**0**	0(0.0%)	0(0.0%)	0(0.0%)		
Occipital	**Alpha**	**40**	5(100.0%)	18(100.0%)	17(100.0%)	--	--
	Theta	**0**	0(0.0%)	0(0.0%)	0(0.0%)		
	Beta	**0**	0(0.0%)	0(0.0%)	0(0.0%)		

Data is presented as frequency (%). * Significant p value <0.05, χ 2: Chi square test, MC: Monte Carlo, FE: Fisher Exact.

There was a significant gender difference in the latency of P300 wave response to tone and amplitude of P300 wave response to speech among the recruited BPD males and females (P<0.05). There were no significant differences among studied BPD patients on studying the relation between the amplitude of P300 wave response to tone and the other parameters including age, sex, level of intelligence, scores of BPFS and DSHI, history of hospital admission, age of starting of self harm, its duration and number of its forms done. There was a significant delay of the P300 wave response to speech about the higher scores of BPFS among the recruited BPD patients (P= 0.040). (**Table. 6).**

Table 6. Relation between P300 (Tone and speech) (Latency and amplitude) and different parameters in studied cases of borderline personality disorder with self-harm behaviour

Variables		**p300 (Tone) (Latency)**	Test of Sig.	P
Age	**18 – <30**	346.3±27.91	H=0.484	0.785
	30 – 40	339.9±25.17		
	>40	345.4±33.78		
Sex	**Male**	330.8±19.28	U=217.0*	**0.041***
	Female	347.7±28.15		
Level of intelligence	**Sub average**	340.0±31.52	U=241.0	0.557
	Average	345.6±27.05		
Mental hospital admission		343.3±27.95	U=383.50	0.497
BPFS total score	**60 – 75**	349.8±26.61	U=593.50	0.841
	>75	342.98±27.82		
DSHI score	**2 – 10**	344.7±28.44	U=0.040	0.841
	>10 – 36	345.0±26.98		
Age of 1st self-harm (years)	**10 – 18**	347.6±28.98	U=495.0	0.349
	>18	340.1±24.53		
Duration of self-harm	**<1**	343.5 ± 20.51	H= 0.762	0.683
	1 – 5	343.9 ± 27.44		

(years)	**>5**	351.7 ± 30.63		
Number of forms of Self harm	**One form**	364.0 ± 32.51	H=2.975	0.226
	Two forms	342.3 ± 25.76		
	> Two forms	343.2 ± 27.28		
P300 (Tone) (Amplitude)				
Age	**18 – <30**	3.70 (1.60 – 19.90)	H=0.391	0.823
	30 – 40	4.10 (2.30 – 12.10)		
	>40	3.40 (2.50 – 7.80)		
Sex	**Male**	4.80 (2.80 – 12.40)	U=249.00	0.123
	Female	3.45 (1.60 – 19.90)		
Level of intelligence	**Sub average**	4.10 (2.20 – 12.14)	U=246.00	0.617
	Average	3.60 (1.60 – 19.90)		
Mental hospital admission		3.80 (1.60 – 12.14)	U=405.00	0.706
BPFS total score	**60 – 75**	4.10 (1.60 – 10.0)	U=461.00	0.756
	>75	3.40 (1.60 – 19.90)		
DSHI score	**2 – 10**	4.0 (1.60 – 19.90)	U=535.500	0.377
	>10 – 36	3.40 (1.60 – 12.14)		
Age of 1st self-harm (years)	**10 – 18**	3.40 (1.60 – 12.14)	U=457.500	0.164
	>18	4.0 (2.60 – 19.90)		
Duration of self-harm (years)	**<1**	4.40 (3.20 – 5.60)	H=1.241	0.538
	1 – 5	4.0 (1.60 – 19.90)		
	>5	3.10 (2.10 – 10.0)		
Number of forms of Self harm	**One form**	2.80 (1.60 – 5.30)	H=2.458	0.293
	Two forms	4.14 (1.60 – 12.40)		
	> Two forms	3.50 (2.10 – 19.90)		
P300 (speech) Latency				
Age	**18 – <30**	347.39 ± 28.62	U=278.0	0.701
	30 – 40	343.08 ± 23.79		
Sex	**Male**	337.83 ± 16.13	U=216.50	0.217
	Female	348.64 ± 29.43		
Level of intelligence	**Sub average**	336.0 ± 42.37	U=146.0	0.199
	Average	348.08 ± 24.60		
Mental hospital admission		352.11 ± 31.97	U=314.0	0.365
BPFS total score	**60 – 75**	335.85 ± 17.74	U=262.0*	**0.040***
	>75	351.87 ± 30.11		
DSHI score	**2 – 10**	341.90 ± 23.31	U=350.0	0.197
	>10 – 36	351.14 ± 30.94		
Age of 1st self-harm (years)	**10 – 18**	350.08 ± 30.14	U=326.0	0.204
	>18	340.32 ± 21.62		
Duration of self-harm (years)	**<1**	343.33 ± 16.07	H=1.242	0.537
	1 – 5	345.16 ± 28.67		
	>5	356.71 ± 22.44		
Number of forms of Self harm	**One form**	357.86 ± 36.24	H=1.592	0.451
	Two forms	344.20 ± 28.29		
	> Two forms	345.86 ± 23.57		
P300 (speech) (Amplitude)				
Age	**18 – <30**	4.10 (1.90 – 14.20)	U=296.500	0.964
	30 – 40	4.10 (2.30 – 9.30)		

Sex	**Male**	5.30 (3.60 – 11.30)	U= 178.00*	**0.050***
	Female	3.80 (1.90 – 14.20)		
Level of intelligence	**Sub average**	6.20 (1.90 – 14.20)	U=159.500	0.324
	Average	4.10 (2.20 – 13.90)		
Mental hospital admission		4.0 (1.90 – 13.90)	U=336.500	0.592
BPFS total score	**2 – 10**	4.95 (2.40 – 9.30)	U=294.00	0.124
	>10 – 36	3.90 (1.90 – 14.20)		
DSHI score	**10 – 18**	4.35 (2.30 – 12.0)	U=384.00	0.439
	>18	3.90 (1.90 – 14.20)		
Age of 1st self-harm (years)	**10 – 18**	3.80 (1.90 – 14.20)	U=317.500	0.160
	>18	4.65 (2.30 – 13.20)		
Duration of self-harm (years)	**<1**	5.0 (3.90 – 6.0)	H=2.095	0.351
	1 – 5	4.10 (1.90 – 14.20)		
	>5	3.10 (2.40 – 7.0)		
Number of forms of Self harm	**One form**	3.10 (2.20 – 13.90)	H=1.592	0.451
	Two forms	4.50 (1.90 – 14.20)		
	> Two forms	4.10 (2.40 – 9.0)		

Data is presented as mean ± SD or median (IQR). * Significant p value <0.05, U: Mann Whitney test, H:H for Kruskal Wallis test, BPFS: Borderline personality features score, DSHI: deliberate self-harm inventory.

There was a significant positive correlation between the (latency of P300 wave response to tone and both age and scores of DSHI scale), (amplitude of P300 wave response to tone and age of start of self-harm), (latency of P300 wave response to speech and age of patients, scores of BPFS and DSHI scales, and longer duration of self-harm) and (amplitude of P300 wave response to speech and age of start of self-harm), while there was a significant negative correlation between (latency of P300 wave response to tone and the score of BPFS of patients, age of start of self-harm and duration of self-harm), (amplitude of P300 wave response to tone and age of patients, scores of BPFS and DSHI scales and longer duration of self-harm), (latency of P300 wave response to speech and the age of start of self-harm) and (amplitude of P300 wave response to speech and age of patients, scores of BPFS and DSHI scales and longer duration of self-harm). There was no significant correlation detected between the latency and amplitude of the P300 wave response to tone and the mentioned parameters. (**Table.7).**

Table 7.Correlation between P300 (Tone and speech) and different parameters

Variables	**P300 (Tone) Latency**		**P300 (Tone) (Amplitude)**	
	r_s	**P**	**r_s**	**P**
Age	0.019	0.873	-0.059	0.627
BPFS total score	-0.027	0.821	-0.111	0.360
DSHI score	0.022	0.857	-0.126	0.297
Age of 1st self-harm (years)	-0.075	0.536	0.151	0.211
Duration of self-harm (years)	-0.065	0.593	-0.017	0.889
	P300 (speech) Latency		**P300 (speech) (Amplitude)**	
Age	0.073	0.582	-0.172	0.192
BPFS total score	0.316	0.015*	-0.285	0.029*
DSHI score	0.153	0.246	-0.108	0.416
Age of 1st self-harm (years)	-0.126	0.341	0.111	0.404
Duration of self-harm (years)	0.093	0.483	-0.203	0.123

r_s: Spearman coefficient, * significant p value ≤ 0.05, BPFS: Borderline personality features score, DSHI: deliberate self-harm inventory.

Regarding the latency and amplitude of P300 wave response to tone and speech in correlation with the EEG findings among the recruited BPD patients, the results showed that cases with predominant frontal beta wave had the shortest latencies and highest amplitudes while cases with predominant frontal theta had the longest latencies and smallest amplitudes, but the differences were not clinically significant. (**Table. 8).**

Table 8. Relation between P300 (Tone and speech) latency and amplitude and EEG findings in studied cases of borderline personality disorder with self-harm behaviour

Variables		P300 (Tone) Latency	Test of Sig	P
Frontal	**Alpha**	345.1±25.75	H=1.423	0.491
	Theta	353.8±34.27		
	Beta	332.8±42.28		
Temporal	**Alpha**	344.4±28.13	U=108.50	0.566
	Theta	352.5±11.70		
	Beta	--		
Parietal	**Alpha**	344.8±27.48	--	--
	Theta	--		
	Beta	--		
Occipital	**Alpha**	344.8±27.48	--	--
	Theta	--		
	Beta	--		
P300 (Tone) Amplitude				
Frontal	**Alpha**	5.06 ± 3.56	H= 2.253	0.324
	Theta	3.18 ± 0.93		
	Beta	5.92 ± 3.23)		
Temporal	**Alpha**	5.10 ± 3.50	U= 89.0	0.295
	Theta	3.23 ± 0.53		
	Beta	--		
Parietal	**Alpha**	4.99 ± 3.43	--	--
	Theta	--		
	Beta	--		
Occipital	**Alpha**	4.99 ± 3.43	--	--
	Theta	--		
	Beta	--		
P300 (speech) Latency				
Frontal	**Alpha**	346.33±28.14	H=1.313	0.519
	Theta	360.67±28.18		
	Beta	337.25±17.33		
Temporal	**Alpha**	346.44±27.49	--	--
	Theta	--		
	Beta	--		
Parietal	**Alpha**	346.44±27.49	--	--
	Theta	--		
	Beta	--		
Occipital	**Alpha**	346.44±27.49	--	--
	Theta	--		
	Beta	--		

P300 (Speech) Amplitude				
Frontal	**Alpha**	5.15 ± 2.92	H=0.949	0.622
	Theta	4.03 ± 2.57		
	Beta	5.38 ± 4.42		
Temporal	**Alpha**	5.11 ± 2.97	--	--
	Theta	--		
	Beta	--		
Parietal	**Alpha**	5.11 ± 2.97	--	--
	Theta	--		
	Beta	--		
Occipital	**Alpha**	5.11 ± 2.97	--	--
	Theta	--		
	Beta	--		

Data are presented as mean ± SD or median (IQR). * Significant p value <0.05, U: Mann Whitney test, H:H for Kruskal Wallis test, EEG: electroencephalography.

Discussion

Regarding the forms of self-injurious behavior committed by the patients in this study, this study results agree with a study done on 2007 by Klonsky **(Klonsky, 2007)** reported that the forms of NSSI in BPD which mostly occur in response to emotional and interpersonal problems, involve behaviors like deliberate cutting or carving, scratching, and burning of the skin, in addition to self-hitting or the consumption of hazardous preparations. Although skin cutting is the predominant form, banging or body striking and burning are also prevalent.

Also, this study reported a significantly higher percentage of jumping from height as a parasuicidal behavior in the studied BPD males rather than females. This aligns with the literature indicating that the typical profile of a survivor of suicidal attempt by jumping is a single male in his 30s with a psychotic disorder and a history of multiple psychiatric problems, involving a prior suicide attempt **(Gore-Jones and O'Callaghan, 2012)**. Similarly, Cantor et al. **(Cantor, 1989)** discovered that males (81.2%) exhibited a higher tendency to commit or try suicide by jumping. The average age is approximately 32.1 years (range: 21 to 55 years), and most of them being single at the time of the attempt (75.0%), followed by married, in complicated relationship (18.2%), or separated (6.2%). A majority of the attempters were unemployed at the time (43.7%), in contrast to those who were employed (31.2%). Also, Kjaer et al. found that many psychiatric disorders were present and severe enough to be listed as the leading problems for hospitalization, which is consistent with our findings regarding the causes of hospital admission in BPD.

In the current study, three patients had predominant theta waves in the frontal cortex during the wakefulness state and two patients had predominant theta waves in the temporal cortex during the wakefulness state. Theta waves were found to be associated with mental performance tests like creativity, intuition, learning, information processing and memory storage. The theta rhythm (3–8 Hz) detected using electroencephalography in the temporal lobe (hippocampus) is believed to facilitate memorization processes by enhancing long-term memory.

The current study reported presence of predominant theta activity in five of the forty included patients. This result strongly agrees with the findings previously stated by Koenig et al. **(Koenig et al., 2016)** who reported that increased theta activity may occur in BPD individuals who engaged in self-injurious behavior. Similarly, Kim et al. **(Kim et al., 2014)** reported increased frontal theta activity in patients with NSSI and showed

significant association of pro-inflammatory cytokines and frontal theta power.

Regarding the recorded values of P300, the wave latencies were found to be significantly longer, and the amplitudes were significantly smaller when compared with normative data from healthy control subjects with the same age group and with the same instruments used in this study. Our results regarding the P300 findings agreed with data from other studies which suggested that patients with BPD features exhibit decrements in P300 amplitude **(Houston et al., 2004)**. He et al. **(He et al., 2010)** recorded a prolonged P300 latency with mean of 344.2±35ms and reduced P300 amplitude with mean of 5.7±3.4 µV in patients with BPD, these results are very close to the results of our study which recorded the mean latency of P300 wave response to tone 344.8±27.48 ms and amplitude with a mean of 4.99±3.43 µV and the P300 wave response to speech had a mean latency of 346.44±27.49 ms and amplitude with a mean of 5.11 ± 2.97 µV.

By correlating the values of P300 wave response with the age of studied patients, the amplitude of P300 wave response to tone ranged from 1.6 µV – 19.9 µV and the latency from 293 ms – 402 ms, while the amplitude of P300 wave response to speech ranged from 1.90 – 14.2 µV and the latency from 287 – 402 ms the results were to some extent similar to the results of previous articles which revealed that the P300 values for amplitude varied from 2.2 µV to 18.5 µV, whereas the latency values ranged from 320 ms to 484 ms. The identified variations might be associated with the characteristics of the examined samples, the analyzed variables, and the methodologies employed in each research **(Pavarini et al., 2018)**.

Regarding the differences in the recorded values of P300 wave response to auditory stimuli in the recruited males and females, the findings of this work revealed presence of a clinically significant gender difference in the latency of P300 wave response to tone and its amplitude in response to speech among the recruited BPD males and females. This does not agree with Puttabasappa et al. **(Puttabasappa et al., 2017)** and Sigita Melynyte et al. **(Melynyte et al., 2018)** who encountered that the existence of a probable gender impact on auditory P300 parameters is minimal, but most of those studies exhibit methodological flaws that made it impossible to thoroughly assess the effects of gender on P300 parameters.

Regarding the differences of recorded values of P300 wave response to tone and speech in relation to the intelligence level of the study participants, the findings of this work showed no clear correlation between both. Here, Wronka et al. **(Wronka et al., 2013)**, Polich and other researches that have linked P300 amplitude and latency to cognitive levels, information processing speed, executive function, and stimulus change detection, those reported similar findings with that the relationship between P300 and intelligence stays unclear.

The current study results regarding the correlation between P300 and personality traits are like that of a study published online by Cambridge University Press on April 2020 whose main results concern the absence of major relationships between dimensions of personalities as evaluated by the Temperament and Character Inventory (TCI) and evoked related potential parameters. Only weak partial positive correlations relate P300 amplitude with the self-directedness dimension that is related to affective and identity problems **(Hansenne et al., 2000)**.

Similarly, previous research of Kreusch et al. **(Kreusch et al., 2014)**, Yin et al. **(Yin et al., 2016)**, Zheng et al. **(Zhiling et al., 2020)** and Wang et al. **(Wang and Dai, 2020)** revealed contradictory P300 amplitude reductions and increases.

Limitations of this work involved the small sample size which generalizes our

study results on BPD patients hardly accepted. The male/female ratio was unbalanced as there were more female participants in the study (82.5%). Our analyses were not controlled by other confounding factors, such as education, medications, and history of childhood trauma, which were not taken into consideration. It is worth noting in this study that medication status is an important factor that can impact EEG activity and ERP components. The study participants were recruited from various settings, inpatient vs outpatient. The difference in the settings in which they were living and being evaluated was a confounding variable that was not adequately controlled for, which could limit the generalizability of our findings. Regarding EEG recordings, only five out of forty patients with BPD and self-harming behavior had slow wave activity (theta wave) and only three had fast wave activity (beta wave), indicating a minimal overall impact from the disorder on EEG.

Conclusion

BPD is one of the most impairing psychiatric disorders, having multiple comorbidities and potentially difficult to treat. Assessing the psychosocial characteristics in BPD patients who harm themselves, showed no significant differences between them and normal population except for impaired functioning. This study has detected some biological abnormalities in BPD patients with self-harm behavior, which included presence of frontal and temporal theta activity in EEG, prolonged P300 latency and reduced P300 amplitude. This reflects the presence of difficulties in information processing and self-control in those patients.

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