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The Relationship Between Finger Ratio (2D:4D) and Criminal Behavior in Bipolar Disorder

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ABSTRACT

Objective: The purpose of this study was to examine the relationship between 2D:4D digit ratio and aggression and impulsivity in manic patients (BP) with and without a history of criminal behavior.
Materials and Methods: The study included a total of 106 subjects, which included 41 healthy individuals, 34 bipolar (BP) patients with a history of criminal behavior (CBP) and 31 BP patients who had not engaged in criminal activity (NCBP). All participants were administered a socio-demographic data form, the Buss-Perry Aggression Scale (BAQ), Barratt Impulsiveness Scale-11 (BIS-11) and the Young Mania Rating Scale (YMRS) and 2D:4D ratio measurement.
Results: The right hand 2D:4D ratios of BP patients included in the study were significantly lower (p: 0.007) compared to the control group. Moreover, the BAQ scores of BP patients were higher compared to the control group. In CBP patients, both the right hand 2D:4D (p: 0.007) and left hand 2D:4D (p: 0.036) were significantly lower when compared to the control group. Furthermore, the BIS-11 score (p: 0.046) and YMRS (p: 0.008) of CBP patients were significantly higher when compared to NCBP.
Conclusion: Based on results, we predict that in the future, the lower 2D:4D ratio in the right and left hand of bipolar manic patients who commit crimes compared to the control group, will guide in advance whether individuals prone to bipolar manic disorder will be involved in criminal activities, utilizing anatomical data (2D:4D) as a potentiel anatomical marker.

Keywords: Bipolar, Crime, Mania, Digit Ratio, 2D:4D.

Bipolar Bozuklukta Parmak Oranı (2D:4D) ile Suç Davranışı Arasındaki İlişki

Araştırma Makalesi

Süreç

Geliş: 16/01/2025
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ÖZET

Amaç: Bu çalışmanın amacı, suç davranışı öyküsü olan ve olmayan manik hastalarda (BP) 2D:4D rakam oranı ile saldırganlık ve dürtüsellik arasındaki ilişkiyi incelemektir.
Gereç ve Yöntem: Çalışmaya 41 sağlıklı birey, suç davranışı öyküsü olan 34 bipolar hasta (CBP) ve suç faaliyetinde bulunmamış 31 BP hastası (NCBP) olmak üzere toplam 106 denek dahil edilmiştir. Tüm katılımcılara sosyo-demografik veri formu, Buss-Perry Saldırganlık Ölçeği (BAQ), Barratt Dürtüsellik Ölçeği-11 (BIS-11) ve Young Mani Derecelendirme Ölçeği (YMRS) uygulanmış ve 2D:4D oranı ölçülmüştür.
Bulgular: Çalışmaya dahil edilen BP hastalarının sağ el 2D:4D oranları kontrol grubuna kıyasla anlamlı derecede düşüktü (p:0.007). Ayrıca BP hastalarının BAQ skorları kontrol grubuna kıyasla daha yüksekti. CBP hastalarında hem sağ el 2D:4D (p:0.007) hem de sol el 2D:4D (p:0.036) oranları kontrol grubuna kıyasla anlamlı derecede düşüktü. Ayrıca, CBP hastalarının BIS-11 skoru (p:0.046) ve YMRS (p:0.008) NCBP ile karşılaştırıldığında anlamlı derecede yüksekti.
Sonuç: Sonuçlara dayanarak, gelecekte suç işleyen bipolar manik hastaların sağ ve sol ellerindeki 2D:4D oranının kontrol grubuna kıyasla daha düşük olmasının, altın standart olarak anatomik verileri (2D:4D) kullanarak bipolar manik bozukluğa yatkın bireylerin suç faaliyetlerine karışıp karışmayacağı konusunda önceden yol göstereceğini tahmin ediyoruz.

Anahtar Kelimeler: Bipolar, Suç, Mani, Rakam Oranı, 2D:4D

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Introduction

Bipolar disorder is a psychiatric condition that leads to significant impairment in functioning due to episodes of mania, hypomania and depression.[1] The common features of depressive, manic or hypomanic episodes are unusual differences in a person's mood. This difference can be seen as reluctance, lack of pleasure, dysphoria in the depressive episode or euphoria or irritability in the manic episode. The condition in which manic symptoms are milder in terms of duration and severity is called "hypomania".[2] Patients with bipolar disorder demonstrate heightened impulsivity and aggression, particularly during manic episodes. [3] Impulsive and aggressive behaviors during manic episodes lead to negative impacts on the lives of patients and those around them, as patients have a tendency towards self-harm and criminal activities. [4] Furthermore, physical violence during manic episodes increases in severity in line with the intensity of the manic attack.[5, 6] Studies have shown that during manic episodes patients frequently display hostility and aggression towards unfamiliar objects, others and themselves.[7]

It has been demonstrated that traits such as aggression, impulsivity, novelty-seeking and competitiveness, which are typical masculine behaviors, are inversely related to the 2D:4D ratio.[8] The relationship between anthropometric measurements and diseases has been known for centuries. However, recent studies in particular have shown that there may be a connection between the 2D:4D finger ratio and psychiatric diseases. The association of the 2D:4D ratio with many diseases has been reported in numerous studies.[9] The 2D:4D ratio (Figure 1), which can be seen in different variations, has been shown to be higher in patients with bipolar disorder, a major psychiatric disorder, compared to healthy controls.[10] Therefore, it is also calculated in psychiatric diseases to get an idea about fetal hormonal exposure.[11] In a study conducted in patients with schizophrenia, the 2D:4D ratio of patients was found to be significantly higher compared to healthy controls and this was said to be related to abnormal cerebral changes in the pathogenesis of the disease.[12] In a study conducted in patients with depression, it was reported that the 2D:4D figure ratios were not related to the severity of depression, thus depression was associated with the absence of gender differences in the 2D:4D ratio.[13]

To the best of knowledge, there has been no study yet comparing the 2D:4D ratio in manic patients with and without a criminal history. Scales used in psychiatry can determine the diagnosis and severity of diseases.[14] Again, the severity of psychiatric illness can provide information about a person's tendency to harm others and themself .[15] In some scales used in patients with bipolar disorder, significant differences were observed in those who had committed a crime compared to those who had not.[16] Therefore, the study reported here investigated the relationship between the 2D:4D ratio and aggression and impulsivity in manic patients with and without a criminal history using the Buss-Perry Aggression Questionnaire (BAQ), Barratt Impulsiveness Scale-11 (BIS-11), and the Young Mania Rating Scale (YMRS).

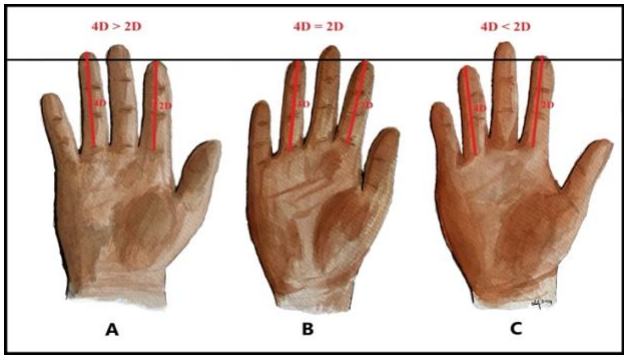

Figure 1. *Different variations and appearance of 2D:4D finger ratio in humans. This figure is hand-drawn by the first author (EE). A shorter (A) 2D:4D ratio in men is genetically considered a normal variation, while an equal (B) or longer (C) 2D:4D ratio is considered to be a pathological variation*

Materials and Methods

Ethical Considerations

The study was approved by the Non-Interventional Local Ethics Committee of Fırat University under reference number 2023/13-06 (Meeting Date: 27.09.2023). Written informed consent from guardians was obtained prior to study commencement. The study complied with the Helsinki Declaration.

The Study Population, Place and Time of Research

It included 41 healthy individuals without psychiatric diagnoses, 34 manic patients with criminal involvement and 31 manic patients without criminal involvement respectively admitted to the Elazig City Hospital forensic psychiatry service and the Elazig Mental Health and Diseases Hospital psychiatry service between the dates of 01.10.2023 and 30.11.2023.

Data Collection

Evaluation and diagnosis were performed by a senior psychiatric specialist according to the Diagnostic and Statistical Manual of Mental Disorders 5th edition (DSM-5) criteria for manic episodes of bipolar disorder.[1]

Exclusion criteria included being under 18 years of age, having any congenital anomaly including bones, finger deformities, or any serious organic condition affecting skin tone. A healthy control group was also included in the study. They were subject to the same exclusion criteria applied to patients with manic episodes of bipolar disorder. The healthy control group was in good physical and mental condition, without any current or past neurological or psychiatric illness, endocrinological abnormalities, or congenital anomalies related to the bones.

2D:4D ratio measurements

Finger measurements were made according to a previously illustrated and described method [9] where individuals were asked to place the dorsal side of their hands on a firm flat surface with the palmar side facing upwards and as open as possible. The measurement was taken from the midpoint of the proximal line that separates the finger root from the palm to the distal end of the finger when the thumb was in slight extension and the other four fingers in adduction (Figure 2). Both the second and fourth fingers were measured three times by two independent assessors who were blind to the group identity of the subjects and the average of the measurements was obtained. The digit ratios were then calculated by dividing the lengths of the second and fourth fingers to obtain the final result. All measurements were performed using a standard digital caliper (Valkyrie 150 x 0.01 mm Digital Stainless Steel Electronic Precision Caliper) with a calibrated precision of 0.01 mm.

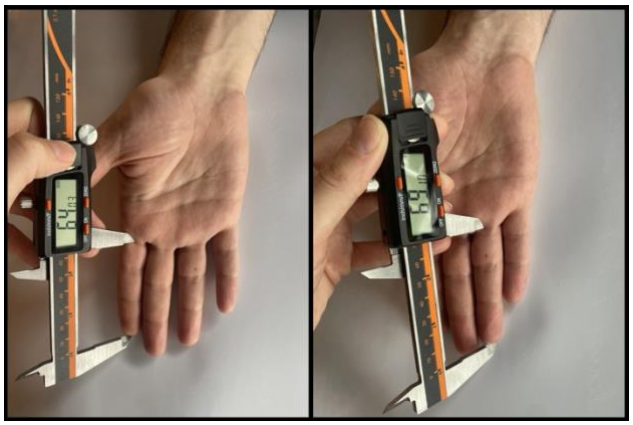

Figure 2. *Representative image of the measurement of 2D:4D finger ratio with a caliper for individuals participating in the study*

Scales used in the study

The Sociodemographic and Clinical Data Form,[17] Barratt Impulsiveness Scale (BIS-11)[18] and Buss Perry Aggression Scale (BPAS) [19] were applied to all participants, while the Young Mania Rating Scale (YMRS)[20] was administered to individuals diagnosed with bipolar manic disorder.

Sociodemographic and Clinical Data Form: This form is semi-structured and includes sociodemographic information such as age, marital status, place of residence, education level, occupation and clinical data such as disease and treatment duration.[17]

Barratt Impulsiveness Scale: The BIS-11 scale developed by Patton *et al*. is a self-report scale developed to measure impulsiveness.[18] Güleç *et al*. carried out both the scale's translation into Turkish and a validity and reliability evaluation. There are three sub-factors in the scale: attentional impulsiveness, motor impulsiveness and non-planning impulsiveness.[21]

Buss Perry Aggression Scale: BPAS is a self-report scale consisting of 29 statements developed to determine level of aggression.[19] It assesses physical aggression, verbal aggression and anger and hostility sub-dimensions. The adaptation to Turkish was done by Evren *et al*.[22]

Young Mania Rating Scale: This scale was prepared by Young *et al*. to measure severity and change of manic state.[20] It consists of 11 items, each measuring five levels of severity, evaluated by the interviewer. A validity and reliability study was conducted in Turkish.[23]

Statistical Analysis

Statistical Package for the Social Sciences (SPSS) version 21.0 was used for statistical analyses. Power analysis was used to estimate a sample size. The calculation ensured 95% statistical power at a significance level (alpha error probability) of 0.05. To achieve sufficient statistical power, a total of 106 samples were included, with a projected required sample size of 100. Categorical variables are given as frequencies and percentages. The normality of continuous variable distributions was assessed using the Kolmogorov-Smirnov test and histograms. Numeric parameters that exhibited a normal distribution were compared between groups using Student's *t*-test or one-way analysis of variance, while data that were not normally distributed were analyzed using either the Mann-Whitney U or Kruskal-Wallis test. Categorical variables were compared using chi-square or Fisher's exact test when appropriate. The strength of the relationship between two variables was evaluated using Spearman or Pearson correlation coefficients. A p-value < 0.05 was considered to indicate statistical significance.

Results

A total 106 male participants were included in the study, comprising 41 healthy controls, 34 manic patients with criminal involvement and 31 manic patients without criminal involvement. The average age of all participants was 35 years (range 20-70). Controls had a higher level of education, were more likely to be married, live in an urban area and had a profession when compared to bipolar patients. The prevalence of smoking was higher in bipolar patients compared to controls.

No significant differences were found between the groups in terms of other chronic diseases and alcohol consumption. The Buss-Perry Aggression Scale score was significantly higher in all bipolar manic patients compared to controls, while there was no significant difference between criminal and non-criminal bipolar patients.

BIS-11 scores were significantly higher for criminal bipolar manic patients compared to controls *(p: 0.003)* and non-criminal bipolar manic patients *(p: 0.046).* The YMRS score was significantly higher in criminal bipolar manic patients compared to non-criminal patients (*p*: 0.008).

In non-criminal patients, there was a correlation between the 2D:4D ratio of the right hand and both the Barratt Aggression Questionnaire *(p: 0.020)* and BIS-11 *(p: 0.009)* scores (Table 1). When bipolar manic patients were divided into two groups (criminal and non-criminal), there were no significant differences between the groups for

age, antipsychotic medication use, suicide attempts, duration of illness and Buss-Perry Aggression Scale (BAQ) score. Detailed results regarding the sociodemographic and clinical characteristics of the patients are given in Table 2.

Regardless of criminal history, the 2D:4D ratio of the right hand was found to be significantly lower in patients compared to the control group and statistically significant differences were found between the control and criminal manic patients in both the right and left 2D:4D ratios *(p = 0.007 and p = 0.036, respectively)* (Table 3). The association between the patients' right and left 2D:4D ratios, age and scale scores is given in Table 1.

Table 1. *Comparison of the relationship between the 2D/4D ratio of the right and left hand of manic individuals with bipolar disorder who have and have not committed crimes, with age, disease duration and some parameters*

Parameters		All patients (n = 65)		Committed crimes (n = 34)		Not committed crimes (n = 31)	
		Right 2D/4D ratio	Left 2D/4D ratio	Right 2D/4D ratio	Left 2D/4D ratio	Right 2D/4D ratio	Left 2D/4D ratio
Right 2D/4D ratio	**r**		0.467		0.583		0.200
	p-value		< 0.001		< 0.001		0.281
Left 2D/4D ratio	**r**	0.467		0.583		0.200	
	p-value	< 0.001		< 0.001		0.281	
Age	**r**	-0.011	0.002	0.114	-0.023	-0.034	0.108
	p-value	0.908	0.986	0.520	0.895	0.856	0.562
Buss–Perry Aggression Scale	**r**	-0.073	-0.070	-0.266	-0.025	0.414	0.015
	p-value	0.458	0.477	0.128	0.887	0.020	0.937
Barratt Impulsiveness Scale	**r**	0.035	0.035	-0.155	0.009	0.462	0.097
	p-value	0.724	0.720	0.382	0.958	0.009	0.605

Table 2. *Comparison of demographic characteristics of manic individuals with bipolar disorder who have either committed or not committed crimes*

Parameters	Control (*n* = 41)[a]	Committed crimes (*n* = 34)[b]	Not committed crimes (*n* = 31)[c]	*p*
Age, median (min-max)	35 (23-54)	35 (20-63)	36 (25-77)	0.705
Marital Status				
Single, *n* (%)	10 (24.4)	22 (64.7)	26 (83.9)	**< 0.001**[ab,ac]
Married, *n* (%)	31 (75.6)	12 (35.3)	5 (16.1)	
Education				
Illiterate, *n* (%)	0 (0)	4 (11.8)	5 (16.1)	**< 0.001**[ab,ac]
Primary school, *n* (%)	0 (0)	18 (52.9)	16 (51.6)	
High school, *n* (%)	13 (31.7)	8 (23.5)	7 (22.6)	
University, *n* (%)	28 (68.3)	4 (11.8)	3 (9.7)	
Place of residence				
Rural area, *n* (%)	0 (0)	9 (26.5)	10 (32.3)	**< 0.001**[ab,ac]
Urban area, *n* (%)	41 (100)	25 (73.5)	21 (67.7)	
Working status				
Unemployed, *n* (%)	0 (0)	22 (64.7)	24 (77.4)	**< 0.001**[ab,ac]
Employed, *n* (%)	41 (100)	12 (35.3)	7 (22.6)	
Other Chronic Illness				
Yes, *n* (%)	5 (12.2)	9 (26.5)	2 (6.5)	**0.032**[bc]
No, *n* (%)	36 (87.8)	25 (73.5)	29 (93.5)	
Smoking				
Yes	16 (39)	29 (85.3)	28 (90.3)	**< 0.001**[ab,ac]
No	25 (61)	5 (14.7)	3 (9.7)	
Alcohol consumption				
No	36 (87.8)	29 (85.3)	27 (87.1)	0.948
Yes	5 (12.2)	5 (14.7)	4 (12.9)	

Antipsychotic drug use No Yes	 41 (100) 0 (0)	 4 (11.8) 30 (88.2)	 2 (6.5) 29 (93.5)	**< 0.001**[ab,ac]
Suicide attempt No, *n* (%) Yes, *n* (%)	 41 (100) 0 (0)	 28 (82.4) 6 (17.6)	 30 (96.8) 1 (3.2)	0.107[bc]
Duration of illness, years, median (min-max)	-	9 (0.5-40)	10 (0.5-30)	0.201 [bc]
Young mania rating scale, median (min-max)	-	7 (2-11)	4 (1-12)	**0.008** [bc]
Buss–Perry Aggression Questionnaire, *n* ± SD	54.02 ± 12.70	77.26 ± 16.00	70.81 ± 12.44	**< 0.001**[ab,bc]
Barratt Impulsiveness Scale (BIS-11), median (min-max)	52 (31-79)	63 (37-111)	58 (39-74)	**0.003**[ab] **0.046**[bc]

Categorical variables are given as n (%), normally distributed variables are given as mean ± standard deviation while skewed distribuions are given as median (min-max), min:minimum, max:maximum

Table 3. Right and left hand 2D/4D ratios in the controls and patients with bipolar disease groups

Parameters	Control (*n* = 41)	Patients with bipolar disease (*n* = 65)		*p*
Right 2D/4D ratio, *n* ± SD	0.994 ± 0.334 [a]	0.974 ± 0.399[b]		**0.007** [ab]
		Committed crimes (*n* = 34)	Not committed crimes (*n* = 31)	**0.007** [ac] 0.281 [ad] 0.334 [cd]
		0.968 ± 0.385[c]	0.981 ± 0.407[d]	
Left 2D/4D ratio, *n* ± SD	0.986 ± 0.328[a]	0.973 ± 0.380[b]		0.063[ab]
		Committed crimes (*n* = 34)	Not committed crimes (*n* = 31)	**0.036** [ac] 0.797 [ad] 0.198 [cd]
		0.965 ± 0.383 [c]	0.981 ± 0.364 [d]	

p [*] : *p*-values in each group after *post-hoc* test, normally distributed variables are given as mean ± standard deviation

Discussion

The association between anatomical measurements and diseases has long been recognized.[24] This study revealed for the first time a relationship between the 2D:4D ratio and crime. It was found that the 2D:4D ratio of both the right and left hand of manic patients who committed crimes was lower than that of healthy controls, but there was no significant difference between manic patients who did not commit crimes. The level of aggression was higher in manic patients compared to the healthy control group, but there was no difference in aggression level between those who committed crimes and those who did not. Similarly, impulsivity levels were higher in manic patients who committed crimes compared to manic patients who did not, as well as the healthy control group.

It is known that patients with bipolar disorder are prone to commit crimes due to increased energy, grandiose thoughts and delusions during the manic period.[25] However, it has been observed that not all manic patients commit crimes.[26] Recent studies have focused on the potential effects of the 2D:4D ratio on mental illnesses such as schizophrenia, depression, anxiety and alcohol dependence.[12, 13, 27, 28] Meta-analyses generally show that psychiatric patients have lower 2D:4D compared to healthy controls.[11] In a study comparing the 2D:4D ratio of 70 bipolar disorder patients with 70 in a healthy control group, higher right hand 2D:4D ratios were found in patients compared to controls. When compared by gender, both right and left 2D:4D ratios in male patients were significantly higher compared to males in the control group. However, in female bipolar disorder patients, no difference in right or left 2D:4D ratio was observed compared to controls. It is thought that the high 2D:4D ratio in the right hand is associated with the presence of bipolar disorder in males.[29]

Another study, however, found no disparity in the 2D:4D ratios between bipolar disorder patients and controls, or between groups of patients with and without histories of suicide attempts.[30] In the current study, which focused exclusively on male participants, it was discovered that manic patients had lower right and left 2D:4D ratios in comparison to healthy controls.

Nevertheless, no variances were observed in the 2D:4D ratio between manic patients who had committed crimes and those who had not. In the current study, a greater level of aggression was observed in manic patients compared to a healthy control group. However, no significant difference was found in aggression between patients who either had or had not committed a crime. Prior research has shown that aggression levels are elevated in manic patients during the acute phase [31], but the specific mechanism behind this phenomenon remains unclear. Thus, it is proposed that the correlation between criminal behavior and low 2D:4D ratios may be a potentially useful measure.

Individuals with a prior history of criminal behavior during manic episodes exhibited a higher severity of mania compared to patients without a criminal history. However, no significant difference in aggression level was found between the two groups, but there was a significant difference in impulsivity level. Additionally, there was no difference in suicide attempts between patients with and without a criminal history. Impulsivity is positively correlated with aggression level [32, 33], but sometimes two different impulsive groups may show different levels of aggressive behavior.[34] Nonetheless, it has been recorded that divergent impulsive groups may exhibit different levels of aggressive behavior, potentially leading to variations in criminal inclinations within the same patient cohort.

The healthy control group tended to possess higher levels of education, were married, resided in urban areas and were employed in contrast to individuals with bipolar manic disorder. Bipolar disorder and its associated episodes have a detrimental impact on various dimensions of quality of life, including education and employment status.[35, 36] Although the prevalence of smoking was higher in manic patients compared to the control group, there was no significant difference between the groups in terms of alcohol use. Smoking is a common addiction in bipolar disorder patients due to chronic mood instability and limited social support.[37] While alcohol use is common in manic patients[38], comparable levels of alcohol use were observed in all three groups. Although a low 2D:4D ratio alone is not sufficient to diagnose bipolar disorder manic episodes, when used in conjunction with other indicators, it can lend support to such a diagnosis.

Limitations and Strengths of the Research

One of the main limitations of this study is that women were not included in the study. Because women have a menstrual cycle. As known, the menstrual cycle is divided into three phases: follicular phase (days 1-14; before release of the egg); ovulation phase (day 14; egg release), and luteal phase (days 14-28; after egg release). [39] The *menstrual cycle* has a significant *impact* on a woman's *mood and emotions*[40]. Measurements (e.g. *YMRS*) used here will be possibly affected by *manic symptoms* and emotional state (Young et al, 1978). [20] Therefore, only men were included in the study. In the future, beside this pioner research, a new important study can be also designed in this context, taking into account 3 different phases of the menstrual cycle.[41, 42] This is important limitation of the study. However, despite of above limitation, a low 2D:4D ratio may help with prediction of male individuals at high risk of developing bipolar disorder manic episodes in the future, the prediction of criminal tendency before the commission of the crime and the development of new strategies. Since the social, environmental, and biological factors of individuals may also influence criminal tendency, the 2D:4D ratio alone may be insufficient to explain the predisposition to criminal behavior. Therefore, we believe that it would be beneficial for future studies to incorporate individuals' social and environmental factors.

Conclusion

It is anticipated that finger length measurement, a non-invasive, inexpensive and applicable method, may facilitate the recognition of individuals predisposed to committing crimes before actually committing them as manic patients. These findings suggest that it may be possible to forecast an individual's propensity for criminal activity based on this physical characteristic. This, in turn, could assist in upholding social order and averting legal proceedings. It should be noted, however, that the current data does not differentiate between individuals with bipolar manic depression who commit crimes and those who do not. This is an important consideration moving forward.

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Conflicts of interest

The authors declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Authorship Contribution

EE, SY, SA, DS and MGG designed the study and developed the survey. EE and SY undertook the statistical analysis, and SA and MGG advised on the statistical approach. EE wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript

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Ethical Approval Statement

Non-Interventional Local Ethics Committee of Fırat University under reference number 2023/13-06 (Meeting Date: 27.09.2023).

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