Unraveling the intricacies of circadian rhythm dynamics and their impact on mood fluctuations in human physiology

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Abstract

This study examines the moderating effect of gender on the link between mood swings and preferences for circadian rhythms. Cross-sectional recruitment was used to find 224 participants (108 males and 116 women), and the sample size had 95% statistical power to identify a small-to-medium effect. Mood states and circadian preferences were measured using the Brunel Mood Scale (BRUMS) and the Reduced Morningness-Eveningness Questionnaire (rMEQ), respectively. Statistical analyses, including Pearson correlation and multiple regression, revealed a little but substantial positive correlation ($p < 0.05$) between morning-oriented chronotypes and better mood outcomes. Furthermore, a two-way ANOVA showed that gender significantly influenced the link between mood changes and circadian type, with females exhibiting bigger mood variations. Participants who favor the mornings report better mood ratings, whereas those who prefer the nights report lower mood levels. These findings show a correlation between emotional well-being and circadian alignment, but further long-term research is needed to prove causation and look at other factors.

Introduction

Circadian Rhythms, Neurotransmitters, and Mood

Numerous physiological and behavioral processes in living things are regulated by endogenous circadian rhythms, which are about 24-hour cycles[1]. These rhythms are controlled by a master pacemaker located in the hypothalamic suprachiasmatic nucleus (SCN), which synchronizes the body's peripheral clocks with external time signals, mainly the light-dark cycle[2]. At the molecular level, self-sustaining oscillations are produced by transcription-translation feedback loops involving key clock genes (e.g., CLOCK, BMAL1, PER, and CRY) that are essential to circadian timing[3]. Circadian alignment, which is crucial for physiological health and well-being, is the state in which this system makes sure that biological processes take place at the best times. Circadian cycles impact the regulation of

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emotions by means of overlapping neural pathways. The SCN controls the circadian release of hormones including melatonin and cortisol and interacts with important mood-related brain areas[4]. These hormones affect monoaminergic neurotransmitter systems, which are essential for mood stability and include dopamine, serotonin, and norepinephrine[5,6]. For instance, serotonin has a distinct diurnal release rhythm and is essential for controlling emotion, appetite, and sleep[7]. Circadian rhythm abnormalities can dysregulate these pathways, making people more susceptible to illnesses and mood swings[8].

Chronotype as an Individual Difference

A person's chronotype, which can be classified as morning, evening, or intermediate type, reflects their natural preferences for the timing of their sleep, activities, and cognitive function[9]. These discrepancies stem from changes in the circadian clock's intrinsic period and phase[10]. While evening types are more prone to mood problems, frequently as a result of chronic social jetlag—the misalignment between biological and social schedules— morning types typically report higher levels of positive affect and well-being[11,12].

Gender Differences in Circadian and Mood Regulation

Gender affects mood management and circadian physiology. Compared to men, women usually have a shorter intrinsic circadian period, which may make them more vulnerable to circadian disturbance[13,14]. A scientific basis for mood swings and decreased circadian sensitivity throughout the menstrual cycle is provided by the interaction of sex hormones such as progesterone and estrogen with circadian clock systems[15,16]. According to epidemiological data, mood disorders are more common in women, and circadian misalignment may make them worse[17].

Research Rationale, Objectives, and Hypotheses

It is commonly known that mood and circadian rhythms are related, but less is known about how gender functions as a moderating factor in this relationship, especially in Bangladesh. Historically, gender has frequently been viewed as a complicating variable rather than a primary focus of research. To create individualized, evidence-based treatments to mental health that take individual biological differences into account, it is imperative to clarify these gender-specific dynamics.

The two main goals of the current study were to determine whether gender moderates the association between chronotype and mood swings and to evaluate the link between chronotype and self-reported mood states in a Bangladeshi population. The study asked two important research questions in order to accomplish these goals. The hypothesis that a morning-oriented chronotype would be significantly connected with higher, more positive mood ratings was based on the first question, which enquired whether there is a significant association between participants' chronotype scores and mood scores. With the expectation

that this correlation would be noticeably stronger for female participants than for male participants, the second question investigated whether gender significantly moderates the relationship between chronotype and mood.

Materials and Methods

Study Design and Participants

This study used a cross-sectional methodology to investigate the connection between mood swings and preferences for circadian rhythms. Convenience sampling was used to recruit 224 Bangladeshi individuals using online sources, such as email lists, social media, and academic networks. 108 men (48.2%) and 116 women (51.8%) made up the sample, which had a mean age of 23.7 years (SD = 4.1). A wide range of occupational backgrounds were represented by the participants: housewives (7.1%, n = 16), government or non-government employees (16.5%, n = 37), business professionals (9.4%, n = 21), students (49.1%, n = 110), and others (17.9%, n = 40).

Sample Size Justification

With the aid of G*Power software (Version 3.1.9.7), the sample size was predetermined. To detect a small-to-medium effect ($f^2 = 0.08$) with 80% power at an alpha level of 0.05, a minimum of 107 participants were needed for a multiple linear regression with two predictors (gender and chronotype). The 224 participants in the final sample surpassed this threshold, offering strong statistical power. In the primary regression model, the sample provided more than 95% power to detect the observed effect size, according to a post-hoc analysis.

Instruments

Reduced Morningness-Eveningness Questionnaire (rMEQ)

The Bengali adaptation of rMEQ, adapted by Siraji M. was used to evaluate chronotype[18]. According to the preferences for sleep-wake pattern and peak alertness times, the five items test assigns people to morning, intermediate or evening types. For the current sample, internal consistency was satisfactory (Cronbach's $\alpha = 0.78$).

Brunel Mood Scale (BRUMS)

The 24-item Bengali version of BRUMS, validated by Hasan and Khan , evaluates six subscales- tension, despair, anger, vigor, exhaustion and confusion- was used to gauge mood states[19]. A five point Likert scale (0 being not at all and 4 being excessively) was used to collect responses. In this investigation, the scale showed strong internal consistency (Cronbach's $\alpha = 0.85$).

Procedure

Data collection was conducted online over an eight months period, from February 2024 to September 2024, to ensure broad accessibility and participant's convenience. A link to the survey was sent via email, social media, and academic networks. An informed consent statement detailing the study's goal, confidentiality, and rights to volunteer participation was presented on the survey's first page. Participants could only continue if they clicked "I agree." The rMEQ, the BRUMS, and demographic data comprised the three portions of the survey. It took about 5 to 10 minutes to finish. Respondents were reminded of their freedom to withdraw at any time without incurring penalties, and participation was anonymous.

Statistical Analysis

SPSS Statistics was used to analyze the data (Version 26.0, IBM Corp., Armonk, NY, USA). Responses were filtered to exclude entries that were inconsistent or lacking information. To summarize the chronotype distribution, mood scores, and demographic data, descriptive statistics (means, standard deviations, frequencies, and percentages) were employed. Pearson's correlation analysis evaluated the bivariate connection between BRUMS scores and rMEQ. Mean BRUMS scores were compared between chronotype groups using a one-way ANOVA. ANCOVA was used to investigate moderation, with mood scores serving as the dependent variable and gender and chronotype serving as independent factors. While adjusting for gender, multiple regression was also used to predict BRUMS scores from rMEQ values. At $p < 0.05$, statistical significance was established.

Results and Discussion

Sample Characteristics and Preliminary Analysis

Table 1. Descriptive statistics of the sample (N = 224)

Characteristic	Male (n = 108)	Female (n = 116)	Total (N = 224)
Age (Years)	23.4 (3.9)	24.0 (4.3)	23.7 (4.1)
rMEQ Score (SD)	3.45 (0.89)	3.52 (0.85)	3.49 (0.87)
BRUMS Score (SD)	4.12 (0.67)	4.19 (0.71)	4.16 (0.69)

As detailed in table 1, the final sample of 224 participants was nearly evenly split by gender. The mean scores for both the rMEQ and BRUMS were similar across male and female participants.

Table 2. Chronotype distribution by gender

Chronotype	Male (n %)	Female (n %)	Total (n %)
Definitely morning	15 (13.9)	18 (15.5)	33 (14.7)
Moderately morning	25 (23.1)	30 (25.9)	55 (24.6)
Neither type	40 (37.0)	45 (38.8)	85 (37.9)
Moderately evening	15 (13.9)	12 (10.3)	27 (12.1)
Definitely Evening	13 (12.0)	11 (9.5)	24 (10.7)

The distribution of chronotypes across genders is shown in table 2. A chi-square test revealed no significant association between gender and chronotype category ($\chi^2 = 0.89$, df = 4, $p > 0.05$).

Association Between Chronotype and Mood

Table 3. Pearson correlation between rMEQ and BRUMS scores

Variables	Correlation Coefficient (r)	p-value
rMEQ and BRUMS	0.18	< 0.05

A Pearson correlation analysis was conducted to test the first hypothesis. As shown in Table 3, a significant positive correlation was found between rMEQ and BRUMS scores ($r = 0.18$, $p < 0.05$), indicating that a greater morningness orientation was associated with more positive mood states.

Table 4. One-way ANOVA of BRUMS scores across chronotype categories

Chronotype Categories	Mean BRUMS Scores	Standard Deviation
Definitely Morning	4.45	0.61
Moderately Morning	4.12	0.65
Neither Type	4.18	0.68
Moderately evening	4.00	0.70
Definitely evening	3.85	0.72

Note: F (4,219) = 1.92, p < 0.05

To further explore this relationship, a one-way ANOVA was performed. The results in Table 4 show a significant main effect of chronotype category on BRUMS scores ($F = 1.92$, $p < 0.05$). Post–hoc comparisons confirmed that "Definitely Morning" types reported significantly higher mood scores than "Definitely Evening" types.
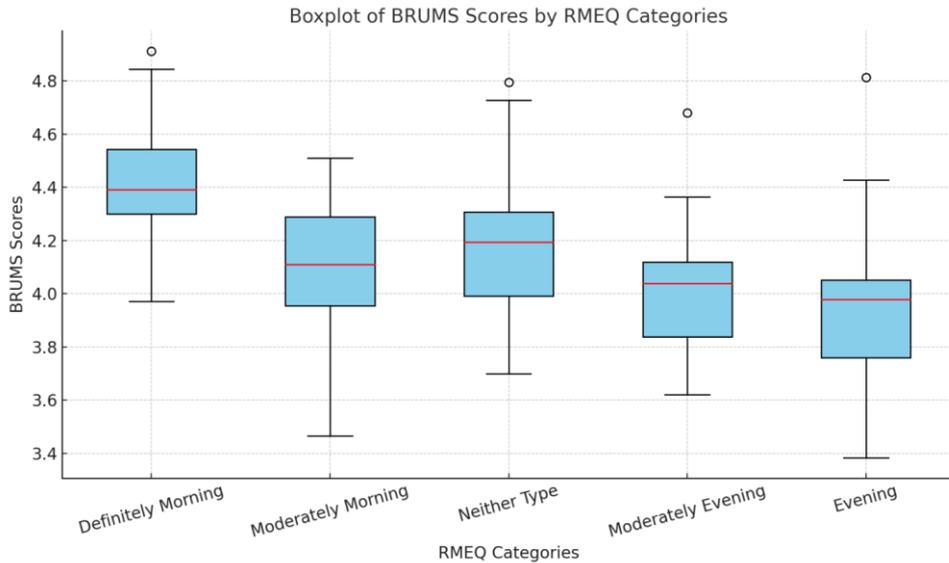
Fig. 1. Box plot of BRUMS scores across rMEQ chronotype categories.

The distribution of BRUMS scores across the five chronotype categories is visualized in Fig. 1. The box plot illustrates a clear downward trend in median mood scores from the "Definitely Morning" to the "Definitely Evening" category. Notably, the "Definitely Morning" group not only shows a higher median but also a tighter inter-quartile range, suggesting more consistent positive mood reports among morning types. In contrast, the "Definitely Evening" group exhibits a lower median and a wider spread of scores, indicating greater variability and generally lower mood states.

Moderating Effect of Gender

Table 5. ANCOVA results for the moderating effect of gender

Source	F –value	df	p-value
Gender	3.21	1,222	0.04
rMEQ Score	4.87	1,222	0.03
rMEQ x Gender	2.56	1,222	0.04

The second hypothesis, which postulated that gender moderates the chronotype-mood relationship, was tested using ANCOVA. As presented in table 5, a significant interaction effect was found between rMEQ score and gender on BRUMS scores ($F = 2.56$, $p < 0.05$).

Table 6. Multiple regression analysis predicting BRUMS scores

Predictor	B	SE	β	p- value
Constant	3.12	0.42	-	<0.001
rMEQ score	0.32	0.15	0.21	0.03
Gender (Female)	0.10	0.12	0.07	0.40
rMEQ x Gender	0.25	0.10	0.16	0.04

A multiple regression analysis was conducted to confirm this moderation effect. The results in table 6 show that rMEQ was a significant predictor of mood ($\beta = 0.21$, $p < 0.05$), and the interaction term (rMEQ x Gender) was also significant ($\beta = 0.16$, $p < 0.05$). Simple slopes analysis demonstrated that the relationship between morningness and positive mood was significantly stronger for females ($\beta = 0.29$, $p < 0.01$) than for males ($\beta = 0.11$, $p = 0.12$).

In addition to demonstrating a strong correlation between mood swings and circadian rhythm preferences in a Bangladeshi population, this study also identifies gender as a crucial moderating element. Positive mood and morningness have a little but significant positive connection ($r = 0.18$, $p < .05$), which is consistent with other international research findings that links morning chronotypes to improved psychological well-being[10,11]. ANOVA results supported the social jetlag hypothesis, which holds that evening types suffer from a persistent misalignment with social schedules[10]. They also showed a distinct gradient in mood scores across chronotype categories ($F_{4,219} = 1.92$, $p < .05$), with "Definitely Morning" types showing the most positive mood profiles.

The moderating effect of gender is one of the research's most salient findings. The ANCOVA revealed a significant interaction effect ($F_{1,222} = 2.56$, $p < .05$), and regression analysis also showed that women had a significantly larger correlation between chronotype and mood ($\beta = 0.29$, $p < .01$) than men ($\beta = 0.11$, $p = .12$). It is possible to comprehend this gender-specific pattern using a bio-psychosocial framework. The shorter intrinsic circadian periods and the modulatory effects of ovarian hormones on clock gene expression may biologically make women's circadian systems more sensitive[13,14]. Psychosocially, the complex matrix of social and domestic responsibilities that women often navigate may exacerbate the stress and emotional impact of an evening orientation in a morning-oriented society[15].

Overall, the results show how clinically useful chronotype assessment is, especially when it comes to women's mental health. The study backs the need for chronobiology-based, gender-informed approaches to emotional health promotion. Despite the limitations of its cross-sectional methodology, this study provides a solid basis for subsequent longitudinal studies that use objective physiological and circadian measurements to prove causation. In summary, it is critical to acknowledge the complex interactions between gender and chrono-biological predispositions in order to create individualized and successful strategies for promoting mental health.

Conclusion

In a Bangladeshi group, this study shows a strong correlation between mood swings and preferences for circadian rhythms. While evening types were associated with worse moods, morning types reported higher levels of happiness. Females had a stronger chronotype–mood association, making gender a significant moderating factor. These results emphasize how gender and chronobiological differences must be taken into account in psychological research and public health initiatives. Future longitudinal research using objective metrics is needed to elucidate causal pathways and guide tailored therapies for regulating circadian rhythms to promote mental health.

Statements

Conflict of Interest

The authors declare no conflict of interest.

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This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data Availability

The datasets generated and analyzed during the current study are not publicly available due to the participant's confidentiality but are available from the corresponding author on reasonable request for academic purpose.

Ethical Considerations

This study was conducted in accordance with the ethical principles for research involving human subjects outlined in the Declaration of Helsinki[20]. The research was designed as a minimal-risk, anonymous online survey that did not collect personally identifiable information. All participants provided digital informed consent before participation, after being informed about the study's purpose, procedures, voluntary nature and right to withdraw at any time. In line with the Institutional Review Board (IRB) of Department of Psychology, University of Dhaka, guidelines for minimal- risk anonymous survey research, formal ethics committee approval was not required. All methods were performed in full adherence to these institutional guidelines and regulations.

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