

## A study on Chrononutrition behaviour and Chronotype among Type 2 Diabetics

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### **ABSTRACT**

**Background:** The rising prevalence of Type 2 Diabetes Mellitus (T2DM) highlights the need for effective lifestyle interventions beyond conventional treatment. **Objectives:** This study aimed to explore the relationship between chronotype, chrononutrition behaviour and glycemic control among Type 2 diabetics. **Methodology:** Two private diabetic clinics in Coimbatore were selected by convenience sampling for the selection of target group. Based on inclusion and exclusion criteria, 200 diabetics including 100 males and 100 females were selected as study subjects using purposive sampling. Background information, anthropometric indices, biochemical parameters, dietary intake, physical activity levels were collected using an interview schedule and standard procedures. Mental health status was assessed using DASS – 21 Scale, chronotype was determined using the Morningness-Eveningness Questionnaire and chrononutrition behaviour was evaluated using the Chrononutrition Profile Questionnaire. **Results:** The findings showed that individuals with evening chronotypes and irregular eating patterns, including late-night eating, breakfast skipping and longer eating windows, had poor glycemic control as indicated by elevated fasting blood sugar, postprandial blood sugar and HbA1c levels. Mental health status such as stress, anxiety, and depression was also higher among diabetics. **Conclusion:** The study suggests that regularizing meal times and aligning eating habits with the biological clock by shortening the eating window and latency could support better blood glucose management in Type 2 diabetics.

**Keywords:** Chrononutrition, Chronotype, Type 2 Diabetes Mellitus, Meal Timing, Blood Glucose Values

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### **Introduction**

Non-communicable diseases (NCDs) such as Type 2 Diabetes Mellitus (T2DM) have become a leading cause of concern due to its rapidly increasing prevalence, severe complications and substantial impact on healthcare systems and economies. As of 2021, 537 million adults aged between 20 – 79 years are living with diabetes, a number projected to rise to 643 million by 2030 and 783 million by 2045.<sup>1</sup> Among the various factors influencing diabetes risk and management, chrononutrition is a field of research in nutritional sciences that investigates the health impact of three different dimensions of feeding behaviour: regularity of meals, frequency and timing of food intake which interact with the body's internal biological clock- the circadian rhythm which regulates physiological processes such as hormone secretion, digestion, and glucose metabolism.<sup>2,3</sup> Disruptions to this rhythm through late-night eating, irregular sleep, or inconsistent meal timing can negatively impact metabolic health and glycemic control.

Another key factor is chronotype, the individual preference for activity and sleep timing (morning, evening, or intermediate types). These variations influence not only sleep patterns but also eating behaviour and peak performance periods, which influences the blood glucose values. Studies suggest that aligning food intake with one's circadian rhythm improve blood sugar regulation and overall well-being. Thus, understanding the role of chrononutrition in blood glucose control and mental well-

being aids in providing better management of blood glucose levels among Type 2 diabetics and hence the study was carried out with the following objectives.

### Objectives

- ) Identify the chronotype of the selected diabetics.
- ) Assess the chrononutrition behaviour of the selected diabetics.
- ) Associate the relationship between chronotype, chrononutrition behaviour with blood glucose control.

### Methodology

The study was approved by the Institutional Human Ethics Committee of Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore. AUW/HEC/24-25/FSMD/XPD02. The target group of diabetics were selected from two diabetes specialty clinics in Coimbatore by convenience sampling. A total of 200 diabetics including 100 males and 100 females aged between 30 – 80 years were selected as study subjects using purposive sampling.

The inclusion and exclusion criteria for the study are as follows

#### Inclusion Criteria:

1. Male and female diabetics aged between 30-80 years
2. Diagnosed with T2DM in the past 0-10 years
3. Diabetics without secondary complications
4. Willing to participate.

#### Exclusion Criteria:

1. Diabetics with T2DM over 10 years.
2. Diabetics with known co-morbidities
3. Poor compliance for follow-up at the clinic

Background information such as age, gender, educational qualification, occupation and family income was collected from the selected diabetics using an interview schedule. The socio-economic status of the diabetics was compared against the modified Kuppuswamy Scale, 2024.<sup>4</sup> Anthropometric measurements included height (cm), weight (kg) and waist and hip circumference (cm). Based on these measurements, calculative indices such as Body Mass Index (BMI) and Waist-Hip Ratio (WHR) were derived using standard formulas. The blood glucose values such as Glycated haemoglobin (HbA1c), Fasting Blood Glucose (FBG) and Postprandial Blood Glucose (PPBG) of the selected diabetics were collected from the hospital Patient Information System (PIS) as secondary data. The dietary pattern, physical activity levels was collected using interview schedule. Depression, Anxiety, and Stress Scale - 21 (DASS-21)<sup>5</sup> a standardized self-report questionnaire was used to assess the mental health of the diabetics.

Chronotype refers to an individual's natural preference for daily activities, particularly the sleep-wake cycle and is associated with various health risks is determined using Morningness - Eveningness Questionnaire (MEQ)<sup>6</sup>. The MEQ is a validated 19-item tool used to evaluate the 200 diabetics based on their alertness and activity levels at different times of the day, preferred sleep and wake times and peak performance hours. The chrononutrition behaviour of all 200 diabetics was assessed using the Chrononutrition Profile Questionnaire (CP-Q)<sup>7</sup>. The CP-Q is a validated 18-item tool that focuses on six key behaviours: breakfast skipping, largest meal timing, evening eating, evening latency, night eating and eating window on both weekdays and weekends. The average weekly chrononutrition score for each diabetic was obtained by separately analyzing weekdays and weekends before summing the values. Statistical analysis for this study was performed using SPSS 21 to explore the association between the chronotype, chrononutrition behaviour and blood glucose values among diabetics.

**Results and Discussion**

**[A] Details on Background Information of the Selected Diabetics**

**Table-1:** Details on Background Information

Background Information		Males (N= 100)	Females (N= 100)
Age (years)	30 -39	12	9
	40 -49	18	19
	50 -59	33	34
	60 -69	30	29
	70 -79	7	9
Educational Qualification	Graduate	55	30
	Intermediate or Diploma	20	16
	High school	25	54
Occupation	Administrative positions	3	1
	Professionals	19	9
	Associate Professionals &Technicians	26	12
	Skilled Workers	22	8
	Unemployed/ Retired	30	70
Income Status	Upper	03	1
	Upper Middle	41	21
	Lower Middle	28	6
	Upper Lower	28	72

The age distribution of the selected diabetics spanned over an age range of 30- 80 years. Among this, the middle age of 50 – 59 years and old age of 60 – 69 years was commonly noticed. The study found that these risk factors were more common among males, particularly in the 45–69 age group.<sup>8</sup> Among the diabetics, 55 males and 30 females were graduates. None of the subjects were illiterate. A higher percent of 30 males and 70 females were either unemployed or retired individuals. This is noticed as many of the subjects belong to the later adulthood and old age category. Among diabetics, the working individuals were professionals, technicians and skilled workers suggesting that sedentary work and life style factors may contribute to the disease. Forty-one and 28 males belonged to the upper middle and lower middle classes respectively. Whereas 72 females were predominantly from the upper lower class. This could be attributed to factors such as educational access and employment opportunities that limit women's financial mobility (Table-1).

**[B] Anthropometric indices**

*Distribution of Body Mass Index of the selected diabetics*

**Table- 2:** Distribution of Body Mass Index

Age (years)	Underweight		Normal		Overweight		Obese	
	Male	Female	Male	Female	Male	Female	Male	Female
30 -39	Nil	1	2	4	7	Nil	3	4
40 -49	Nil	Nil	4	5	11	6	3	8
50 -59	1	Nil	5	8	21	12	6	11
60 -69	1	Nil	7	12	13	10	9	7
70 -79	Nil	Nil	4	3	3	5	Nil	11
<b>Total</b>	2	1	22	32	55	36	21	32

\*WHO (2010)

Table 2 represents the Body Mass Index (BMI) of the selected diabetic individuals across different age groups revealed that overweight and obesity was prominently observed in the age group of 50–59 years and 60–69 years. There is a strong correlation between type 2 diabetes and being overweight or obese, along with factors such as advancing age, ethnicity and family history, although the exact underlying causes remain unclear.<sup>9</sup>

[a] **Waist Hip Ratio**

**Table- 3: Waist Hip Ratio**

Age (years)	<0.95 /<0.80		0.95 -1.0 / 0.81-0.85		> 1.0 / >0.85	
	Male	Female	Male	Female	Male	Female
30 -39	2	2	8	3	2	4
40 -49	5	3	12	4	1	12
50 -59	7	6	23	11	3	17
60 -69	11	10	7	2	12	Nil
70 -79	5	2	2	7	Nil	7
<b>Total</b>	30	23	63	32	7	45

\*WHO, 2011

A high WHR was predominantly observed in females aged 50–59 years (17) and 60–69 years (12), indicating a greater prevalence of central obesity in older women. The age group of 40–49 years showed a considerable proportion of diabetics in the moderate risk category with 23 males and four females having a WHR between 0.95–1.0 and 0.81–0.85 respectively. The study found that postmenopausal women with higher WHR had a greater risk of developing type 2 diabetes due to hormonal changes leading to increased visceral fat deposition<sup>10</sup> (Table 3).

[b] **Biochemical Parameters**

**Table-4: Blood Glucose values**

Glycated Haemoglobin (HbA1c) (%)	Diabetics		Fasting Blood Glucose Level (mg/dl)	Diabetics		Postprandial Blood Glucose Level (mg/dl)	Diabetics	
	Males (N=100)	Females (N=100)		Males (N=100)	Females (N=100)		Males (N=100)	Females (N=100)
<5.7	1	Nil	100– 150	59	69	140– 220	45	66
5.7-6.4	13	16	150– 200	22	20	220– 300	32	24
6.5 – 9.0	60	64	200– 250	13	4	300– 380	13	7
>9.0	26	20	250– 300	6	7	380– 460	10	3

\* Recommended values (HbA1c) = <5.7%; Recommended values (FBG) = <100mg/dl

\* Recommended values (PPBG) = <140mg/dl

Table 4 represents the blood glucose value of the selected diabetics. Twenty-six males and 20 females had HbA1c levels >9.0%, signifying poorly controlled diabetes and a high risk of complications. In fasting blood glucose (FBG) values, none of the diabetics had levels within the recommended range of less than 100mg/dl. Thirteen males and four females had the range of 200-250 mg/dl and severe fasting hyperglycemia was observed in six males and seven males.

In postprandial blood glucose levels, none of the diabetics had levels within the recommended range of less than 140 mg/dl. Higher levels were seen in 32 males and 24 females (220–300 mg/dl) and ten males and three females (380–460 mg/dl). Poor glycemic control despite treatment may be due to unhealthy diets, sedentary lifestyles, medication non-adherence, stress and inadequate treatment adjustments.

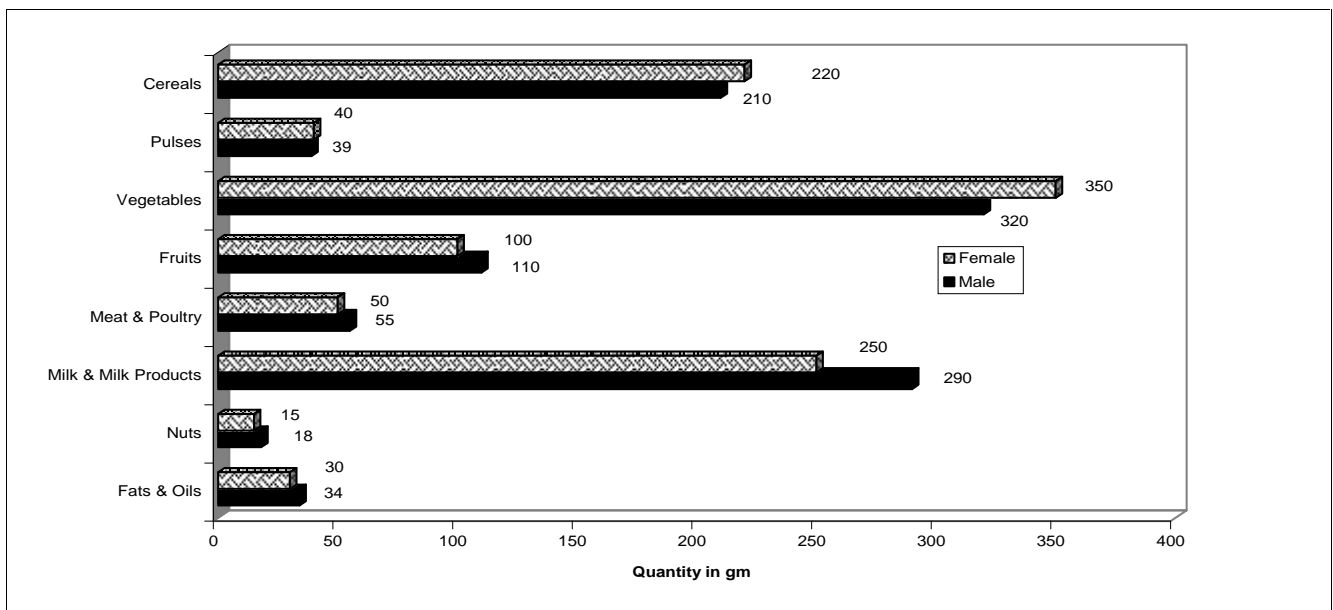
**Dietary Pattern**

The dietary habits showed that 88 males and 81 females were non vegetarian. Twelve males and 17 females were being vegetarian; meanwhile only two females were Ovo vegetarian. Weekly consumption of out side food is higher among males

(56) than females (48) while fortnightly eating out is common among females (28) than males (24). The higher weekly intake among males may be due to work routines or social habits, whereas females may prefer occasional indulgence. Dietary restrictions are essential for individuals with diabetes to maintain stable blood glucose levels and prevent complications. Higher percent of females (64) follow dietary restrictions compared to males (56), while 44 males and 36 females had no restrictions. Adhering to dietary restrictions is crucial.

**Intake of Food Groups among the Selected Diabetics**

**Figure 1: Intake of Food Groups**



The findings revealed that both groups showed a moderate level of adherence to dietary guidelines. Intake of cereals and pulses was slightly lower than the recommended values, which could be a deliberate reduction as part of carbohydrate management in diabetes care. Notably, vegetable consumption was relatively high in both males (350 ± 80) and females (320 ± 37). This may be attributed to their participation in diabetes treatment programs and regular diet counselling which emphasize the importance of fiber-rich foods like vegetables in controlling blood sugar levels. Fruit intake was fairly adequate and comparable across genders, reflecting an effort to include natural source of vitamins and minerals (Figure 1).

**Nutrient Intake of the Selected Diabetics**

**Table- 5: Nutrient Intake for diabetes**

Variables	Mean ± SD	
	Males (N=100)	Females (N=100)
Energy (Kcal)	1657 ± 13	1549 ± 13
Carbohydrate (g)	240 ± 56	198 ± 48
Protein (g)	42 ± 12	38 ± 14
Fat (g)	32 ± 21	35 ± 18
Fiber (g)	35 ± 16	34 ± 16

The nutrient intake among diabetic participants reflected dietary adaptations aligned with recommended diabetes management practices. Male participants had a higher mean energy intake (1657±13 kcal) and carbohydrate intake (240±56g) compared to females (1549±13 kcal & 198±48 g, respectively), which aligns with their higher physiological and caloric needs. Protein intake was slightly lower, particularly among females, indicating a need to promote protein-rich foods for improved satiety and blood sugar regulation. Fiber intake was satisfactory among both males (35±16 g) and females (34±16 g), supporting its known role in improving glycemic response. This may reflect good treatment adherence and the impact of regular diet counselling, which likely promoted the inclusion of vegetables, fruits and whole grains (Table-5).

**[E] Physical Activity**

The assessment of physical activity habits among diabetic individuals highlights a concerning lack of regular exercise. Only 15 males and six females preferred walking as a form of physical activity, while the others remained inactive. This sedentary lifestyle is strongly associated with poor glycemic control, insulin resistance and increased diabetes-related complications. According to ADA, individuals with diabetes are advised to engage in at least 150 minutes of physical activity per week to support effective disease management.

**[F] Mental Health of the Selected Diabetics**

**Table-6: Mental Health**

Severity*	Selected Diabetics					
	Depression		Anxiety		Stress	
	Males (N=100)	Female (N=100)	Males (N=100)	Female (N=100)	Males (N=100)	Female (N=100)
Normal	10	2	1	1	11	10
Mild	8	13	1	1	47	30
Moderate	69	56	18	13	38	48
Severe	11	26	38	32	3	10
Extremely severe	2	3	42	53	1	2

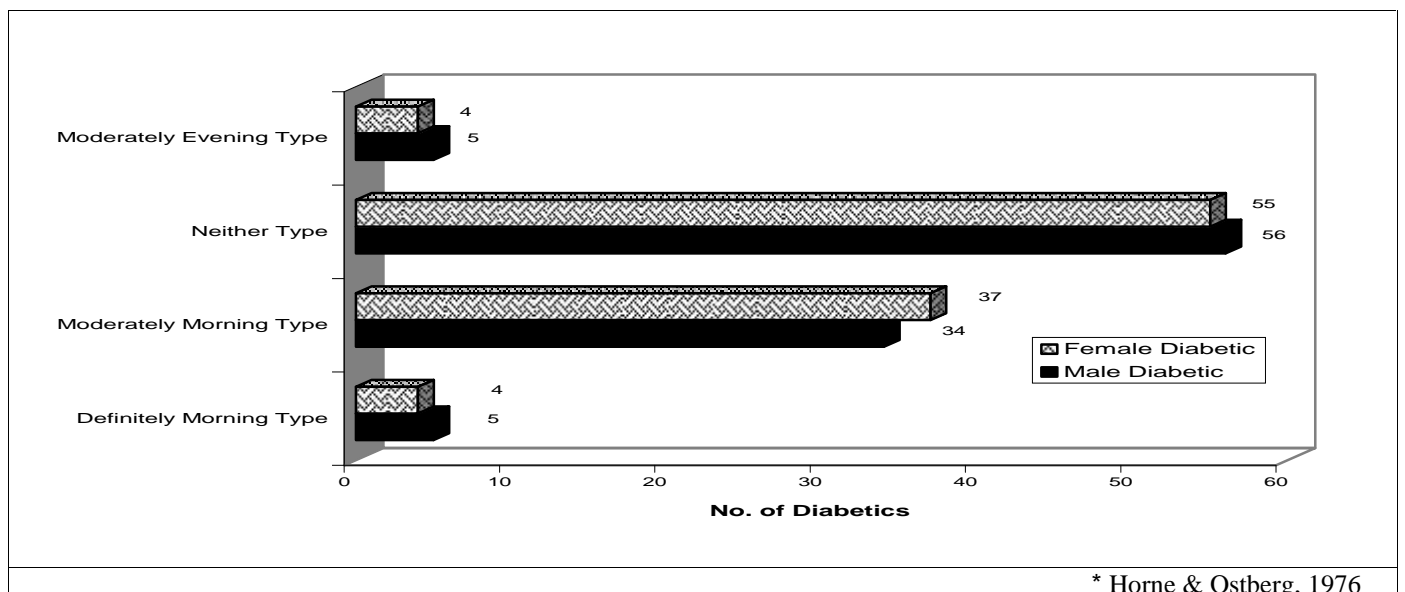
\*DASS 21

Table 6 shows the mental status of the selected Diabetics. Moderate depression was found in 69 males and 56 females. Anxiety was high in both groups, but extremely severe anxiety was seen in 42 males and 53 females. Interms of stress, moderate stress was found to be higher in females (48) than males (38). These findings suggest that females experience greater psychological distress, particularly severe depression, anxiety and stress, whereas males tend to report moderate depression and mild stress. The depression and anxiety are more common in individuals with diabetes and it can negatively impact diabetes self-management, leading to poor health outcomes.

**Details on Chronotype and Chrononutrition profile**

**[a] Determination of Chronotype**

**Figure-2: Chronotype**



Among the 200 diabetics, 56 males and 55 females were in the category of "Neither type" indicating no strong preference for morning or evening activity. However, 34 males and 37 females were in moderate morning type and five males, four females were identified as "Moderately evening type". None of the subjects were "Definitely evening type". According to research, about 60% of the adult population globally is neither type, with the remaining individuals being either morning or evening type.<sup>11</sup>

**[b] Details on Chrononutrition behaviour**

Eating window is the time gap between the first and last meal of the day. 61 males and 81 females were following an eating window of 10–12 hours. Maintaining a shorter eating window has been associated with better glycemic control.<sup>11</sup> Morning latency is the time gap between the wake time and the first meal of the day. Fifty-three males and 69 females had a latency of 2 – 4 hours. Following that, 43 males and 25 females had 0 - 2 hours as their morning latency. The definitely morning type diabetics are having the longer morning latency. Evening latency is the time gap between dinner and bed time. Seventy males and 71 females had latency of 0-2 hours.

Skipping break fast was prevalent among females (70) than male (57) for 1–3 days a week, while only one in each group skipped breakfast for 4–7 days a week. Skipping breakfast has been associated with poorer glycemic control, increased insulin resistance and a higher risk of metabolic complications. Sixty-eight males and 59 females consuming lunch as their largest meals of the day. Twenty-five males and 30 females consumed inner as the largest meal of the day.

**Table -7:** Chrononutrition Behaviour

Chrononutrition Behaviour		Diabetics	
		Males (N=100)	Females (N=100)
Eating Window	10 – 12 hours	61	81
	12 – 14 hours	39	19
Morning Latency	0 – 2 hours	43	25
	2 – 4 hours	53	69
	4 – 6 hours	4	6
Evening Latency	0 – 2 hours	70	71
	2 – 4 hours	30	27
	4 – 6 hours	Nil	2
Breakfast Skipping	Never	42	29
	1– 3 days	57	70
	4– 7 days	1	1
Largest meal	Breakfast	7	11
	Lunch	68	59
	Dinner	25	30
Night eating	7.00 – 8.00 pm	27	25
	8.00 – 9.00 pm	44	65
	9.00 –10.00 pm	16	8
	10.00–11.00pm	13	2
<i>*Veronda et.al.,2020</i>			

Individuals with T2DM who consumed a large breakfast and smaller dinner had better glycemic control compared to those who had an inverse eating pattern<sup>12</sup>. Forty-four males and 65 males had dinner between 8.00 – 9.00 pm. Thirteen males and two females had dinner at 10.00 -11.00 pm. Consuming a large breakfast and smaller dinner had better glycemic control compared to those who had an inverse eating pattern (Table-7).

**[c] Association of Chronotype with Blood Glucose Levels**

**Table- 8:** Association of Chronotype with Blood Glucose Levels

Chronotype	Mean ± SD		
	Glycated Haemoglobin (HbA1c)	Fasting Blood Glucose (FBG)	Postprandial Blood Glucose (PPBG)
Definitely Morning Type	7.15 ± 0.89	138.88 ± 38.52	239.37 ± 56.96
Moderately Morning Type	7.42 ± 1.36	138.19 ± 43.87	198.11 ± 67.19
Neither Type	8.23 ± 1.83	149.06 ± 52.19	225.70 ± 79.88
Moderately Evening Type	8.69 ± 3.04	201.04 ± 54.83	295.08 ± 77.48

Morning chronotype diabetics had better blood glucose control than the evening type. Definitely morning type had lower mean HbA1c (7.15 ± 0.89) and FBG levels (138.88±38.52) compared to other types but the PPBG was almost similar in all chronotype. On the contrary, moderately evening type diabetics had highest levels for all three blood glucose levels. Evening chronotypes may have irregular routines, delayed meals, and sleep disturbances, which can negatively affect blood glucose levels. These findings highlight that chronotype plays a role in diabetes control (Table-8).

**[d] Correlation between Chronotype, Chrono nutrition Behaviour and Blood Glucose values****Table -9:** Correlation between Chronotype, Chrono nutrition Behaviour and Blood Glucose values

Details	HbA1c*		Fasting Blood Glucose		Postprandial Blood Glucose	
	r	p	r	p	r	p
Chronotype	-0.258**	0.000	-0.205**	0.004	-0.168*	0.017
<b>Chrono nutrition behaviour</b>						
Skipping breakfast	0.291**	0.000	0.265**	0.000	0.225**	0.001
Largest meal	0.256**	0.000	0.201**	0.004	0.200**	0.005
Late Dinner	0.132*	0.05	0.140*	0.04	0.73	0.304

\*HbA1c-Glycated Haemoglobin,

\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

The correlation between chronotype and blood glucose values revealed that a significant negative correlation was noted with HbA1c ( $r = -0.258$ ,  $p < 0.001$ ), FBS ( $r = -0.205$ ,  $p = 0.004$ ), and PPBS ( $r = -0.168$ ,  $p = 0.017$ ), indicating that individual chronotype has a strong association with blood glucose levels. Among the chrononutrition behaviour, skipping breakfast showed a significant positive correlation with HbA1c ( $r = 0.291$ ,  $p < 0.001$ ), FBS ( $r = 0.265$ ,  $p < 0.001$ ), and PPBS ( $r = 0.225$ ,  $p = 0.001$ ), suggesting that diabetics who frequently skip breakfast tend to have poor blood glucose control. A significant positive correlation was observed between consuming the largest meal in the day with HbA1c ( $r = 0.256$ ,  $p < 0.001$ ), FBS ( $r = 0.201$ ,  $p = 0.004$ ), and PPBS ( $r = 0.200$ ,  $p = 0.005$ ). This result indicates that those who consume the largest meal at night had poor control on glucose levels. Late dinner timing is positively correlated with HbA1c ( $r = 0.132$ ,  $p = 0.050$ ) and FBS ( $r = 0.140$ ,  $p = 0.040$ ), but the association with PPBS was not significant ( $r = 0.073$ ,  $p = 0.304$ ). These findings underscore the influence of circadian-aligned eating behaviour on blood glucose levels and support the potential role of chrononutrition in diabetes management (Table 9).

**Conclusion**

Chronotype and chrononutrition behaviour plays a significant role in the management of Type 2 Diabetes Mellitus (T2DM). Diabetics with morning chronotype demonstrated significantly better glycemic control. Chrononutrition behaviour, including breakfast skipping, largest meal and late dinner timing, were positively correlated with poor blood glucose values. Breakfast skipping particularly had a strong association with elevated HbA1C and fasting blood glucose levels. The study confirms that not only-what diabetics eat but-when they eat has profound effects on glucose regulation. Late eating habits and disruption of the body's natural circadian rhythm can contribute towards poor glycemic control. Understanding and aligning meal patterns with an individual's chronotype can enhance metabolic outcomes, support better glycemic control and provide a personalized approach to management of diabetes.

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