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Original Research Article

Association of chronotype with glycemic control, sleep patterns and meal timings among adults with type 2 diabetes mellitus

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ABSTRACT

Background: Type 2 Diabetes Mellitus (T2DM) is a major public health concern, with lifestyle factors such as chronotype potentially influencing glycemic control and daily behavioral patterns. The present study aimed to assess the association of chronotype with glycemic control, sleep patterns, and meal timings among adults with type 2 diabetes mellitus.
Methods: A hospital-based cross-sectional study was conducted among 100 adults with T2DM attending Yashoda Hospital, Malakpet, Hyderabad. Data were collected using a structured questionnaire, clinical records, and the Reduced Morningness-Eveningness Questionnaire (rMEQ). Glycemic control was assessed using fasting blood glucose (FBG), postprandial blood glucose (PPBG), and glycated haemoglobin (HbA1c). One-way analysis of variance (ANOVA) and Chi-square tests were used for statistical analysis, with $p<0.05$ considered statistically significant.
Results: The intermediate chronotype was the most prevalent (49%), followed by the evening chronotype (28%) and morning chronotype (23%). The mean HbA1c was highest among participants with the evening chronotype (8.257±1.641%) and lowest among those with the morning chronotype (7.617±0.780%); however, the difference was not statistically significant ($p=0.242$). Similarly, no significant associations were observed between chronotype and FBG ($p=0.962$) or PPBG ($p=0.725$). Significant associations were observed between chronotype and wake-up time ($p<0.001$), bedtime ($p<0.001$), lunch timing ($p=0.013$), and dinner timing ($p=0.004$). No significant associations were observed with breakfast timing ($p=0.089$), sleep duration ($p=0.640$), sleep quality ($p=0.109$), or BMI ($p=0.229$).
Conclusions: Chronotype was significantly associated with certain daily behavioral patterns, particularly wake-up time, bedtime, lunch timing, and dinner timing, but was not significantly associated with glycemic control in the study population.

Keywords: Chronotype, Glycemic control, HbA1c meal timings, Sleep patterns, Type 2 diabetes mellitus

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a major global public health concern characterized by chronic hyperglycemia resulting from insulin resistance, impaired insulin secretion, or both. It is the most common form of diabetes and accounts for approximately 90-95% of diabetes cases worldwide. The prevalence of T2DM has increased substantially over recent decades, particularly in low- and middle-income countries, with urbanization, sedentary lifestyles, dietary patterns, obesity and other lifestyle-related factors contributing to the growing burden.[1,2]

In addition to conventional metabolic and lifestyle factors, increasing evidence suggests that the timing of daily behaviours may influence metabolic health. The circadian system regulates approximately 24-hour rhythms in physiological processes including sleep–wake behaviour, feeding and metabolism. Chronotype describes an individual's preference for the timing of sleep and wakefulness and is generally classified as morning, intermediate or evening type. Differences in chronotype may influence sleep schedules, activity patterns and the timing of food intake.[3]

The relationship between chronotype and glycemic control has been investigated in individuals with T2DM. A later chronotype has been associated with poorer glycemic control, including higher HbA1c levels, and the distribution of energy intake across the day may partly contribute to this relationship.[4] However, findings across studies have not been entirely consistent. Some studies have reported higher fasting blood glucose and HbA1c among individuals with an evening chronotype, whereas other investigations have not found significant associations between late chronotype and glycemic measures.[5,6] These differences indicate the need for further investigation across different populations and clinical settings.

Meal timing is another component of chrononutrition that may interact with chronotype and metabolic health. Glucose tolerance and insulin sensitivity exhibit circadian variation, and the timing of food intake may therefore influence postprandial glucose regulation.[7] Individuals with an evening preference may be more likely to follow delayed eating schedules. Among adults with T2DM, later breakfast timing has been associated with evening preference and higher BMI, with breakfast timing partly explaining the relationship between chronotype and BMI.[8] Research has also suggested that a greater proportion of energy intake later in the day may be associated with less favourable metabolic outcomes.[9]

Sleep is closely linked to circadian rhythms and metabolic regulation. Short sleep duration, poor sleep quality and circadian misalignment have been associated with impaired insulin sensitivity and adverse glucose metabolism.[10,11] Sleep disturbances are also common among individuals with T2DM and may interact with other lifestyle factors affecting glycemic control.

Although chronotype, glycemic control, sleep and meal timing have each been examined previously, studies assessing these factors together remain limited, particularly among Indian adults with T2DM.

Therefore, the present study aimed to assess the association of chronotype with glycemic control, sleep patterns and meal timings among adults with T2DM.

METHODS

Study design

A hospital-based cross-sectional observational study was conducted using a structured questionnaire, along with clinical and anthropometric assessments. No intervention was administered.

Study settings

The study was conducted in May 2026 at Yashoda Hospital, Malakpet, Hyderabad, Telangana, India. Participants were recruited from patients attending the outpatient Endocrinology department and patients consulting General Physician during their routine hospital visits. Following informed consent, the structured questionnaire was administered through direct interviews, and participants' responses were recorded. Clinical and anthropometric data were collected during the same visit.

Inclusion criteria

Adults aged 18 years and above diagnosed with type 2 diabetes mellitus were eligible for participation. Participants of both genders were included.

Exclusion criteria

Individuals with type 1 diabetes mellitus, gestational diabetes mellitus, those engaged in shift work, and pregnant or lactating women were excluded.

Participants who met the eligibility criteria and agreed to participate were recruited using convenience sampling. A total of 100 participants were included in the study. The sample size of 100 was determined based on convenience and feasibility during the study period. All recruited participants provided informed consent and completed the study questionnaire.

Study outcomes

The primary exposure variable was chronotype, assessed using the Reduced Morningness-Eveningness Questionnaire (rMEQ) and classified into morning, intermediate, and evening chronotypes.[12] Glycemic control was assessed as the primary outcome using glycated haemoglobin (HbA1c), with fasting blood glucose (FBG) and postprandial blood glucose (PPBG) also recorded. Other variables assessed included age, gender, duration of diabetes, family history of diabetes, current diabetes treatment, height, weight, body mass index (BMI), bedtime, wake-up time, breakfast, lunch and dinner timings, sleep duration, and sleep quality.

Data sources/measurement

Height and weight were measured using a weighing machine and stadiometer, respectively. Body mass index

(BMI) was calculated as weight in kilograms divided by height in metres squared (kg/m²). Clinical parameters including fasting blood glucose (FBG), postprandial blood glucose (PPBG), and glycated haemoglobin (HbA1c) were obtained from the patients' clinical reports available during their hospital visit, using the most recent available values. Information regarding age, gender, duration of diabetes, family history of diabetes, current diabetes treatment, bedtime, wake-up time, meal timings, sleep duration, and sleep quality was collected using the structured questionnaire.

Chronotype was assessed using the Reduced Morningness-Eveningness Questionnaire (rMEQ), consisting of five questions. The questions were administered through direct interviews, and scores were assigned according to the established scoring system. Based on the total rMEQ score, participants were classified into morning, intermediate, or evening chronotype groups.

To minimise potential selection and measurement bias, the same predefined inclusion and exclusion criteria were applied to all participants. Data were collected using the same structured questionnaire and the same questions were administered to all participants through direct interviews. Clinical parameters were obtained consistently from the most recent available clinical reports for each participant. Chronotype was assessed using the same Reduced Morningness–Eveningness Questionnaire and scoring system for all participants. Anthropometric measurements were obtained using standard measurement equipment and procedures.

Study size

A total of 100 participants were included in the study. The sample size was determined based on convenience and feasibility of participant recruitment during the study period.

Quantitative variables

Age, duration of diabetes, height, weight, FBG, PPBG, HbA1c, and sleep duration were recorded as quantitative variables without categorisation. BMI was categorised according to the Asian BMI classification.[13] Wake-up time, bedtime, and breakfast, lunch, and dinner timings were categorised for analysis.

Statistical tools and methods

Data were initially organised and entered in Microsoft Excel and subsequently analysed using JASP statistical software. Quantitative variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Associations between categorical variables were assessed using the chi-square test. One-way analysis of variance (ANOVA) was used to compare mean HbA1c levels across the three chronotype groups. A p-value <0.05 was considered statistically significant.

Ethical considerations

Written informed consent was obtained from all participants before data collection. Participants were informed about the purpose and procedures of the study, and participation was voluntary. Confidentiality of the information collected from participants was maintained throughout the study.

RESULTS

Of the 100 participants, 49% were classified as having an intermediate chronotype, followed by 28% with an evening chronotype and 23% with a morning chronotype (Figure 1).

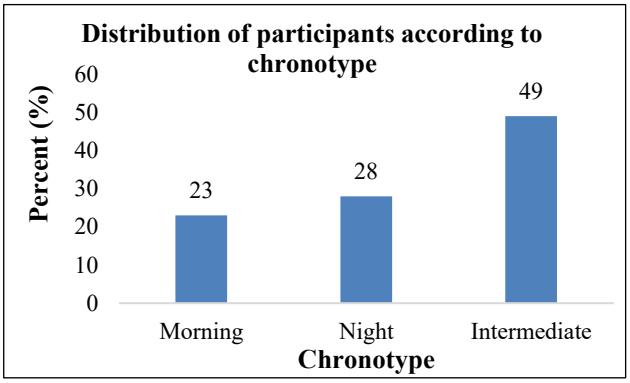


Figure 1: Distribution of participants according to chronotype (n=100).

The study included 52% male and 48% female participants. Most participants had primary-level education (45%) and were engaged in sedentary occupations (88%). The majority belonged to the middle socioeconomic group (86%) (Table 1).

Table 1: Sociodemographic characteristics of study participants (n=100).

Variables	Categories	Number (%)
Gender	Male	52 (52.0)
	Female	48 (48.0)
Educational status	No formal education	7 (7.0)
	Primary	45 (45.0)
	Secondary	25 (25.0)
	Graduate	19 (19.0)
	Postgraduate	4 (4.0)
Type of occupation	Sedentary work	88 (88.0)
	Moderate work	11 (11.0)
	Heavy work	0 (0.0)
Socioeconomic status	Low	7 (7.0)
	Middle	86 (86.0)
	High	7 (7.0)

A family history of diabetes was reported by 75% of participants. Most participants were receiving oral hypoglycemic agents (86%), while 6% were receiving insulin therapy and 8% were receiving both. Regarding BMI classification, 41% were classified as obese I and 31% as obese II. Diabetes-related complications were reported in 15% of participants, with neuropathy being most frequently reported complication (10%) (Table 2).

Table 2: Clinical and anthropometric characteristics of study participants (n=100).

Variables	Categories	Number (%)
Family history of diabetes	Yes	75 (75.0)
	No	25 (25.0)
Current treatment	Oral hypoglycemic agents	86 (86.0)
	Insulin therapy	6 (6.0)
	Both	8 (8.0)
BMI classification	Normal	11 (11.0)
	Overweight	17 (17.0)
	Obese I	41 (41.0)
	Obese II	31 (31.0)
Diabetes-related complications	Nephropathy	2 (2.0)
	Retinopathy	3 (3.0)
	Neuropathy	10 (10.0)
	None	85 (85.0)

Most participants reported waking between 5 and 7 a.m. (51%), while bedtime was most commonly between 11 p.m. and 1 a.m. (46%). Breakfast was predominantly consumed between 8 and 10 a.m. (57%), while 83% reported having lunch between 1 and 3 p.m. and 69% reported having dinner between 8 and 10 p.m. Most participants reported never skipping meals (77%). The majority were sedentary (90%) and non-vegetarian (74%). Regarding lifestyle behaviours, 12% reported smoking and 13% reported alcohol consumption, while 28% reported junk-food consumption and 52% reported between-meal snacking (Table 3).

Sleep duration ranged from 4 to 11 hours, with 7 hours being the most reported duration (34%), followed by 8 hours (27%). Regarding sleep quality, 42% of participants reported good sleep quality, while 33% reported average and 25% reported poor sleep quality (Table 4).

Mean FBG and PPBG levels were comparable across the three chronotype groups, with no statistically significant differences observed for FBG ($F=0.038$, $p=0.962$) or PPBG ($F=0.322$, $p=0.725$). Mean HbA1c was highest among participants with an evening chronotype ($8.257\pm1.641\%$) and lowest among those with a morning chronotype ($7.617\pm0.780\%$); however, the difference was not statistically significant ($F=1.439$, $p=0.242$) (Table 5).

Wake-up time and bedtime showed statistically significant associations with chronotype ($p<0.001$), whereas sleep duration and sleep quality were not significantly associated with chronotype ($p=0.640$ and $p=0.109$, respectively) (Table 6).

Table 3: Lifestyle and meal-timing patterns of study participants (n=100).

Variables	Categories	Number (%)
Wake- up time	Before 5:00 am	11 (11.0)
	5:00-7:00 am	51 (51.0)
	7:00-9:00 am	35 (35.0)
	After 9:00 am	3 (3.0)
Bedtime	Before 9:00 pm	2 (2.0)
	9:00-11:00 pm	44 (44.0)
	11:00-1:00 am	46 (46.0)
	After 1:00 am	8 (8.0)
Breakfast time	Before 8:00 am	26 (26.0)
	8:00-10:00 am	57 (57.0)
	After 10:00 am	17 (17.0)
Lunch time	Before 1:00 pm	13 (13.0)
	1:00-3:00 pm	83 (83.0)
	After 3:00 pm	4 (4.0)
Dinner time	Before 8:00 pm	19 (19.0)
	8:00-10:00 pm	69 (69.0)
	After 10:00 pm	12 (12.0)
Frequency of skipping meals	Never	77 (77.0)
	Occasionally	20 (20.0)
	Frequently	3 (3.0)
Physical activity	Sedentary	90 (90.0)
	Moderate	10 (10.0)
	Highly active	0 (0.0)
Dietary preference	Vegetarian	26 (26.0)
	Non- vegetarian	74 (74.0)
Smoking	Smoker	12 (12.0)
	Non- smoker	88 (88.0)
Alcohol consumption	Consumer	13 (13.0)
	Non- consumer	87 (87.0)
Junk food consumption	Yes	28 (28.0)
	No	72 (72.0)
Intermediate snacking	Yes	52 (52.0)
	No	48 (48.0)

Table 4: Sleep characteristics of study participants (n=100).

Variables	Category	Number (%)
Sleep duration	4 hours	3 (3.0)
	5 hours	9 (9.0)
	6 hours	12 (12.0)
	7 hours	34 (34.0)
	8 hours	27 (27.0)
	9 hours	9 (9.0)
	10 hours	4 (4.0)
	11 hours	2 (2.0)
Sleep quality	Good	42 (42.0)
	Average	33 (33.0)
	Poor	25 (25.0)

Breakfast timing was not significantly associated with chronotype (p=0.089), whereas lunch and dinner timings showed statistically significant associations with chronotype (p=0.013 and p=0.004, respectively) (Table 7).

Table 5: Glycemic parameters according to chronotype: One-way ANOVA (n=100).

Glycemic parameters	Morning (n=23) Mean±SD	Intermediate (n=49) Mean±SD	Evening (n=28) Mean±SD	F value	P value
FBG (mg/dl)	158.4±42.42	160.4±42.07	162.4±70.15	0.038	0.962
PPBG (mg/dl)	280.2±65.68	263.9±66.89	280.3±79.19	0.322	0.725
HbA1c (%)	7.617±0.780	8.047±1.394	8.527±1.641	1.439	0.242

Table 6: Association between chronotype and sleep patterns: Chi-square test(χ^2) (n=100).

Sleep parameters	χ^2	df	P value
Wake up time	25.30	6	<0.001
Bed time	35.34	6	<0.001
Sleep duration	11.58	14	0.640
Sleep quality	7.556	4	0.109

Table 7: Association between chronotype and meal timings: Chi-square test (χ^2) (n=100).

Meal timings	χ^2	df	P value
Breakfast	8.067	4	0.089
Lunch	12.06	4	0.013
Dinner	15.15	4	0.004

DISCUSSION

In the present study, the majority of participants with type 2 diabetes mellitus were classified as having an intermediate chronotype (49%), followed by evening chronotype (28%) and a morning chronotype (23%). The predominance of the intermediate chronotype is consistent with the concept that most individuals lie between clear morning and evening preferences, while distinct morning and evening preferences represent the extremes of the chronotype spectrum.[14] The distribution observed in the present study provides an important context for interpreting the subsequent differences in sleep timing, meal timing, and glycemic parameters across chronotype groups.

Glycemic parameters showed no statistically significant differences across the three chronotype groups. Mean fasting blood glucose and postprandial blood glucose were comparable among participants with morning, intermediate, and evening chronotypes. Although mean HbA1c was numerically higher among those with an evening chronotype (8.257±1.641%) than among those with an intermediate (8.047±1.394%) or morning chronotype (7.617±0.780%), this difference was not statistically significant (F=1.439, p=0.242). These findings suggest that chronotype alone was not significantly associated with glycemic control in this study population. Previous studies have reported poorer glycemic control among individuals with an evening chronotype, including higher HbA1c levels, suggesting that the relationship may be influenced by other behavioural and metabolic factors. Differences in study population, sample size, chronotype classification, diabetes management, and lifestyle characteristics may contribute to the variation between findings.

A significant association was observed between chronotype and both wake-up time and bedtime. Participants with a morning chronotype generally reported earlier wake-up and bedtime patterns, whereas later sleep and wake-up timings were more common among those with an evening chronotype. The associations were statistically significant for both wake-up time (χ^2=25.30, p<0.001) and bedtime (χ^2=35.34, p<0.001). In contrast, sleep duration and sleep quality did not show statistically significant associations with chronotype (χ^2=11.58, p=0.640 and χ^2=7.556, p=0.109, respectively). These findings indicate that chronotype was more clearly reflected in the timing of the sleep-wake cycle rather than the duration or perceived quality of sleep.

Meal timing showed a mixed pattern across the chronotype groups. Breakfast timing was not significantly associated with chronotype (χ^2=8.067, p=0.089), whereas significant associations were observed for lunch timing (χ^2=12.06, p=0.013) and dinner timing (χ^2=15.15, p=0.004). The significant associations for lunch and dinner suggest that the timing of later meals may vary according to an individual's chronotype, while breakfast timing appeared relatively less differentiated across the three groups. These findings highlight the potential relevance of meal timing as a behavioural component of circadian patterns among individuals with type 2 diabetes mellitus.

The findings of the present study should be interpreted considering certain limitations. The hospital-based cross-sectional design and relatively small sample size may limit the generalizability of the findings to the wider population of adults with type 2 diabetes mellitus. Convenience sampling may also have introduced selection bias. Sleep patterns and meal timings were obtained through a structured questionnaire and may therefore be subject to recall or reporting bias. In addition, the cross-sectional nature of the study does not allow causal relationships between chronotype, sleep or

meal timing and glycemic control to be established. Further studies involving larger and more diverse populations, preferably using longitudinal designs and objective measures of sleep and circadian patterns, are warranted.

CONCLUSION

In conclusion, the present study found that intermediate chronotype was the most prevalent among adults with type 2 diabetes mellitus. Although glycemic parameters did not differ significantly across chronotype groups, significant associations were observed between chronotype and wake-up time, bedtime, lunch timing, and dinner timing. Sleep duration, sleep quality, and breakfast timing were not significantly associated with chronotype. These findings suggest that chronotype may be more closely reflected in the timing of sleep and meals than in glycemic control among adults with type 2 diabetes mellitus. The study contributes to the understanding of circadian-related behavioural patterns in type 2 diabetes and highlights the potential relevance of considering individual chronotype when evaluating sleep-wake and meal-timing patterns as part of comprehensive diabetes care.

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REFERENCES

1. International Diabetes Federation. IDF Diabetes Atlas 11th edition 2025. Available at: https://diabetesatlas.org/resources/idf-diabetes-atlas-2025/. Accessed 11 August 2026.
2. American Diabetes Association Professional Practice Committee. 2. Diagnosis and classification of diabetes: Standards of Care in Diabetes 2024. Diabetes Care. 2024;47(Suppl 1):S20-S42.
3. Roenneberg T, Pilz LK, Zerbini G, Winnebeck EC. Chronotype and social jetlag: a (self-) critical review. Biology (Basel). 2019;8(3):54.
4. Reutrakul S, Hood MM, Crowley SJ, Morgan MK, Teodori M, Knutson KL, et al. Chronotype is independently associated with glycemic control in type 2 diabetes. Diabetes Care. 2013;36(9):2523-9.
5. Osonoi Y, Mita T, Osonoi T, Saito M, Tamasawa A, Nakayama S, et al. Morningness-eveningness questionnaire score correlates with glycated hemoglobin in Japanese patients with type 2 diabetes mellitus. Diabetes Res Clin Pract. 2014;105(1):44-50.
6. Mokhlesi B, Temple KA, Tjaden AH, Edelstein SL, Utzschneider KM, Nadeau KJ, et al. Association of self-reported sleep and circadian measures with glycemia in adults with prediabetes or recently diagnosed untreated type 2 diabetes. Diabetes Care. 2019;42(7):1326-32.
7. Henry CJ, Kaur B, Quek RYC. Chrononutrition in the prevention and treatment of obesity and metabolic syndrome. Nutr Diabetes. 2020;10:35.
8. Nimitphong H, Siwasaranond N, Saetung S, Ongphiphadhanakul B, Reutrakul S. The relationship between breakfast time, chronotype, and body mass index in individuals with type 2 diabetes. Chronobiol Int. 2018;35(7):943-51.
9. Qian J, Scheer FAJL. Circadian system and glucose metabolism: implications for physiology and disease. Trends Endocrinol Metab. 2016;27(5):282-93.
10. Reutrakul S, Van Cauter E. Interactions between sleep, circadian function, and glucose metabolism: implications for risk and severity of diabetes. Ann N Y Acad Sci. 2014;1311(1):151-73.
11. Chaput JP, McNeil J, Després JP, Bouchard C, Tremblay A. Short sleep duration as a risk factor for the development of the metabolic syndrome in adults. Prev Med. 2013;57(6):872-7.
12. Adan A, Almirall H. Horne and Östberg morningness-eveningness questionnaire: a reduced scale. Personality and Individual Differences. 1991;12(3):241-53.
13. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;363(9403):157-163.
14. Malone SK, Patterson F, Lu Y, Lozano A, Hanlon A. Ethnic differences in sleep duration and morning-evening type in a population sample. Chronobiol Int. 2016;33(1):10-21.

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