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Chronotype in bipolar disorder: Differences in sleep quality, social jet lag, physical activity, and diet

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ABSTRACT

Introduction. People with bipolar disorder are at a higher risk of metabolic morbidity and mortality. Chronotype may play a significant role due to its effect on sleep quality, eating patterns, and physical activity. **Objective.** To compare sleep quality, social jetlag, physical activity, and diet, depending on the chronotype of people with bipolar disorder, and to determine the association between these variables. **Method.** Cross-sectional, comparative, correlational study. The sociodemographic and clinical characteristics of subjects were assessed. Chronotype was determined using the Composite Scale of Morningness while sleep quality was evaluated through the Pittsburg Sleep Quality Index. Social jet lag was calculated through the absolute difference between the midpoint of sleep on weekends and workdays. Physical activity was measured through the Bouchard Activity Record and diet was evaluated through a food frequency questionnaire. Comparative analyses were performed between chronotype categories and the association between variables was measured. **Results.** 116 subjects were included. Subjects with evening chronotype reported poorer sleep quality than those with morning chronotype. Eveningness was associated with lower sleep quality scores and more hours of sleep on workdays, as well as with higher consumption of cold meats, calories, and sodium. Trends indicate greater social jet lag and low physical activity levels among evening chronotypes. **Discussion and conclusion.** The effects of chronotype on study variables require further research to clarify this complex relationship and develop educational strategies to promote sleep hygiene, physical activity, and a healthy diet.

Keywords: Chronotype, circadian rhythm, sleep, eating behavior, exercise, bipolar disorder.

RESUMEN

Introducción. Las personas con trastorno bipolar corren mayor riesgo de presentar morbimortalidad metabólica. El cronotipo podría desempeñar un rol importante por su efecto sobre la calidad de sueño, los patrones de alimentación y la actividad física. **Objetivo.** Comparar la calidad de sueño, el *jet lag* social, la actividad física y la dieta en función del cronotipo de personas con trastorno bipolar, así como determinar la asociación entre estas variables. **Método.** Estudio transversal, comparativo y correlacional. Se evaluaron las características sociodemográficas y los antecedentes clínicos de los participantes. El cronotipo se determinó con la Escala Compuesta de Matutinidad y la calidad de sueño con el Índice de Calidad de Sueño Pittsburg. El *jet lag* social se calculó como la diferencia absoluta entre el punto medio de sueño en días libres y de trabajo. La actividad física se midió con el registro de Bouchard y la dieta con un cuestionario de frecuencia de consumo de alimentos. Se realizaron análisis comparativos entre categorías de cronotipo y se evaluó la asociación entre variables. **Resultados.** Se incluyeron 116 participantes. Las personas de cronotipo vespertino reportaron menor calidad de sueño en comparación con las del cronotipo matutino. La vespertinidad se asoció a puntuaciones de menor calidad de sueño y más horas para dormir en días de trabajo, así como a mayor consumo de embutidos, calorías y sodio. Las tendencias indican mayor *jet lag* social y bajo nivel de actividad física entre cronotipos vespertinos. **Discusión y conclusión.** Los efectos del cronotipo sobre las variables de estudio requieren más investigación, que aclare esta compleja relación, para desarrollar estrategias educativas de higiene de sueño, actividad física y dieta saludable.

Palabras clave: Cronotipo, ritmos circadianos, sueño, conducta alimentaria, ejercicio, trastorno bipolar.

INTRODUCTION

Affective disorders are the third most prevalent psychiatric illnesses in Mexico, affecting 9.1% of the population (Ritchie & Roser, 2018). This group includes bipolar disorder (BPD), a serious, disabling condition with a significant personal and social cost associated with comorbid medical conditions (Bobes et al., 2008). People with BPD are at a higher risk of suffering from metabolic syndrome, which has been detected in 61% of cases in Mexico (Díaz-Castro, Cabello-Rangel, Cuevas-Pineda, Reza-Garduño, & Castañeda-González, 2011). This condition leads to a five-fold increase in the risk of developing diabetes mellitus and cardiovascular disease in people with BPD. Cardiovascular disease reduces life expectancy by 20% and is the leading cause of death in this population (Casey, 2005; Forty et al., 2014).

Metabolic morbimortality in people with BPD can be explained by the side effects of the drugs used for its treatment, as well as with the lifestyles characterized by physical inactivity and unhealthy eating habits, linked to the exacerbation of psychiatric symptoms (Forty et al., 2014). However, not all the factors affecting food intake and energy expenditure are understood. It has been suggested that circadian modulation directly impacts food intake, diet quality, physical activity, and sedentary behavior, encouraging the progression toward metabolic abnormalities (Gonnissen et al., 2012; Wennman et al., 2015).

Circadian rhythms are regular cycles of approximately twenty-four hours related to physiological and behavioral processes, which enable an organism to predict and adapt to periodic changes in its environment (Fisk et al., 2018). In turn, all individuals have characteristics indicating the time of day when their physical functions and cognitive faculties are active, reflecting a greater state of alertness and willingness to perform their activities. This trait, called chronotype, makes it possible to distinguish people who perform better in the morning (morning chronotype), those who do so later (evening chronotype), and a third group with no specific inclination (neutral chronotype; Horne & Ostberg, 1976; Roenneberg et al., 2007).

Research conducted on people with no mental illness suggests that circadian preference is related to behavioral and psychological factors. Thus, evening chronotype has been reported to lead to less healthy lifestyles, including increased tobacco and alcohol use, physical inactivity, altered sleep and eating patterns, as well as more health and behavioral problems than the morning subtype (Natale & Cicogna, 2002). In addition, evening chronotype promotes desynchronization between biological and social rhythms. This phenomenon, known as social jet lag (SJL) means that people are constantly forced to adjust to external demands imposed by social norms, creating a discrepancy with respect to their natural circadian rhythms. This variability affects sleep quality and duration, physical activity levels, and nutritional status, which could lead to the development of metabolic alterations (Wittmann, Dinich, Merrow, & Roenneberg, 2006; Castilhos et al., 2017). These considerations are relevant since the disruption of biological rhythms is part of the pathophysiology of affective disorders. People with BPD suffer from circadian disturbances that are not limited to acute episodes but persist during the remission period. Indeed, up to 70% have clinically significant sleep disturbances (Godin et al., 2017). Therefore, the study of the influence of circadian rhythms on lifestyles constitutes an approach to understanding predisposing factors for the development of metabolic alterations, which may be improved in this population. The objective of this research is to compare sleep quality, SJL, physical activity, and diet as a function of the chronotype of people with BPD, and to determine the association between these variables. We hypothesize that people with evening chronotype BPD will be characterized by lower sleep quality, as well as less healthy levels of physical activity, and diet than morning and neutral chronotype groups.

METHOD

Study design

This is a cross-sectional, comparative, correlational study (Villa, Alvarado, Pérez, & Payán, 2011).

Participants

Subjects were recruited at the affective disorders clinic of the National Institute of Psychiatry Ramón de la Fuente Muñiz (INPRFM, Instituto Nacional de Psiquiatría Ramón de la Fuente Muñiz), a tertiary care center specializing in mental health in Mexico City. A formula to estimate proportions was used to calculate that a sample of at least 110 people was required to achieve the research objective, with a confidence level of 95% (bilateral $\alpha = .05$, $Z\alpha = 1.96$) and an accuracy rate of 10% (Rodríguez, Ordaz, Hernández, García, & Rentería, 2003). Men and women of legal age who had a prior diagnosis of type 1 BPD and had been confirmed by the treating physician at the time of agreeing to participate in the study, according to the Diagnostic and Statistical Manual of Mental Disorders version 5 (American Psychiatric Association, 2013), were invited to take part. Subjects could have any pharmacological prescription for the treatment of BPD and had to be in complete remission from the last affective episode, in other words, with no significant signs or symptoms of BPD during the two months prior to data collection (American Psychiatric Association, 2013). Women at any stage of pregnancy and people being treated with melatonin, a chronobiotic used to adjust biological rhythms, were excluded.

Measurements

A form was designed to record information from subjects in a face-to-face interview. Sociodemographic characteristics including sex, age, marital status, educational attainment, and socioeconomic status were evaluated. For educational attainment, subjects were asked about the number of school years they had successfully completed at an educational institution from primary school onwards. Socioeconomic status was obtained from the clinical files as reported in the sociodemographic study of the subject at the time of their admission to the institution. Clinical history included age at onset of BPD, years of evolution since its diagnosis, and previous finding of hypothyroidism. Current use of psychotropic drugs was retrieved from the clinical files, considering the last pharmacological prescription prior to inclusion in the study. Because lithium and valproate are more frequently included in long-term medication regimens, they are reported as independent categories (Baldessarini, Tondo, & Vázquez, 2019). The remaining drugs were grouped into antipsychotics, benzodiazepines, antiepileptic drugs, and antidepressants.

Chronotype was determined through the Composite Scale of Morningness (CSM). The Spanish version has demonstrated its reliability (Cronbach's alpha = .87; Adan, Caci, & Prat, 2005). The questionnaire comprises three items scored from one to five points and ten items with a possible score of one to four points. The instrument evaluates the time a person wakes up and goes to sleep, their preferred time for engaging in physical and mental activities, and their subjective state of alertness. The sum of the items produces a global score. Cut-off points at the 20th and 80th percentiles were established from sample scores to determine the three chronotype categories used to classify subjects (Lee, Lee, Jhung, & Park, 2017). In addition, the total CSM score was analyzed as a continuous variable to determine its linear association with the study variables. Low CSM scores are associated with eveningness, whereas high ones indicate morningness.

Subjects completed the Pittsburgh Sleep Quality Index (PSQI), whose Spanish version, evaluated on psychiatric patients, proved to be reliable (Cronbach's alpha = .78; Jiménez-Genchi, Monteverde-Maldonado, Nenclares-Portocarrero, Esquivel-Adame, & Vega-Pacheco, 2008). The questionnaire consists of eighteen questions, including four open-ended ones to describe sleep and wake up times, and fourteen items scored on a scale of zero to three points, where lower values represent lower frequency of sleep difficulties and fewer problems performing daily activities or related to lower subjective sleep quality. Items are grouped into seven components (subjective sleep quality, sleep latency, sleep duration, efficiency, sleep disturbances, sleep medication use, and daytime dysfunction). The sum of the components is used to obtain a total score ranging from zero to twenty-one reported for the purposes of this project. High scores reflect more difficulty falling asleep and therefore lower sleep quality.

Social jet lag (SJL) was calculated through the absolute difference between the midpoint of sleep on weekends (MSWE) and on weekdays (MSWD) of subjects, expressed as a formula (MSWE–MSWD). The MSWE and MSWD are expressed in local time and defined as the midpoint between the start and end of sleep, on both weekends and weekdays. SJL is expressed as a continuous variable in hours and reflects the discrepancy between biological and social rhythms. The MSWE represents biological time on the assumption that, on weekends, people follow their circadian rhythm. The MSWD corresponds to the social rhythm, since sleep times are adjusted to the beginning of social commitments such as school or work (Wittmann et al., 2006). Items in this section made it possible to estimate sleep duration on a continuous scale.

The Activity Record of Bouchard et al. (1983) was used to determine the time spent in activity categories. The adaptation of the instrument to the Mexican population demonstrated its reproducibility (IQC = .86, $p < .001$) and sensitivity ($r = .90$, $p < .01$) (López-Alvarenga, Reyes-Díaz, Castillo-Martínez, Dávalos-Ibáñez, & González-Ravine, 2001). The questionnaire divides the twenty-four hours of the day into fifteen-minute periods and subjects are asked about the number of intervals spent on each of their daily activities. Information from one weekend day and one weekday was recorded to assess the time spent on sedentary, light, moderate, and vigorous activities.

The characteristics of the diet were evaluated through an ad hoc questionnaire. Each respondent was asked about the weekly frequency and number of servings per day they had consumed of food groups and beverages in the past month: 1. Fruits and vegetables, 2. Pulses, 3. Foods of animal origin (fish, chicken, pork, beef, and dairy products), 4. Cereals with fat, 5. Cereals without fat, 6. cold meats, 7. Alcoholic beverages, 8. Coffee, and 9. Sugary drinks (fresh or packed juice, soft drinks, and fruit-flavored water). The standardized size of portions and home measurements was based on the Mexican System of Equivalent Foods (Pérez-Lizaur, Palacios-González, Castro-Becerra, & Flores-Galicia, 2014). This information was used to determine daily food and beverage intake. The average nutritional contribution of food and beverage groups was used to estimate caloric intake, proportion of macronutrients (protein, lipids, and carbohydrates), and sodium (Pérez-Lizaur et al., 2014). Sodium determination was evaluated as a dietary component that affects cardiovascular health (Cook et al., 2009). The variables are reported on a continuous scale and represent daily consumption.

Procedure

Between April 2019 and March 2020, all those seeking an outpatient psychiatric consultation at the INPRFM affective disorders clinic were invited to participate in the study. Two previously trained intern nutritionists were responsible for individually reading the informed consent form and obtaining the signatures of those wishing to participate. Next, the treating physician used a clinical interview to confirm the bipolar disorder diagnosis, total remission of the last affective episode, and ensure that subjects were neither pregnant nor melatonin users. For eligible participants, the same nutritionist responsible for recruitment extracted in each case the necessary information from the clinical file and conducted the interview to complete the record of sociodemographic data and clinical history, as well as the questionnaires to determine the subject's chronotype, sleep quality, SJL, physical activity and diet. Based on the CSM, participants were grouped into three chronotype categories (morning, neutral and evening). All the information was captured in a template of the Microsoft Excel for macOS 16.50 for cleaning and subsequent processing in specialized statistical software. The principal investigator of this project coordinated the stages of the work and supervised all the activities conducted by the research team.

Statistical analysis

First, data distribution was evaluated using the Shapiro-Wilk test to determine the distribution of the variables included in the study. In the descriptive analysis, categorical variables are presented in frequencies and proportions. Continuous variables with normal distribution are reported as means and standard deviation (M ± SD), while variables with non-normal distribution are presented as median (Me) and interquartile range (IQR). As hypothesis tests for the comparison between chronotypes, Chi square (χ^2) was used to contrast categorical variables and analysis of variance (ANOVA), while the Kruskal-Wallis test was used for continuous variables, depending on the data distribution. The level of statistical significance was set at $p \leq .05$. In the variables where differences were detected, post hoc tests of multiple comparisons were conducted. The Bonferroni method was used for parametric contrasts and the Mann-Whitney U method was used for non-parametric contrasts. For these analyses, statistical significance was set at $p \leq .01$ according to the number of comparison groups (.05/3 groups = .01). Pearson and Spearman correlation coefficients were calculated, depending on the data distribution, to determine the association between the global score for CSM, circadian variables, physical activity, and diet. In the significant findings ($p \leq .05$), partial correlations were studied to control the effect of third variables and eliminate any influence that might affect the previously detected association. In this analysis, sociodemographic characteristics (sex, marital status, socioeconomic status, age, and schooling), medical history (evolution of BPD, age at onset of the disorder, diagnosis of hypothyroidism, drug use), and sleep duration were considered adjustment variables and only those that were shown to influence the association are reported. All analyses were performed using SPSS Statistics 25 on macOS.

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki and the protocol was approved by the INPRFM Ethics and Research Committee (registration number: CONBIOÉTICA-09-CEI-010-20170316). Subjects indicated their willingness to participate by signing an informed consent form.

RESULTS

Sample description: sociodemographic, characteristics, and clinical history

The study population consisted of 116 subjects. According to the distribution of CSM scores, the 20 and 80 percentiles were set at the 28 and 41 scores. Thus, 25% (n = 29) of subjects were classified as having morning chronotype (≥ 41 points), 48.3% (n = 56) with neutral chronotype (≥ 29 ≤ 40 points), and 26.7% (n = 31) with evening chronotype (≤ 28 points). The highest proportion of the sample were women (75.9%, n = 88), unpartnered (56.9%, n = 66) and with medium socioeconomic status (69.8%, n = 81). The mean age of participants was 40.0 (IQR = 20.0) years and they reported 15.0 (IQR = 4.0) years of schooling. There were no differences in sociodemographic characteristics between groups, except for age, which was higher in those with morning than neutral or evening chronotype.

In general, subjects comprising the study had a mean number of years of evolution of BPD of 11.5 (IQR = 11.0) years and reported an age of onset of the disorder of 25.5 (IQR = 13.8) years.

As for the treatment used, the median was 3.0 (IQR = 2.0) drugs. Most subjects reported using some form of antipsychotic drug (70.7%, n = 82), valproate (68.1%, n = 79), and benzodiacepines (51.7%, n = 60). With regard to clinical characteristics, differences were only identified between chronotypes in the proportion of antipsychotic drug users, which pointed to greater use among subjects in the evening group. Table 1 shows the sociodemographic information and clinical history of subjects.

Circadian characteristics, physical activity, and diet

Table 2 presents the circadian characteristics of the sample participants and their classification by chronotype. In general, the average PSQI score was 7.7 (± 3.4) points. Sleep duration was similar on weekends and weekdays (Me 9.0 hours) and the median SJL was .5 (IQR = 1.5) hours. Evening chro-

Table 1
Sociodemographic characteristics and clinical history of subjects

Variable	*Total* (*N* = 116)	*Chronotype* *Morning* (*n* = 29)	*Neutral* (*n* = 56)	*Evening* (*n* = 31)	*p*
Sex					
Men, *n* (%)	28 (24.1)	6 (20.6)	16 (28.5)	6 (19.3)	.555
Women, *n* (%)	88 (75.9)	23 (79.3)	40 (71.4)	25 (80.6)	
Marital status					
Partnered, *n* (%)	50 (43.1)	16 (55.1)	22 (39.2)	12 (38.7)	.317
Unpartnered, *n* (%)	66 (56.9)	13 (44.8)	34 (60.7)	19 (61.2)	
Socioeconomic status					
Low, *n* (%)	17 (14.7)	3 (10.3)	11 (19.6)	3 (9.6)	
Medium, *n* (%)	81 (69.8)	22 (75.8)	36 (64.2)	23 (74.1)	.663
High, *n* (%)	18 (15.5)	4 (13.7)	9 (16.0)	5 (16.1)	
Age, *Me (IQR) years*	40 (20.0)	46 (15.0)	39.5 (19.0)	37 (12.0)	.008*
Educational attainment, *Me (IQR) years*	15 (4.0)	12 (4.0)	16 (3.8)	15 (4.0)	.133
Evolution of TBP, *Me (IQR) years*	11.5 (11.0)	12 (11.0)	11.5 (10.8)	11 (12.0)	.766
Age of onset of TBP, *Me (IQR) years*	25.5 (13.8)	32 (21.0)	25 (13.5)	24 (9.0)	.012&
Previous diagnosis of hypothyroidism, *n* (%)	39 (33.6)	11 (35.5)	21 (37.5)	7 (24.1)	.451
Number of psychotropic drugs, *Me (IQR)*	3 (2.0)	2 (2.0)	3 (2.0)	3 (2.0)	.067
Valproate, *n* (%)	79 (68.1)	21 (72.4)	37 (66.1)	21 (67.7)	.837
Lithium, *n* (%)	34 (29.3)	8 (27.6)	21 (37.5)	5 (16.1)	.108
Antipsychotics, n (%)	82 (70.7)	15 (51.7)	40 (71.4)	27 (87.0)	.011
Benzodiazepines, *n* (%)	60 (51.7)	16 (55.1)	26 (46.4)	18 (58.0)	.531
Antiepileptic drugs, *n* (%)	31 (26.7)	11 (35.5)	13 (23.2)	7 (24.1)	.435
Antidepressants, *n* (%)	21 (18.1)	8 (25.8)	11 (19.6)	2 (6.9)	.151

Notes: *Me* = median; *IQR* = interquartile range; *p* = probability value.
* Multiple comparisons between chronotypes: morning *vs.* neutral (*U* = 5.26, *p* = .022); morning *vs.* evening (*U* = 11.27, *p* = .001); neutral *vs.* evening (*U* = 1.08, *p* = .299).
& Multiple comparisons between chronotypes: morning *vs.* neutral (*U* = 6.15, *p* = .013); morning *vs.* evening (*U* = 4.24, *p* = .039); neutral *vs.* evening (*U* = .483, *p* = .487).

Table 2
Circadian characteristics and physical activity

Variable	*Total* (*N* = 116)	*Chronotype* *Morning* (*n* = 29)	*Neutral* (*n* = 56)	*Evening* (*n* = 31)	*p*
PSQI, *M (± SD) points*	7.7 (3.2)	6.3 (2.3)	7.9 (3.6)	8.7 (3.0)	.014*
Length of sleep on workdays, *Me (IQR) hours*	9 (2.0)	9.0 (1.2)	8.4 (2.0)	9 (2.0)	.390
Length of sleep on weekends, *Me (IQR) hours*	9 (3.0)	9 (2.9)	9 (3.7)	9.5 (3.0)	.668
SJL, *Me (IQR) hours*	.5 (1.5)	.5 (1.3)	.5 (1.2)	1 (2.5)	.603
Physical activity on workdays					
Sedentarism, *Me (IQR) minutes/day*	330 (420.0)	360 (495.0)	240 (337.5)	450 (465.0)	.184
Light, *Me (IQR) minutes/day*	240 (334.9)	300 (342.8)	240 (326.2)	165 (360.0)	.445
Moderate, *Me (IQR) minutes/day*	0 (56.2)	0 (60.0)	0 (56.2)	0 (0)	.269
Physical activity on weekends					
Sedentarism, *Me (IQR) minutes/day*	247.5 (296.2)	285 (315.0)	180 (273.7)	300 (285.0)	.250
Light, *Me (IQR) minutes/day*	240 (330.0)	270 (345.0)	240 (308.3)	180 (376.2)	.599
Moderate, *Me (IQR) minutes/day*	0 (56.0)	0 (143.0)	0 (41.2)	0 (56.0)	.551

Notes: PSQI = Pittsburg Sleep Quality Index; M = mean; SD = standard deviation; SJL = social jet lag.
Me = mean; *IQR* = interquartile range, *p* = probability value.
* Difference between means in multiple comparisons: morning *vs.* neutral (-1.61, *p* = .086); morning *vs.* evening (2.39, *p* = .013); neutral *vs.* evening (-.781, *p* = .829).

notype subjects reported higher ICSP scores (Me 8.7 [IQR = 3.0] points) than morning chronotypes (Me 6.3 [IQR = 2.3] points), with no differences from the neutral chronotype being detected. Likewise, evening chronotypes reported sleeping more on weekends (Me 9.5 [IQR = 3.0] hours) and higher SJL (Me 1.0 [IQR = 2.5] hours) than other groups.

Table 3
Food and beverage consumption, and diet characteristics

Variable	Total (N = 116)	Chronotype: Morning (n = 29)	Neutral (n = 56)	Evening (n = 31)	p
Fruit and vegetables, *Me (IQR) portions/day*	2.2 (2.7)	3 (3.5)	2.4 (2.2)	1.8 (2.2)	.216
Pulses, *Me (IQR) portions/day*	.2 (.4)	.4 (.4)	.3 (.4)	.2 (.7)	.924
Food of animal origin, *Me (IQR) portions/day*	3.8 (2.5)	3.5 (2.5)	3.8 (2.6)	3.8 (1.7)	.928
Cereals without fat, *M (± SD) portions/day*	4.5 (3.0)	4.3 (3.1)	4.4 (2.9)	4.9 (3.2)	.699
Cereals with fat, *M (± SD) portions/day*	5 (2.3)	2 (2.4)	2.6 (2.0)	2.8 (2.7)	.366
Cold Meats, *Me (IQR) portions/day*	.2 (.8)	.1 (.5)	.2 (.8)	.4 (.7)	.114
Alcoholic beverages, *Me (IQR) portions/day*	0 (.1)	0 (.1)	0 (.1)	.1 (.4)	.075
Coffee, *Me (IQR) portions/day*	.7 (2.0)	.4 (1.2)	.5 (1.3)	1 (1.8)	.170
Sugary drinks, *Me (IQR) portions/day*	.4 (1.6)	.1 (.7)	.5 (2.0)	.5 (2.0)	.183
Calorie intake, *Me (IQR) Kcal/day*	1521.4 (849.1)	1416.2 (836.4)	1469 (791.6)	1722.7 (1038.6)	.248
Carbohydrates, *Me (IQR) %*	45.1 (9.3)	44.9 (9.9)	44.6 (9.5)	46.4 (13.1)	.830
Lipids, *Me (IQR) %*	41.5 (9.6)	40.3 (9.6)	41.8 (8.7)	41.6 (14.0)	.943
Protein, *Me (IQR) %*	13.6 (3.6)	14.3 (2.9)	13.6 (3.8)	13.6 (4.1)	.685
Sodium, *Me (IQR) mg/day*	3625 (2446.4)	3000 (2973.2)	3629.4 (2325.8)	4142.8 (2910.7)	.167

Notes: *Me* = median; *IQR* = interquartile range; *M* = mean; *SD* = standard deviation; *Kcal* = kilocalories; *g* = grams, *p* = probability value.

As for physical activity, subjects with evening chronotype reported spending more time on sedentary activities than other circadian categories, on both weekdays (450.0 [465.0] minutes/day), and weekends (300.0 [285.0] minutes/day). Morning chronotypes spent more time on light activities (300.0 [342.8] minutes/weekday and 270.0 [345.0] minutes/weekend day) than neutral and evening chronotypes. The time spent on moderate activities was less in all chronotype categories, provided they did not report vigorous activities (Table 2).

In respect to food consumption, subjects cited cereal as the most widely consumed food, mainly cereals with fat (Me 5.0 [IQR = 2.3] portions/day). Pulses were the least widely consumed healthy food (Me .2 [IQR = .4] portions/day). For their part, subjects drank .7 (IQR = 2.0) daily portions of coffee, which was the most commonly reported beverage. The remaining foods and beverages evaluated as well as the differences in consumption between chronotype groups are shown in Table 3.

An analysis of the characteristics of the population's diet showed a consumption of 1521.4 (IQR = 849.1) Kcal/day. The largest proportion of their diet consisted of carbohydrates (Me 45.1 [IQR = 9.3] %); followed closely by lipids (Me 41.5 [IQR = 9.6] %). A median of 3625.0 [IQR = 2446.4] mg/day of sodium in the diet was also detected. Although no difference were found between chronotype groups, higher consumption of calories (Me 1722.7 [IQR = 1038.6] Kcal/day) and sodium (Me 4142.8 [IQR = 2910.7] mg/day) was observed in evening chronotype subjects (Table 3).

Association between chronotype, sleep quality, physical activity, and diet

Table 4 shows a negative correlation between the CSM and PSQI scores (r = -.367); hours of sleep on weekdays

Table 4
Association between CSM and circadian variables, physical activity, and diet

Variable	Correlation coefficient	p
PSQI	- .367	< .001*
Sleep duration on workdays	- .192	.040[&]
Sleep duration on weekends	- .140	.134
SJL	- .088	.349
Sedentarism on workdays	- .041	.660
Light physical activity on workdays	.148	.114
Moderate physical activity on workdays	.164	.078
Sedentarism on weekends	- .014	.878
Light physical activity on weekends	.047	.614
Moderate physical activity on weekends	.044	.636
Fruit and vegetables	.157	.092
Pulses	.059	.528
AOA	- .153	.101
Cereals without fat	- .125	.181
Cereals with fat	- .165	.077
Cold meats	- .218	.019
Alcoholic beverages	- .137	.141
Coffee	- .153	.102
Sugary drinks	- .137	.142
Calorie intake	- .189	.043
Carbohydrates	- .058	.539
Lipids	- .009	.926
Protein	.019	.839
Sodium	- .224	.017[†]

Notes: *p* = probability value. The Pearson correlation coefficient was used to determine the association between CSM and PSQI and cereals with and without fat, The association with the remaining variables was evaluated using Spearman's correlation coefficient.
* Partial correlations adjusted for schooling, evolution of BPD, sleep duration on weekdays, and SJL.
[&] Adjusted for sex.
[†] Adjusted for educational attainment, evolution of BPD and sleep duration on weekends.

(r = -.192); cold meat consumption (r = -.218); calorie intake (-.189); and sodium consumption (r = -.224). This suggests that when CSM scores decrease, the result of the second variable in question increases. The association persisted after the analysis of partial correlations.

DISCUSSION AND CONCLUSION

This research compared sleep quality, SJL, physical activity, and diet variables, depending on the chronotype of people with BPD, while evaluating the association between these variables. In general terms, the sociodemographic characteristics of the population were similar between the groups. However, grouping by chronotypes showed that people categorized as evening people were younger while morning people were older. This is consistent with other research, which reports that morningness is a more prevalent characteristic as age advances, due to the displacement of the circadian phase (Randler, Faβl, & Kalb, 2017). In relation to clinical history, it is striking that subjects with the evening chronotype had an earlier onset of bipolar disorder, which coincides with a cohort study citing evening preference as a chronic characteristic among people with BPD (Melo, Abreu, Linhares Neto, de Bruin, & de Bruin, 2017).

In respect of sleep quality, it was observed that there are differences when subjects are compared by chronotype. In people with BPD, sleep disturbances are common in all phases of the disease and negatively impact its course and treatment (Steardo et al., 2019). The differences pointed to lower sleep quality in people with evening chronotype than in those with morning chronotype. The finding of a predisposition to poor sleep quality in people with evening chronotype is consistent with other studies conducted in the general population (Merikanto et al., 2012) and those with mental illnesses (Rose et al., 2014). The association analysis indicated that a tendency towards eveningness is related to lower sleep quality scores and more hours of sleep on working days. It is documented that poor sleep quality, as well as short and long sleep duration, have detrimental effects on endocrine and metabolic pathways (Godin et al., 2017) by promoting sympathetic nervous activity, high cortisol levels, glucose intolerance, and decreased insulin sensitivity (Depner, Stothard, & Wright, 2014). These physiological changes may directly contribute to the development of metabolic syndrome, diabetes mellitus, and cardiovascular disease, but also impact food choice, timing, and portion size in the diet (Nedeltcheva et al., 2009; Kim, DeRoo, & Sandler, 2011; Godin et al., 2017).

Regarding physical activity, no differences were detected between chronotype groups. Nonetheless, it is striking that subjects spend more time on sedentary activities than the average reported by Mexican adults in the general population (247.5 to 330.0 *vs*. 214.0 minutes/day, respectively; Shamah-Levy et al., 2020). In addition, according to the World Health Organization recommendations (WHO, 2010), all subjects would be classified as physically inactive since they accumulated fewer than twenty-five minutes of moderate-vigorous physical activity per day. It was not possible to identify the association between chronotype and level of physical activity. However, the results point in the expected direction: for weekends and weekdays, eveningness pointed to a longer duration of sedentary activities and a lower duration of those classified as light and moderate. Confirmation of this possible relationship should be explored in greater depth. However, since evidence indicates that sedentary behavior and physical inactivity are among the major modifiable risk factors for the prevention of cardiovascular diseases and all-cause mortality, reducing sedentary lifestyle and increasing the level of physical activity could represent a benefit for these people (Lavie, Ozemek, Carbone, Katzmarzyk, & Blair, 2019).

A comparison of the diet between chronotypes yielded no statistically significant differences. Nevertheless, results suggest that evening chronotypes have a lower preference for healthy eating patterns. These subjects tended to consume fewer daily servings of fruit, vegetables and pulses and reported the highest intake of cereals with and without fat, cold cuts, coffee, total calories, and sodium. Regarding the latter, it should be noted that the intake of the study population (3625.0 mg/day) exceeds that observed in healthy Mexican adults (3150 mg/day; Vallejo et al., 2017). In both cases, consumption is higher that recommended for the adult population (2500 mg/day: WHO, 2013). Although other cross-sectional studies have found an association between chronotype and dietary variables in the general population (Sato-Mito, Shibata, Sasaki, & Sato, 2011; Mota et al., 2016), this project only observed that higher evening scores corresponded to higher consumption of cold meats, total calories, and sodium. This increased caloric intake coincides with the trends in higher intake of carbohydrates and lipids as CSM scores decrease (indicative of eveningness), which coincides with other findings (Mota et al., 2016). This could be consistent with the correlation between consumption of cereals and sugary drinks that tend to rise as eveningness increases, while sodium intake could be influenced by the consumption of cold meats. Certain mechanisms may predispose individuals with evening chronotype to adopt less healthy diets than other groups. Research has observed that increased SJL is likely to affect food consumption together with other lifestyles (Maukonen et al., 2016). Although our research found that individuals with eveningness chronotype seemed prone to higher SJL, this association was not observed. Another hypothetical explanation could be found in personality characteristics between chronotypes. According to Tonetti, Fabbri, and Natale (2009), people with the evening chronotype tend to be less conscientious and have less self-control than morning and neutral chronotypes, which could influence the choice of foods and beverages in their diet.

This research has certain limitations. The cross-sectional study design was based on a sample of 116 people, who, in turn, were classified into smaller groups with different sociodemographic characteristics and clinical history. Moreover, subjects were drawn from a single mental health care institution. For the evaluations, questionnaires were administered which, despite having been previously validated, are subjective and dependent on the memory and motivation of subjects. Since the exploration of the components in the subjects' diet did not investigate either the dishes or the food preparation techniques used, their intake may have been underestimated. There were no objective measurements of sleep quality or physical activity. In addition, since the associations found were weak and do not imply causation, they should be addressed in future studies through appropriate methods and analyses. Moreover, the relationships detected could be a result of factors that were not considered or sufficiently controlled in this project. For example, the evolution of BPD and psychotropic drug treatment can induce changes in physical activity and diet that could impact the results observed. In addition, due to the high psychiatric comorbidity of BPD, it was decided not to exclude anyone from the study on the basis of this criterion. The simultaneous occurrence of BPD with another mental illness could influence the study variables. Results should therefore be interpreted with caution.

In conclusion, the results of this research partially confirm the hypotheses posited by suggesting that eveningness is associated with less healthy habits. The range of ways in which chronotype can influence sleep quality, physical activity, and eating patterns, and in which these variables could be related to metabolic outcomes reflect the complexity of the problem. Further studies are required to clarify how chronotype modulates these habits and impacts the physical health of people with BPD to develop educational strategies for sleep hygiene, physical activity and a healthy diet that will contribute to the prevention and treatment of metabolic disorders in this population. Moreover, one should recall that the implementation of these actions, together with appropriate pharmacological and psychotherapeutic management for each subject, could have repercussions on the evolution of their psychiatric condition, reduce treatment abandonment rates and decrease the incidence of cardiovascular disease.

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Conflict of interest

The authors declare that they have no conflicts of interest.

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