European Journal of Clinical and Experimental Medicine

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Article type: Original Article

Received: 7 June 2026

Accepted: 21 September 2026

Published online: 13 November 2026

eISSN: 2544-1361

Eur J Clin Exp Med

doi:10.15584/ejcem.2026.4.3

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Comparison of chronotype between women with high-risk and low-risk pregnancies – a cross-sectional study

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ABSTRACT

Introduction and aim. Chronotype reflects an individual's preferred timing of sleep and daily activities and is an important behavioral manifestation of the circadian timing system. This study aimed to determine chronotype characteristics and compare chronotype distributions between women with high- and low-risk pregnancies.

Material and methods. This descriptive cross-sectional study included 214 pregnant women. The study sample consisted of 107 women with high-risk pregnancies and 107 women with low-risk pregnancies. Data were collected using the Pregnancy Identification Form and the Morningness-Eveningness Questionnaire through in-person interviews.

Results. Mean Morningness-Eveningness Questionnaire scores were 46.75±9.77 in the high-risk group and 57.28±8.86 in the low-risk group, and this difference was statistically significant (p=0.001). Chronotype distribution likewise differed by risk status (p=0.001): the evening type was identified in 36.4% of the high-risk group compared with only 5.6% of the low-risk group. In the multivariable logistic regression analysis, higher MEQ scores remained independently associated with lower odds of high-risk pregnancy (adjusted OR=0.890; 95% CI: 0.857–0.925).

Conclusion. Evening chronotype was more common, and MEQ scores were lower, among women with high-risk pregnancies. After adjustment for potential confounders, a higher morningness score remained

associated with lower odds of high-risk pregnancy status. These findings indicate an association between chronotype and pregnancy risk status; however, causal or predictive conclusions cannot be drawn from this cross-sectional design.
Keywords. chronotype, circadian rhythm, high-risk pregnancy, morningness-eveningness, pregnancy

Introduction

Many bodily functions, from the alternation of sleep and wakefulness to the release of hormones, thermoregulation, metabolic activity, and cellular processes, follow rhythms controlled by the circadian system. These internally generated cycles allow the organism to prepare for, and respond to, the regular daily shift between light and darkness, which is essential for preserving homeostasis.[1] Chronotype reflects how circadian rhythms are expressed in behavior and describes whether a person tends to sleep and be active earlier or later in the day. Accordingly, chronotype is commonly categorized as the morning, intermediate, or evening type.[2,3] People with a morning chronotype generally report better mental health and healthier habits, whereas an evening chronotype is more often linked to sleep problems, metabolic and chronic diseases, and other unfavorable health outcomes.[4,5]

A pregnancy is classified as high-risk when one or more maternal or fetal conditions increase the likelihood of adverse maternal or neonatal outcomes and require closer antenatal surveillance.[6,7] The physiological adaptations required during pregnancy depend on the coordinated regulation of metabolic, endocrine, and circadian systems.[8] Increasing evidence suggests that circadian disruption during pregnancy is associated with metabolic disorders and adverse pregnancy outcomes.[9] Studies have shown that pregnant women who work night shifts are at an increased risk of hypertensive disorders, miscarriage, preterm birth, and low birth weight.[10] Circadian disruption, such as that caused by night-shift work, may alter melatonin secretion, thereby impairing placental implantation and fetal development.[11,12] Furthermore, reduced melatonin levels and impaired melatonin receptor activity have been reported in women with high-risk pregnancy.[13] Decreased melatonin concentrations may contribute to recurrent pregnancy loss and complications such as preeclampsia.[14] In addition, melatonin has been proposed as a potential therapeutic approach for improving sleep disturbances during pregnancy.[13]

Although growing evidence has linked circadian disruption and chronotype to individual obstetric complications, it remains unclear whether chronotype differs according to overall pregnancy risk status. Previous studies have predominantly investigated chronotype in relation to specific pregnancy complications, whereas evidence comparing chronotype characteristics according to overall pregnancy risk status remains limited. Therefore, the novelty of the present study lies in the direct comparison of chronotype characteristics between women with a heterogeneous spectrum of high-risk pregnancies and women with low-risk pregnancies.

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Aim

The objective was to examine whether chronotype preferences differ between women with high-risk and low-risk pregnancies and whether pregnancy risk status is related to these preferences. Our hypothesis was that, compared with women with low-risk pregnancies, those with high-risk pregnancies would show a higher proportion of evening chronotype and lower MEQ scores.

Material and methods

Study design

A descriptive, cross-sectional, comparative design was used to examine chronotype in pregnant women according to their pregnancy risk status.

Setting and participants

The research took place in central Kahramanmaraş, in southern Türkiye. Participants were pregnant women attending the obstetrics and gynecology outpatient clinics of Necip Fazıl City Hospital who were assessed as having either a high-risk or a low-risk pregnancy. Participants were recruited using convenience sampling. Pregnant women who attended the outpatient clinics during the study period and met the inclusion criteria were invited to participate, and those who declined were not included in the study.

Power analysis was used to estimate the sample size. Because no previous study comparing MEQ scores between women with high-risk and low-risk pregnancies in Türkiye was identified during the planning stage, the effect size was derived from a national study of pregnant women that used the same scale (exercising: 51.29±7.69; non-exercising: 47.05±9.13).[15] With an effect size of 0.49, α=0.05, and 95% power for an independent-samples t-test, 107 women were required in each group (214 in total).

Definition of high-risk pregnancy

Pregnancy risk status was determined by obstetricians based on routine clinical assessments and hospital records. Women attending the high-risk pregnancy outpatient clinic constituted the high-risk group, whereas those attending the routine antenatal outpatient clinic constituted the low-risk group. Women were classified as having a high-risk pregnancy if they had one or more maternal and/or fetal conditions that required enhanced antenatal surveillance. Each woman in the high-risk group was assigned to only one category according to the principal diagnosis for which she was referred to the high-risk pregnancy outpatient clinic, even if more than one condition was present. Individual diagnoses were grouped into the categories presented in Table 2 as follows: hypertensive disorders of pregnancy (gestational hypertension, chronic hypertension, and preeclampsia); gestational diabetes mellitus; chronic maternal diseases (e.g., thyroid disease and obesity); risk of preterm birth (threatened preterm labor and previous preterm birth); amniotic fluid abnormalities (oligohydramnios and polyhydramnios); antepartum hemorrhage (e.g.,

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placenta previa); infectious diseases; premature rupture of membranes; and other obstetric/medical complications (e.g., fetal growth restriction, Rh incompatibility, multiple pregnancy, and recurrent pregnancy loss). Women without any diagnosed maternal or fetal obstetric or medical complications during the current pregnancy were classified as having low-risk pregnancies.

Inclusion criteria

High-risk pregnancy group

Pregnant women were included in this group if they:

- were 18 years of age or older,
- were able to read and communicate in Turkish.
- voluntarily agreed to participate in this study.
- had no diagnosed psychiatric disorders or cognitive impairments that would interfere with completing the questionnaires.
- were diagnosed with high-risk pregnancy according to the predefined clinical criteria.

Low-risk pregnancy group

Pregnant women included in this group were required to meet the following conditions:

- were 18 years of age or older,
- were able to read and communicate in Turkish.
- voluntarily agreed to participate in this study.
- had no diagnosed psychiatric disorders or cognitive impairments that would interfere with completing the questionnaires.
- had no maternal or fetal obstetric or medical complications during their current pregnancy.

Exclusion criteria

Pregnant women who declined to participate, were unable to complete the questionnaires, or had incomplete questionnaire data were excluded from the study.

Data collection instruments

Pregnancy identification form

The Pregnancy Identification Form was developed by the researchers after reviewing the relevant literature.[5-7] The questionnaire consisted of two sections. The first section included 13 questions related to the participants' sociodemographic characteristics, and the second section included 10 questions that assessed obstetric characteristics. Planned pregnancy was defined as a pregnancy that had been planned before conception, whereas wanted pregnancy referred to whether the woman wanted the current pregnancy, regardless of whether it had been planned. Thus, an unplanned pregnancy could still be wanted.

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Morningness-Eveningness Questionnaire (MEQ)

The MEQ, developed by Horne and Östberg[16] and adapted into Turkish by Pündük et al., was used to determine chronotype. This 19-item instrument yields total scores between 16 and 86.[17] Scores of 16–41, 42–58, and 59–86 correspond to evening, intermediate, and morning chronotypes, respectively; higher totals reflect a stronger morning orientation and lower totals a stronger evening orientation. Cronbach's alpha was 0.81 for the Turkish version[17] and 0.86 in the present study, indicating good reliability.

Data collection

Data was collected between May 2024 and December 2024. After written informed consent was obtained, the researchers interviewed each participant in person at the outpatient clinics; each interview took approximately 10–15 minutes.

Statistical analysis

All analyses were carried out using IBM SPSS Statistics for Windows, version 23.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics comprised the mean±standard deviation (SD) for numerical variables and frequency with percentage for categorical ones. Skewness and kurtosis values were examined to check for normal distribution. The two groups were compared with the independent-samples t-test for numerical variables, whereas Pearson's chi-square or Fisher's exact test was applied to categorical variables according to the characteristics of the data. Cohen's d effect sizes, along with their 95% confidence intervals (CIs), were calculated for significant comparisons.

To assess whether chronotype was independently associated with high-risk pregnancy status after controlling for possible confounders, a multivariable binary logistic regression analysis was performed. Sociodemographic and obstetric variables considered potentially relevant to pregnancy risk status (maternal age, gestational week, number of pregnancies, miscarriages, living children, and births, smoking status, wanted pregnancy, planned pregnancy, regular antenatal care, and income status) were entered into the model together with the MEQ score. High-risk pregnancy status was coded as 1 and low-risk pregnancy as 0. "No" served as the reference group for dichotomous variables, and "income lower than expenditure" served as the reference group for income status. Adjusted odds ratios (ORs) and their 95% CIs are reported. Model fit was evaluated with the Omnibus test of model coefficients, the Hosmer–Lemeshow test, the −2 log-likelihood value, and the Cox and Snell and Nagelkerke R^2 statistics. Two-sided p values <0.05 were regarded as statistically significant.

Ethical considerations

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The study protocol was approved by the Clinical Research Ethics Committee of Kahramanmaraş Sütçü İmam University (Decision No. 2024/11-04, Date: April 22, 2024), and permission to collect data was granted by the Kahramanmaraş Provincial Health Directorate. Every participant gave written informed consent before taking part. The research was carried out in line with the Declaration of Helsinki.

Results

The two groups did not differ significantly in education, place of residence, family type, occupation, spouse's education and occupation, or smoking status ($p>0.05$). Income distribution, however, differed significantly between the high- and low-risk groups ($p=0.008$). No participant in either group reported alcohol use (Table 1).

Table 1. Selected characteristics of pregnant women according to pregnancy risk status[a]

	High-risk pregnancy n (%)	**Low-risk pregnancy n (%)**	**Total**	**p**
Education level				
Illiterate	4 (3.7)	3 (2.8)	7 (3.3)	
Primary school	20 (18.7)	14 (13.1)	34 (15.9)	$\chi2=4.98$*
Middle school	37 (34.6)	28 (26.2)	65 (30.4)	p=0.289
High school	25 (23.4)	36 (33.6)	61 (28.1)	
University	21 (19.6)	26 (24.3)	47 (22.0)	
Total	107 (100.0)	107 (100.0)	214 (100.0)	
Current place of residence				
Province	54 (50.5)	53 (49.5)	107 (50.0)	$\chi2=0.914$**
District	37 (34.6)	33 (30.8)	70 (32.7)	p=0.633
Village	16 (15.0)	21 (19.7)	37 (17.3)	
Total	107 (100.0)	107 (100.0)	214 (100.0)	
Family type				
Nuclear family	75 (70.1	83 (77.6)	158 (73.8)	$\chi2=1.548$**
Extended family	32 (29.9)	24 (22.4)	56 (26.2)	p=0.213
Total	107 (100.0)	107 (100.0)	214 (100.0)	
Occupation				
Housewife	93 (86.9)	93 (86.9)	186 (86.9)	$\chi2=5.902$*
Worker	2 (1.9)	0 (0.0)	2 (0.9)	p=0.116

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Officer	8 (7.5)	13 (12.1)	21 (9.8)	
Other	4 (3.7)	1 (0.9)	5 (2.4)	
Total	107 (100.0)	107 (100.0)	214 (100.0)	
Spouse's education level				
Illiterate	1 (0.9)	0 (0.0)	1 (0.5)	$\chi 2=2.680$*
Primary school	20 (18.7)	15 (14.0)	35 (16.4)	p=0.613
Middle school	27 (25.2)	31 (29.0)	58 (27.1)	
High school	37 (34.6)	41 (38.3)	78 (36.4)	
University	22 (20.6)	20 (18.7)	42 (19.6)	
Total	107 (0.0)	107 (100.0)	214 (100.0)	
Spouse's occupation				
Worker	60 (56.1)	64 (59.8)	124 (57.9)	$\chi 2=0.912$**
Officer	12 (11.2)	14 (13.1)	26 (12.1)	p=0.823
Self-employment	24 (22.4)	19 (17.8)	43 (20.1)	
Other	11 (10.3)	10 (9.3)	21 (9.8)	
Total	107 (100.0)	107 (100.0)	214 (100.0)	
Income status				
Income lower than expenditure	26 (24.3)	25 (23.4)	51 (23.8)	$\chi 2=9.588$**
Income matches expenditure	78 (72.9)	67 (62.6)	145 (67.8)	p=0.008
Income more than expenditure	3 (2.8)	15 (14.0)	18 (8.4)	
Total	107 (100.0)	107 (100.0)	214 (100.0)	
Smoking				
Yes	12 (11.2)	10 (9.3)	22 (10.3)	$\chi 2=0.203$**
No	95 (88.8)	97 (90.7)	192 (89.7)	p=0.822
Total	107 (100.0)	107 (100.0)	214 (100.0)	

[a] * – Fisher's exact test, ** – Pearson's chi-square test

The clinical characteristics of the women with high-risk pregnancies are presented in Table 2. Hypertensive disorders of pregnancy were the most common clinical condition (20.6%), followed by gestational diabetes mellitus (17.8%), chronic maternal diseases (15.0%), other obstetric/medical complications (14.0%), and

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risk of preterm birth (13.1%). The remaining participants were classified as having amniotic fluid abnormalities (6.5%), antepartum hemorrhage (5.6%), infectious diseases (4.7%), or premature rupture of membranes (2.8%) (Table 2).

Table 2. Clinical characterization of the high-risk pregnancy group

Clinical characteristics	**n**	**%**
Hypertensive disorders of pregnancy	22	20.6
Gestational diabetes mellitus	19	17.8
Chronic maternal diseases	16	15.0
Other obstetric/medical complications	15	14.0
Risk of preterm birth	14	13.1
Amniotic fluid abnormalities	7	6.5
Antepartum hemorrhage	6	5.6
Infectious diseases	5	4.7
Premature rupture of membranes	3	2.8
Total	107	100

No significant differences emerged between the two pregnancy risk groups in terms of wanted pregnancy or regular antenatal care ($p>0.05$). Planned pregnancies were reported by 71.0% of the high-risk pregnancy group versus 84.1% of the low-risk pregnancy group ($p=0.032$). The two groups also showed a significant difference in chronotype ($p<0.001$). Evening chronotype accounted for 36.4% of the high-risk pregnancy group but only 5.6% of the low-risk pregnancy group, while morning chronotype was identified in 45.8% and 20.6% of the low- and high-risk pregnancy groups, respectively (Table 3).

Table 3. Comparison of obstetric parameters and chronotype between women with low- and high-risk pregnancies[a]

	High-risk pregnancy n (%)	**Low-risk pregnancy n (%)**	**Total**	**p**
Pregnancy trimester				
1st trimester	14 (13.1)	5 (4.7)	19 (8.9)	$\chi2=9.540$*
2nd trimester	29 (27.1)	18 (16.8)	47 (22.0)	p=0.008
3rd trimester	64 (59.8)	84 (78.5)	148 (69.1)	
Total	107 (100.0)	107 (100.0)	214 (100.0)	

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Wanted pregnancy				
Yes	94 (87.9)	96 (89.7)	190 (88.8)	$\chi 2$=0.188*
No	13 (12.1)	11 (10.3)	24 (11.2)	p=0.829
Total	107 (100.0)	107 (100.0)	214 (100.0)	
Planned pregnancy				
Yes	76 (71.0)	90 (84.1)	166 (77.6)	$\chi 2$=5.264*
No	31 (29.0)	17 (15.9)	48 (22.4)	p=0.032
Total	107 (100.0)	107 (100.0)	214 (100.0)	
Regular antenatal care				
Yes	103 (96.3)	101 (94.4)	204 (95.3)	$\chi 2$=0.420**
No	4 (3.7)	6 (5.6)	10 (4.7)	p=0.748
Total	107 (100.0)	107 (100.0)	214 (100.0)	
Chronotype				
Evening type	39 (36.4)	6 (5.6)	45 (21.0)	
Intermediate type	46 (43.0)	52 (48.6)	98 (45.8)	$\chi 2$=34.835*
Morning type	22 (20.6)	49 (45.8)	71 (33.2)	p=0.001
Total	107 (100.0)	107 (100.0)	214 (100.0)	

[a] * – Fisher's exact test, ** – Pearson's chi-square test

Sociodemographic, obstetric, and chronotype scores of the two groups are compared in Table 4. Maternal age, spouse's age, duration of marriage, gestational week, and MEQ scores differed significantly between the groups ($p<0.05$). Women with high-risk pregnancies were significantly older (29.07±6.61 vs. 27.24±6.10 years; Cohen's d=0.29; p=0.037). Their spouses were also older (33.43±7.15 vs. 31.03±6.11 years; Cohen's d=0.36; p=0.009), and their duration of marriage was longer (7.89±6.66 vs. 6.13±5.28 years; Cohen's d=0.29; p=0.033); all of these effect sizes were small. Mean gestational week was greater in the low-risk group than in the high-risk group (32.28±8.08 vs. 28.10±10.45; Cohen's d=−0.45; p=0.001), corresponding to a small-to-moderate effect. The groups were comparable in the number of pregnancies (Cohen's d=0.08; p=0.554), miscarriages (Cohen's d=0.06; p=0.642), living children (Cohen's d=0.09; p=0.496), and births (Cohen's d=0.07; p=0.593), with negligible effect sizes. The mean MEQ score was significantly lower in women with high-risk pregnancies than in those with low-risk pregnancies (46.75±9.77 vs. 57.28±8.86; Cohen's d=−1.13; $p<0.001$), indicating a large effect size. Overall, high-risk pregnancy status was associated with differences in age-related characteristics, gestational week, and particularly lower MEQ scores.

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Table 4. Comparison of selected characteristics and mean MEQ scores between women with low- and high-risk pregnancies*

Variables	High-risk pregnancy (Mean±SD)	Low-risk pregnancy (Mean±SD)	Cohen's d	95% CI	p*
Age (years)	29.07±6.61	27.24±6.10	0.29	0.02 to 0.56	0.037
Spouse's age (years)	33.43±7.15	31.03±6.11	0.36	0.09 to 0.63	0.009
Duration of marriage (years)	7.89±6.66	6.13±5.28	0.29	0.02 to 0.56	0.033
Gestational week	28.10±10.45	32.28±8.08	-0.45	-0.72 to -0.18	0.001
Number of pregnancies	2.73±1.81	2.59±1.64	0.08	-0.19 to 0.35	0.554
Number of miscarriages	0.40±0.69	0.35±0.76	0.06	-0.20 to 0.33	0.642
Number of living children	1.39±1.55	1.31±1.24	0.09	-0.18 to 0.36	0.496
Number of births	1.42±1.55	1.31±1.24	0.07	-0.20 to 0.34	0.593
MEQ score	46.75±9.77	57.28±8.86	-1.13	-1.42 to -0.84	0.001

* SD – standard deviation, CI – confidence interval, MEQ – Morningness-Eveningness Questionnaire, independent-samples t-test

The multivariable binary logistic regression model was statistically significant (Omnibus $\chi^2(13)=80.526$, $p<0.001$) and explained 31.4% (Cox and Snell R^2) to 41.8% (Nagelkerke R^2) of the variance in high-risk pregnancy status. A non-significant Hosmer–Lemeshow test ($\chi^2(8)=11.168$, $p=0.192$) indicated adequate calibration. The model converged after five iterations (−2 log-likelihood=216.141), and the overall classification accuracy was 77.1%. MEQ score remained independently associated with high-risk pregnancy status after adjustment for the variables included in the model (B=−0.116, SE=0.019, Wald=36.267; adjusted OR=0.890; 95% CI: 0.857–0.925; $p<0.001$). Each one-point higher MEQ score was associated with 11.0% lower odds of high-risk pregnancy status; however, given the cross-sectional design, this finding reflects an association and should not be interpreted as indicating that increasing the MEQ score would reduce pregnancy risk. Gestational week was also independently associated with high-risk pregnancy status (B=−0.043, SE=0.019, Wald=5.033, $p=0.025$), with each additional week associated with 4.2% lower odds (adjusted OR=0.958; 95% CI: 0.923–0.995). Women with planned pregnancies had 68.5% lower odds of high-risk pregnancy status than those with unplanned pregnancies (B=−1.156, SE=0.530, Wald=4.760, $p=0.029$; adjusted OR=0.315; 95% CI: 0.111–0.889).

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Age was not independently associated with high-risk pregnancy status (B=0.041, SE=0.035, Wald=1.374, p=0.241; adjusted OR=1.042; 95% CI: 0.973–1.116). Likewise, the number of pregnancies (p=0.778), miscarriages (p=0.723), living children (p=0.815), and births (p=0.671), as well as smoking status (p=0.614), wanted pregnancy (p=0.218), regular antenatal care (p=0.762), and income equal to expenses (p=0.912), were not significantly associated with high-risk pregnancy status. Income higher than expenses showed a borderline association (B=1.613, SE=0.828, Wald=3.793, p=0.051; adjusted OR=5.017; 95% CI: 0.990–25.431); however, this association was not statistically significant because the confidence interval included 1.00 (Table 5).

Table 5. Multivariable logistic regression analysis of factors associated with high-risk pregnancy*

Variables	B	SE	Wald	p	Adjusted OR (95% CI)
Smoking (Yes)	0.277	0.550	0.255	0.614	1.320 (0.449–3.875)
Wanted pregnancy (Yes)	−0.775	0.629	1.519	0.218	0.461 (0.134–1.581)
Regular antenatal care (Yes)	−0.304	1.004	0.092	0.762	0.738 (0.103–5.276)
Planned pregnancy (Yes)	−1.156	0.530	4.760	0.029	0.315 (0.111–0.889)
Income equal to expenses (Yes)	0.045	0.409	0.012	0.912	1.046 (0.470–2.332)
Income higher than expenses (Yes)	1.613	0.828	3.793	0.051	5.017 (0.990–25.431)
MEQ score	−0.116	0.019	36.267	<0.001	0.890 (0.857–0.925)
Age (years)	0.041	0.035	1.374	0.241	1.042 (0.973–1.116)
Gestational week	−0.043	0.019	5.033	0.025	0.958 (0.923–0.995)
Number of pregnancies	−0.160	0.567	0.079	0.778	0.852 (0.280–2.592)
Number of miscarriages	0.208	0.585	0.126	0.723	1.231 (0.391–3.873)
Number of living children	−0.206	0.882	0.055	0.815	0.814 (0.144–4.585)
Number of births	0.348	0.817	0.181	0.671	1.416 (0.285–7.027)

* B – regression coefficient, SE – standard error, OR – odds ratio, CI – confidence interval, MEQ – Morningness-Eveningness Questionnaire, model fit: the multivariable logistic regression model was statistically significant (Omnibus $\chi^2(13)=80.526$, $p<0.001$), the model explained 31.4% of the variance according to the Cox and Snell R^2 and 41.8% according to the Nagelkerke R^2, model calibration was adequate, as indicated by the non-significant Hosmer–Lemeshow goodness-of-fit test ($\chi^2(8)=11.168$, $p=0.192$), the final model converged after five iterations, with a −2 log likelihood of 216.141. The overall classification accuracy of the model was 77.1%

Discussion

High-risk pregnancy is a major obstetric condition in which biological, psychological, and physiological changes endanger the mother and fetus and raise morbidity and mortality. Physiological conditions that

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render a pregnancy high-risk may arise from chronic diseases present before pregnancy or from pregnancy-related complications such as preeclampsia, eclampsia, hemorrhage, hypertension, and gestational diabetes mellitus (GDM).[18] Chronotype may play a role in how the body adapts physiologically and metabolically to pregnancy. Some authors have proposed that when a woman's chronotype is poorly aligned with the metabolic needs of pregnancy, the timing of physiological and metabolic processes may be disturbed, potentially leading to adverse outcomes; this possible mechanism could not be tested with our data.[19–21]

Our data showed lower MEQ scores in the high-risk pregnancy group than in the low-risk pregnancy group ($p<0.001$), a difference that remained evident when potential confounders were taken into account (adjusted OR=0.890; 95% CI: 0.857–0.925). In line with this finding, evening chronotype was observed more frequently among women whose pregnancies were classified as high-risk. Nevertheless, caution is needed in deciding which factor precedes the other. Because chronotype and pregnancy risk status were assessed at the same time, reverse causality cannot be excluded. A high-risk pregnancy itself, together with its associated symptoms, hospitalization or increased medical surveillance, psychological burden, altered daily routines, reduced physical activity, and sleep disturbances, may shift sleep–wake behavior and thereby lower MEQ scores. Thus, the observed association may reflect an effect of pregnancy risk on chronotype-related behavior, an influence of chronotype on pregnancy risk, or both. Moreover, the high-risk group was clinically heterogeneous, and the association may be driven more strongly by some conditions than by others; the present sample size did not allow sufficiently powered condition-specific analyses. Similarly, a study of 313 pregnant women in Türkiye found poorer sleep quality and a significantly higher proportion of evening chronotype among women with preeclampsia or preterm labor than among those with low-risk pregnancies.[22]

Circadian disruption has been associated with metabolic imbalance,[23] and previous studies have linked an evening chronotype to a higher risk of GDM, including approximately 2.5-fold higher odds in the second trimester.[24,25] In women diagnosed with GDM, evening chronotype has further been related to poor sleep quality, symptoms of depression, preeclampsia, admission of the newborn to intensive care, and hypertensive disorders.[20,26,27] Researchers have explained these links through circadian control of hormone release, metabolic activity, and the sleep–wake cycle; however, we could not evaluate such mechanisms.[28] Light exposure may represent one possible pathway: excessive artificial light at night and insufficient daylight may shift sleep timing toward an evening preference,[29] and prospective studies have reported that greater presleep light exposure and outdoor artificial light at night are linked to increased GDM risk.[30,31] Because our study did not measure light exposure, this pathway should be regarded as speculative.

Overall, 21% of the participants had an evening chronotype; this proportion reached 36.4% among women with high-risk pregnancies, compared with 5.6% among those with low-risk pregnancies ($p<0.001$). A similar rate of roughly one-quarter was found in research involving 1,796 pregnant women, where those with an evening chronotype more often experienced anxiety and post-traumatic stress disorder.[32]

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Evening chronotype has additionally been linked to poorer perinatal mental health, while women with a consistently morning-oriented chronotype tend to report greater psychological well-being both before and after childbirth.[33] Recent reviews have further linked an evening chronotype, short sleep, late-night eating, and night-shift work to GDM risk and have suggested that meal timing adapted to chronotype may be a promising area for future research in GDM management.[34,35]

Pooled data from 62 studies have also shown that pregnant women working rotating shifts experience more preterm births, low-birth-weight infants, preeclampsia, and gestational hypertension,[36] whereas working at night has been tied to pregnancy loss, prematurity, and low birth weight.[37] Since information on shift work was not collected from our participants, we could not determine whether it contributed to the association observed here.

In conclusion, unlike earlier work that concentrated on single obstetric complications, this study evaluated chronotype in a heterogeneous high-risk pregnancy population and compared it with a low-risk pregnancy group. Our results, however, do not show that chronotype is a risk factor for high-risk pregnancy. One may hypothesize that women with an evening chronotype are more vulnerable to physical and psychological stressors and that those with a morning chronotype adapt more favorably in physiological terms; neither possibility was tested here. Owing to the cross-sectional nature of the data, cause-and-effect conclusions cannot be drawn, and prospective longitudinal studies are required to clarify whether chronotype precedes later pregnancy outcomes.

Study limitations

This study has several limitations. First, because all participants were recruited at one center in Türkiye, the results may not be applicable to other populations or healthcare settings. Chronotype may also be influenced by cultural and environmental factors, including dietary patterns, social norms, work schedules, and daylight exposure, which may vary between populations. Accordingly, multicenter and cross-cultural research is required before wider clinical conclusions are drawn. Second, the cross-sectional nature of the data prevents conclusions about causality or about which variable came first, so reverse causality remains possible. Third, chronotype was determined from participants' own answers to the MEQ; such self-reports are open to response and recall errors and do not objectively confirm circadian rhythms. Likewise, obstetric history, including the number and timing of earlier miscarriages and whether the pregnancy had been planned, relied on participants' recall and may therefore be inaccurate. In addition, some medical conditions included in the high-risk pregnancy classification, such as thyroid disease, may have been present before pregnancy or developed during pregnancy; however, their timing and clinical characteristics were not systematically assessed, preventing us from distinguishing pre-existing factors potentially associated with chronotype from conditions that emerged during pregnancy. Moreover, the high-risk pregnancy group comprised a heterogeneous range of obstetric and medical conditions that may have different effects on

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chronotype and sleep patterns. Given the limited sample size within individual clinical subgroups, reliable subgroup analyses were not feasible; therefore, this heterogeneity should be considered when interpreting these findings. Data on potentially relevant lifestyle factors, such as shift work, diet, and physical activity, were not collected in a structured way, so these factors could not be added to the multivariable model. Furthermore, we did not formally test for multicollinearity among the obstetric history variables entered into the regression, and their estimates should therefore be read cautiously. Lastly, no validated instrument (e.g., the Pittsburgh Sleep Quality Index) was used to measure sleep quality, and sleep and circadian function were not objectively evaluated through actigraphy, polysomnography, or circadian biomarkers such as melatonin or cortisol rhythms. These limitations prevented the objective validation of self-reported chronotypes and limited our ability to distinguish chronotype characteristics from broader sleep and circadian disturbances. Future multicenter prospective research should include standardized sleep questionnaires together with objective assessment of sleep, circadian function, and light exposure.

Conclusion

The present study revealed significant differences in chronotype characteristics according to pregnancy risk status. Compared with women with low-risk pregnancies, those with high-risk pregnancies had lower MEQ scores and more frequently had an evening chronotype, and the MEQ score remained independently linked to high-risk pregnancy status in the multivariable analysis. These results broaden earlier observations, which were largely limited to single pregnancy complications, by showing an association across a wider range of high-risk pregnancies. Nevertheless, given the cross-sectional design and the clinical diversity of the high-risk group, it is not possible to establish whether this relationship is temporal or causal.

Multicenter prospective research using objective assessments of sleep and circadian function is needed to clarify whether chronotype has prognostic or clinical value in antenatal care.

Declarations

Funding

The authors received no financial support for this study.

Author contributions

Conceptualization, F.Y.F. and E.D.İ.; Methodology, E.D.İ.; Validation, F.Y.F., E.D.İ. and R.S.D.; Formal Analysis, E.D.İ.; Investigation, F.Y.F; Resources, F.Y.F. and E.D.İ.; Data Curation, E.D.İ.; Writing – Original Draft Preparation, F.Y.F., E.D.İ. and R.S.D.; Writing – Review & Editing, F.Y.F., E.D.İ. and R.S.D.; Visualization, E.D.İ.; Supervision, F.Y.F.; Project Administration, F.Y.F.

Conflicts of interest

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The authors declare no conflict of interest.

Data availability

All data are available within the manuscript.

Ethics approval

The study adhered to the principles of the Declaration of Helsinki and received approval from the Clinical Research Ethics Committee of Kahramanmaraş Sütçü İmam University (Decision No. 2024/11-04, Date: April 22, 2024).

Use of AI and AI-assisted technologies in the writing process

The language of the manuscript was edited with the help of AI-based tools. All authors checked the edited text and are fully accountable for its content.

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