CHRONONUTRITION AND ITS ASSOCIATION WITH GLYCAEMIC CONTROL, BODY COMPOSITION & SOCIAL JET LAG IN PEOPLE WITH TYPE 2 DIABETES MELLITUS

APRIL, 2023

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P.G. Diploma

(APPLIED NUTRITION)

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A Dissertation submitted in partial fulfilment of the requirement for the degree of
Master of Science
(Family and Community Sciences)
(Dietetics)

BY

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CERTIFICATE

This is to certify that the research work presented in this thesis has been carried out independently by Ms. Gauri Jaimini under the guidance of Dr. Suneeta Chandorkar in pursuit of Degree of Master of Science (Family and Community Sciences) with major in Foods and Nutrition (Dietetics) and this is her original work.

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With Warm Regards,

Gauri Jaimini

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ABBREVIATIONS

ACTH	Adrenocorticotropic Hormone
ADA	American Diabetic Association
BMI	Body Mass Index
BP	Blood Pressure
CAD	Coronary Artery Disease
CI	Castelli Index
CRH	Corticotropin releasing hormone
CSRWD	Circadian Sleep- wake Disorder
DKA	Diabetic Ketoacidosis
DN	Diabetic Nephropathy
EEE	Exercise Energy Expenditure
ESRD	End Stage Renal Disease
FPG	Fasting Plasma Glucose
GPAQ	Global Physical Activity Questionnaire
HDL	High Density Lipoprotein
HPA	Hypothalamic-pituitary-adrenal axis
ICMR	Indian Council of Medical Research
IDF	International Diabetic Federation
Kcal	Kilo Calorie
LDL	Low Density Lipoprotein
MET	Metabolic Equivalent
MT	Melatonin Receptor
NCDs	Non-communicable Diseases

NES	Night Eating Syndrome
NHFS	National Health and Family Welfare
NHLBI	National Heart, Lung and Blood Institute
NIDDM	Non-Insulin Dependent Diabetes Mellitus
PAD	Peripheral Artery Disease
PPBS	Post Prandial Blood Sugar
PSS	Perceived Stress Scale
PSQI	Pittsburgh Sleep Quality Index
RPG	Random Plasma Glucose
SCN	Suprachiasmatic Nucleus
SDG	Sustainable Development Goals
T2DM	Type 2 Diabetes Mellitus
TRE	Time Restricted Feeding
WHR	Waist- Hip Ratio
WHtR	Waist-Height Ratio

ABSTRACT

ABSTRACT

INTRODUCTION: Chrono-nutrition is the study of how biological cycles and nutrition interact, as well as how these elements relate to people`s health. It includes the distribution of energy, the regularity and meal frequency, the eating window (the duration of the eating period), and the relative weight given to each of these aspects in relation to risk of chronic illness and metabolic health. An individual's "chronotype" determines chrononutrition. A person's chronotype can be used to express their circadian phenotype, which could include their propensity for morning or evening behaviour. Glucose metabolism is related to circadian rhythm, and irregular rhythms result in a number of acute (delirium, hallucinations) or chronic health issues (obesity, diabetes). Circadian rhythm disruption has an impact on every function in the body, including the digestion and sleeping cycles and intolerance for metabolism of lipids, glucose and insulin which leads to a number of disorders. Timed meal consumption affects glucose metabolism in humans because it is controlled by the SCN and helps synchronise circadian rhythms in peripheral tissues. The association between elements like meal timings and nutrients (chrononutrition), which can contribute to circadian perturbance and impact the emergence of metabolic illnesses like type 2 diabetes, is evident in the effects of meal timings on circadian rhythmicity.

OBJECTIVES: To study the association of Chrononutrition with Glycaemic control (Fasting blood glucose, Post prandial plasma glucose, HbA1c), Body composition and Social jetlag in people with Type 2 Diabetes Mellitus.

METHODS: A cross-sectional study was carried out at three diabetes clinics of Vadodara. 227 participants of age 35-60 years with Type 2 Diabetes Mellitus from not more than five years, without secondary complications (Nephropathy/ Retinopathy/ Cardiovascular disease), on oral glycaemic drugs and informed consent were included. Data was collected through personal interview method through structured questionnaire for collection of personal information, diet information (24hr dietary recall and Food frequency questionnaire), physical activity (Global physical activity questionnaire), screen time, stress (Perceived stress scale), sleep (Pittsburgh sleep quality index), chronotype (Horne and *Ostberg Morningness-Eveningness* questionnaire), chrononutrition profile (Chrononutrition profile

questionnaire) and social jelag (Munich chronotype questionnaire). Anthropometric measurements and body composition was done and biochemical parameters were collected from the case file. The data was analysed using the SPSS version 29.

RESULTS: Poor glycaemic control was seen among participatns where nearly three-fifth of the participants had uncontrolled fasting blood glucose levels (59.9%), three-fourth of the participants had uncontrolled PP2BS (66.9%) and nearly two-fifth participants (40%) had poor HbA1C levels and the TyG index indicated that all the participants were insulin resistant. Participants with an evening chronotype had a higher consumption of carbohydrates and fat and a lower consumption of protein and fiber ($p < 0.000$). Higher consumption of cereals, oils & fat and sugar ($p < 0.001$) and lower consumption of pulses & legumes, fruits, nuts and vegetables ($p < 0.000$) was seen among evening chronotyped individuals. Evening chronontyped individuals consumed breakfast with a higher glycemic index than the morning chronotyped individuals ($p < 0.001$) and had a higher Fasting blood glucose ($\beta= 0.3$, $p=0.000$), TyG index ($\beta= 0.2$, $p=0.002$), Triglyceride levels ($\beta= 0.4$, $p=0.001$), Post-prandial plasma glucose ($\beta= 0.1$, $p=0.001$) and HbA1c ($\beta= 0.4$, $p=0.000$). The largest meal consumed was during dinner with a higher glycemic index for evening chronotyped individuals ($p < 0.000$). Participants with a poor chrononutrition profile consumed Breakfast, Lunch and Dinner with a higher Glycemic Index ($p < 0.000$). Participants with a poor chrononutrition profile had a higher total body fat % and visceral fat and a lower skeletal muscle % ($p < 0.000$). Participants with eating window of 14 hours or more, poor evening latency, night eating for 2-3 days/ week and heavy dinner/supper consumption had poor glycaemic control, poor lipid profiles along with higher atherogenic indices. Variability of meal timings (breakfast, lunch and dinner) in weekday and weekend was positively associated with Social jetlag ($p <0.000$). Higher consumption of carbohydrate, protein and fat and a lower consumption of fiber was seen among participants with social jetlag ($p < 0.000$). Participants with social jetlag had a higher total body fat % and visceral fat and a lower skeletal muscle % ($p < 0.002$). Variability of meal timings in weekday and weekend (breakfast, lunch and dinner) with a threshold of 2 hours of more was associated with a poor glycaemic control as assessed using cubic splines ($p < 0.000$).

CONCLUSION: The findings of this study suggest that in people with Type 2 Diabetes Mellitus, Circadian misalignment, Poor Chrononutrition profile, Social jetlag was positively linked with poor glycaemic control and unhealthy body composition. Chrononutrition profile and correction of the misalignment of sleep timings may be an important advisory and counselling tool in the study of dietary behavior and lifestyle patterns of the people with Type 2 Diabetes Mellitus and help in treatment of T2DM along with the metabolic health of the entire population.

INTRODUCTION

INTRODUCTION

In the field of nutrition, a newly developing area of chrononutrition covers three elements of eating behavior—timing, frequency, and regularity (Almoosawi S et.al, 2019). Chrono-nutrition is the study of how biological cycles and nutrition interact, as well as how these elements relate to people's health. It includes the distribution of energy, the regularity and meal frequency, the eating window (the duration of the eating period), and the relative weight given to each of these aspects in relation to risk of chronic illness and metabolic health (Flanagan A et. al, 2020). Our inbuilt 24-hour biological timing system, the circadian clock, and the significant function it plays in regulating metabolic activities throughout the body are linked to the significance of when we eat. Almost every living thing on the earth has developed innate biological rhythms centred on the light-dark cycle brought on by the Earth's 24-hour daily rotation (Flanagan A et. al, 2020). The suprachiasmatic nucleus, often known as SCN, is the body's "Greenwich Mean Time" and serves as the primary pacemaker in mammals. The SCN is located above the optic chiasm, which is where the optic nerves from the left and right eyes converge which maybe synchronised with the 24-hour light/dark cycle because of its location, to collect photic (light) information (Buijs FN et. al, 2016). The 24-hour daily rotation of the Earth causes significant variations in the amount of light, heat, and food available. Since this occurrence can be predicted and repeated, most organisms have an internal biological timer that corresponds to and predicts these daily variations. The circadian system, which controls these endogenous rhythms, enables coordination of appropriate behavioural and physiological responses in response to recurrent changes in the environment and to shifting requirements of an organism's own biology. The study of the biological rhythms, oscillating series of events that take place in a predictable temporal order and endure in the absence of environmental factors is chronobiology (Postolache T.T et. al, 2016). Circadian clocks are able to sustain an independent periodicity of about 24 hours while being extremely receptive to external stimuli that synchronise them to the outside environment (Dunlap et al., 2004). The most frequently observed interindividual variation in circadian rhythmicity is chronotype, or morningness-eveningness (i.e., the tendency to be an early "lark" or a late "owl"). People who are more morning or evening oriented have different circadian phases in their biological clocks (Kerkhof G et. al, 1996; Baehr EK et. al, 2009). The biological clock n mammals triggers energy cycles to preserve physiologic homeostasis. Hormone production, the electrical activity of the heart,

immunity, heart rate, blood pressure, coagulation, body temperature, hemodynamics, respiratory motion, and sleep-wakefulness are all regulated by biological rhythms (Flanagan A et. al, 2020; Gnocchi D et. al, 2017; Poggiogalle E et. al, 2017; Brown SA et. al, 2016). Glucose metabolism is related to circadian rhythm, and irregular rhythms result in a number of acute (delirium, hallucinations) or chronic health issues (obesity, diabetes) (Bollinger T et. al, 2014; McKenna HT et. al, 2017; Sans-Fuentes MA et. al, 2010). Impaired sleep, circadian rhythms and neurogenesis in diet-induced premature aging (International Journal of Molecular Sciences, 2017). Circadian rhythm disruption has an impact on every function in the body, including the digestion and sleeping cycles and intolerance for metabolism of lipids, glucose and insulin which leads to a number of disorders (McKenna HT et. al, 2017; Sans-Fuentes MA et. al, 2010; Stankiewicz AJ et. al, 2017). Obesity and metabolic syndrome (diabetes, stroke, etc.) are the two most common metabolic illnesses associated with circadian dysrhythmia and Circadian Rhythm & Chronobiology. (McKenna HT et. al, 2017; Stankiewicz AJ et. al, 2017). Due to the dependence of glucose homeostasis on the daily cycle of light and darkness, inadequate glucose control in the case of desynchrony results in metabolic syndrome and even diabetes mellitus. (Stankiewicz AJ et. al, 2017; Potter GDM et. al, 2016; Poggiogalle E et. al, 2017) From a chronobiological perspective, glucose metabolism in humans follows a circadian rhythm through diurnal variation in glucose tolerance, which normally peaks during daytime hours when food consumption typically occurs and decreases during night time hours when fasting typically occurs(Sassone-Corsi P et. al, 2016). Circadian oscillation is shown by a number of hormones involved in the metabolism of glucose, including cortisol and insulin. (Kalsbeek, A et. al, 2014; Froy, O et. al, 2007). Timed meal consumption affects glucose metabolism in humans because it is controlled by the SCN and helps synchronise circadian rhythms in peripheral tissues (Czeisler, C. A. et. al, 1999; Johnston, J. D. 2014; Oike, H et. al, 2014). The association between elements like meal timings and nutrients (chrononutrition), which can contribute to circadian perturbance and impact the emergence of metabolic illnesses like type 2 diabetes, is evident in the effects of meal timings on circadian rhythmicity (Oike, H et. al, 2014).

Diabetes mellitus remains a leading chronic disease in the world with the number of diabetics quadrupling in the past three decades (Wehrens, S. M. T. et. al, 2017). The International Diabetes Federation (IDF) estimated that 415 million adults had diabetes in 2015, and by 2040, it is projected to reach 642 million (Zheng Y et. al, 2017). The

highest rates of type 2 diabetes mellitus are found in countries like India, which paradoxically have far lower rates of obesity (as defined by body mass index). The distinctive thin-fat phenotype that predominates in this area helps to partially explain this conundrum. In the scientific literature, the thin-fat phenotype is sometimes referred to as normal weight obesity, metabolic obesity, metabolically unhealthy non-obese, etc. It is described as a condition in which a person has a normal body mass index but an excessively high body fat percentage (based on ethnicity and gender specific cutoffs). This phenotype is discovered to be quite prevalent in tropical nations and related with a significant cardiometabolic risk, equivalent to people who are obviously obese. (Postolache T.T et. al, 2016)

Diet is regarded as the cornerstone of preventing and treating insulin resistance (IR) and glucose dysmetabolism, and food has a significant impact on postprandial glycemia and general physical health. (Herman, W. H. 2017) Our modern lifestyles are characterised by irregular eating occasions and times of eating, skipping meals, chronic psychological stress, emotional eating, and exposure to a "toxic" food environment. We also spend more time in the postprandial state, have lower energy expenditure, and spend more time sitting down. (Herman, W. H. 2017). This style of living sets off processes, such as the growth of insulin resistance (IR), which is thought to be a defensive mechanism against metabolic stress, particularly for the heart (Shapira N. 2019)

The "Asian Indian Phenotype," which has been proposed as the primary cause of this greater propensity to acquire type 2 diabetes at a younger age, is characterised by high levels of abdominal fat and enhanced insulin resistance even at low levels of body-mass index (BMI). Four unique phenotypic clusters can be identified in Asian Indians with type 2 diabetes, and this has significant ramifications for diabetes management and prognosis in Indians.

Cluster 1 (also known as SIDD, or "severe insulin deficient diabetes") was distinguished by having the lowest BMI, waist circumference, and C-peptide levels. In this cluster, which had the highest HbA1C values, both beta cell activity and insulin resistance were low. Cluster 2 is a brand-new cluster known as IROD (Insulin Resistant Obese Diabetes). These people had the greatest BMIs, waist measurements, C-peptide concentrations, beta cell activity, and insulin resistance. CIRDD is the name of Cluster 3, a different new group that was discovered (Combined Insulin Resistant and Deficient Diabetes). The youngest age at onset was present in this group. Between

SIDD and IROD, BMI, waist size, beta cell activity, and insulin resistance were all intermediate, and CIRDD had the highest triglyceride and lowest HDL cholesterol values among the four clusters. The most prevalent cluster in this cohort was Cluster 4, or MARD (Mild Age-Related Diabetes), which was distinguished by a later age at start than other clusters. They had the greatest metabolic management of the four groups, the highest HDL cholesterol, and fairly stable C-peptide readings. Compared to other groups, this one used the least insulin (Kapoor N, 2021).

The findings of the study conducted in the urban area of Vadodara, suggest that in patients with Type 2 Diabetes Mellitus, Circadian misalignment and Poor Chrononutrition profile was positively linked with poor glycaemic control. Chrononutrition profile may serve as an important counselling tool which can help in examining the feeding behavior and lifestyle patterns of the people with Type 2 Diabetes Mellitus and help in treatment of T2DM along with metabolically strengthening the health of general population. For the measurement of insulin resistance in research, Matthews et al. created the homeostasis model assessment-estimated insulin resistance (HOMA-IR) (Ranjit Mohan A et. al, 2020). For the surrogate evaluation of IR, the Homeostasis Model Assessment of IR (HOMA-IR) has proven to be a reliable method (Matthews DR et. al, 1985; Lann D et. al, 2007). It is computed as HOMA-IR = (FPIFPG)/22.5 which is multiplying fasting plasma insulin (FPI) by fasting plasma glucose (FPG), and then dividing by 22.5 (Antuna-Puente B et. al, 2011). The World Health Organization has defined IR as a HOMA-IR of ≥ 1.8 (Wallace TM et. al, 2004).

High triglyceride and low HDL cholesterol levels have long been linked to insulin resistance and type 2 diabetes (T2DM). Increased levels of triglyceride-rich lipoproteins have been theorised to be primarily caused by increased production of VLDL particles in the liver. High blood FFA levels in individuals with insulin resistance have been theorised to be the cause of this overproduction of VLDL and triglycerides in the liver. High levels of VLDL cholesterol have also been seen in T2DM, which may lead to modestly elevated levels of LDL cholesterol (Reaven G.M, 1991; M.R. Taskinen, 2002). Cholesterol production and absorption have been linked to obesity, type 2 diabetes, and the metabolic syndrome (Miettinen T.A et. al, 2000, Chan D.C et. al, 2003, Simonen P.P. et. al, 2002). According to Webmd, having too much carbohydrate in your diet is a typical reason for excessive triglycerides. When cells (like muscle cells) that ordinarily respond to insulin are resistant to it, it is indicated by

high TG levels. Because of this, the amount of insulin needed to keep the cells from absorbing glucose increases. This causes blood sugar levels to be higher than usual.

RATIONALE:

- According to the International Diabetes Federation, 537 million adults (20-79 years) are living with diabetes out of which The prevalence of diabetes in India has risen from 7.1% in 2009 to 8.9% in 2019 contributing to burden of diabetes in the world. Currently, 25.2 million adults are estimated to have Impaired Glucose Tolerance, which is estimated to increase to 35.7 million in the year 2045 in India.
- Through cellular and visceral malfunction in the human body, circadian dysrhythmia directly contributes to illness. Intolerance of glucose, insulin, and fat metabolism results from disrupted biological clocks which can result in metabolic syndrome or even diabetes mellitus.
- Unusual eating occasions and times, missing meals, persistent psychological stress, irregular sleeping pattern, and exposure to a "toxic" food environment are traits of our contemporary lifestyles. We also spend more time sitting down, have reduced energy expenditure, and spend more time in the postprandial state. This way of life triggers events like the development of insulin resistance (IR).

OBJECTIVES

➢ Broad Objective:

- To study the association of Chrono nutrition Profile and Type 2 Diabetes Mellitus.

➢ Specific Objectives:

- To identify Chronotype of subjects with type 2 diabetes Mellitus.
- To derive Chrono nutrition profile of subjects with type 2 diabetes Mellitus.
- To assess the correlation of Chrono nutrition profile with Nutritional status of subjects with type 2 diabetes mellitus.
- To assess the correlation of chrono nutrition profile with blood parameters of subjects with type 2 diabetes mellitus.

- To assess the correlation of chronotype and nutrient composition of meal of subjects, sleep pattern and physical activity with type 2 diabetes mellitus.
- To assess the correlation of chrononutrition on social jet lag and glycemic control with type 2 diabetes mellitus
- To assess the correlation of chrononutrition and GI of meals with Type 2 diabetes.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The present chapter includes literature review which focuses on Circadian Rhythm and Circadian clocks, Chrononutrition, Chrononutrition Profile, Chronotype, Circadian misalignment, Non-communicable diseases, Type 2 Diabetes Mellitus, Associate of Diabetes and Triglycerides, Association of Diabetes with chrononutrition, Sleep, Hormones (Melatonin, Insulin, Leptin, Ghrelin, Cortisol), Meal timing & Meal composition. Social Jet lag and Physical Activity.

Circadian Rhythm and Circadian clocks

The circadian clock, an intrinsic regulator found in organisms' cells, keeps biological and behavioural processes in sync with daily environmental changes over the course of two 24-hour cycles (Patke A et. al, 2017). The discovery of the genes that encode biological time in Drosophila, or fruit flies, by geneticist Seymour Benzer and his student Ron Konopka marks the beginning of the science of circadian biology. Many Drosophila core clock protein homologues, such as CLK and PER, function similarly in mammals' circadian timekeeping (Papazyan R et. al, 2016). Jeffry Hall and Michael Rosbash found a protein that is encoded by the gene PER. The amount rises at night and falls throughout the day. The presence of this protein might be a key factor in telling a cell what time it is. PER concentrations steadily rise over the night. A negative feedback loop is when the protein levels eventually drop and the process starts over again. The same kind of biological balancing mechanism regulates circadian rhythms and blood sugar levels throughout the body (The Noble Assembly at Karolinska Institute, 2017). The retina (light input) regulates circadian rhythms, as do the suprachiasmatic nuclei of the hypothalamus (clock genes), and the pineal gland (melatonin synthesis). Daylight or an analogous artificial light source affects retinal cells and travels down the retinohypothalamic tract to the hypothalamic suprachiasmatic nuclei, or "internal clock," in the brain. A physiological system called a biological clock may track the passage of time inside a living thing. According to research by Weger et al., adult stem cell activity, particularly in the brain and neurogenesis, is influenced by the circadian clock.

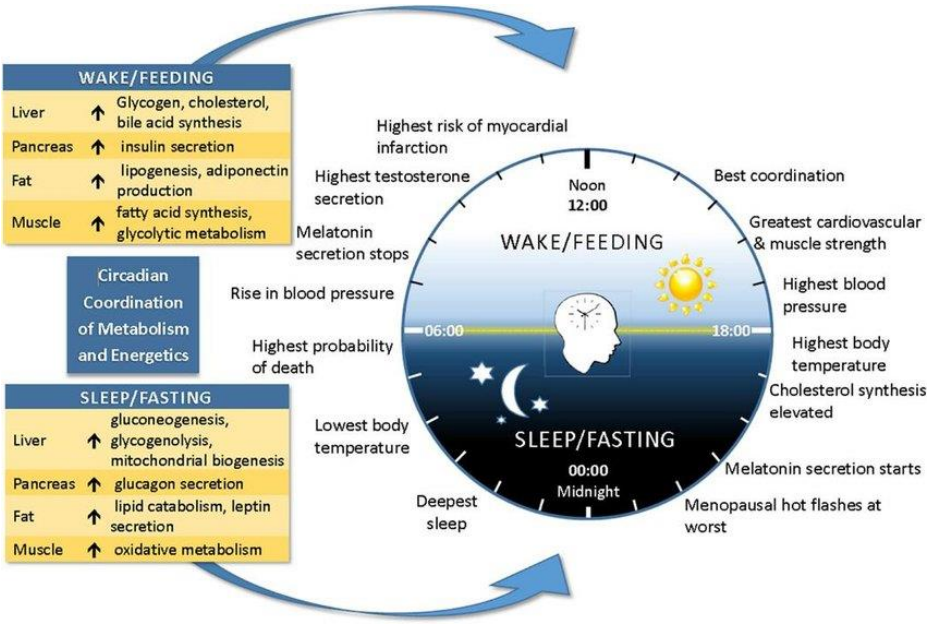


Figure 2.1: Circadian clock (Source: Patterson R et. al, 2016)

Chrononutrition

Recently, a novel field between nutrition and circadian clock system is referred as "chrononutrition" (Tahara Y et. al, 2013 & 2014). Chrono-nutrition includes energy distribution, meal frequency and regularity, eating window length, and the relative weight of these elements on risk of chronic illness and metabolic health. The timing of food consumption throughout the day can have a significant influence on metabolic health and general wellness, according to a growing body of research from both animal and human studies. (Almoosawi et. al.; 2016; Johnston et al.; 2016; Potter et al., 2016; West & Bechtold, 2015). The suprachiasmatic nucleus (SCN) in the hypothalamus, which primarily controls activity-related rhythms including sleep/wake cycles, the autonomic nervous system, core body temperature, and melatonin production, is where the central clock is entrainable by light/dark cycles. Contrarily, feeding/fasting cycles synchronise peripheral clocks found in the majority of tissues, including in a portion of the brain. While feeding cues affect the phase of peripheral clocks that dominate local metabolic rhythms, light/dark cycles entrain the suprachiasmatic nucleus' (SCN) central clock, which dominates activity rhythms. As a result of the clock system's vulnerability to both nutrients and meal time, "chrononutrition" comprises two components: 1) The time of meals impacts how the clock system functions and is regulated by nutrients and dietary components. Regular, time-limited feedings synchronise and magnify the clock system's rhythms, whereas irregular, atypical feedings desynchronize and weaken the rhythms, likely resulting in metabolic

problems (Tahara Y et. al, 2013 & 2014). Nearly every cell and tissue in the body, aside from the SCN, exhibits molecular clock activity, which helps local tissue function during the day and night. Nearly every element of human biology is under the regular control of this network of circadian clocks, ranging from broad behavioural cycles like when we eat and sleep to cellular rhythms in gene expression and energy consumption. It's significant to note that the molecular parts of the circadian clock are also quite susceptible to dietary and hormonal signals associated with food consumption. Under normal conditions, this serves to strengthen our natural cycles, in which timing of food intake is determined by our circadian rhythm and feeds back onto it (West & Bechtold, 2015).

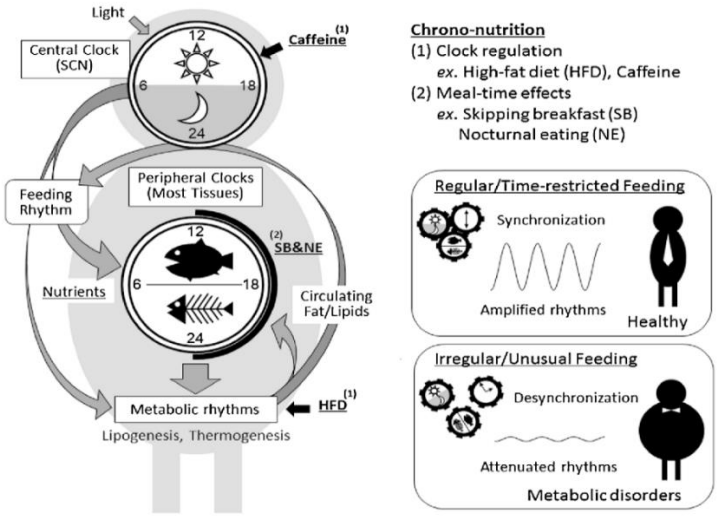


Figure 2.2: Chrononutrition (Source: Hideaki Oike et. al, 2014)

Chrononutrition Profile

The 6 chrononutrition behaviours that make up the chrononutrition profile assist to assess how the six chrononutrition elements are likely to affect a person's health. These six factors—eating window, missing breakfast, evening latency, evening eating, night eating, and biggest meal—help to assess a person's overall chrononutrition behaviour and the optimal timing of food intake. An in-depth evaluation of one's eating habits may be obtained using the Chrononutrition profile alone. Additionally, this can aid in evaluating the chrononutrition profile, identifying the target demographic, and preventing and treating the many health effects linked to poor meal time as well as contributing to an improvement in overall health (Prior, 2020) The Chrononutrition Profile – Questionnaire (CP-Q) used is to analyse the overall chrononutrition habits and favourite eating times. The CP-Q can be used to evaluate chrononutrition alone or

in conjunction with other dietary measurements to give a thorough review of a person's eating habits.

CHRONONUTRITION CUT-OFF	DESCRIPTION	FORMAT	SCORING CUT-OFF (POOR, FAIR, GOOD)
Eating Window	Duration between first eating event and last eating event	HH:MM	14:00 12:01 to 14:00 ≤12:00
Breakfast Skipping	Frequency of breakfast skipping	Days/Week	≥ 4 days/week 2-3 days/week 1 day/week or less
Evening Latency	Duration between last eating event and sleep onset	HH:MM	≤2:00 2:01 to 6:00 >6:00
Evening Eating	Risk of eating late in the waking day	HH:MM	≥23:00 20:00 to 22:59 < 20:00
Night Eating	Frequency of night eating	Days/Week	≥ 4 days/week 2-3 days/week 1 day/week or less
Largest Meal	Meal in which largest amount of food is eaten	Meal Name	Dinner/Supper Lunch Breakfast

Table: 2.1: Chrononutrition Profile Source: (Prior, 2020)

The six components of the chrononutrition behaviour are graded on a scale of poor, fair, and good, with scores of 0, 1, and 2 being assigned to each. The results of the six components are added together to provide a total Chrononutrition profile score that runs from 0 to 12, with 0 denoting good Chrononutrition status and 12 denoting poor Chrononutrition status. This score is used to illustrate the Chrononutrition profile of a specific person. (Prior, 2020)

Chronotype

An individual's "chronotype" determines chrononutrition (Henry et al. 2020). A person's chronotype can be used to express their circadian phenotype, which could include their propensity for morning or evening behaviour. A person's chronotype, which designates whether they are a morning or an evening person, is said to be governed by their internal clock. Chronotype variance among people is influenced by both genetic and environmental factors. The chronotype is impacted by both modifiable and non-modifiable factors. One example of a non-modifiable chronotype determinant is gender. According to certain research, women tend to be more morning-oriented while males tend to be more evening-oriented. Age is a significant factor for defining the chronotype. The morning chronotype was more common in children, whereas a change towards eveningness was detected after puberty and a move towards morningness was shown at the age of 50, showing that ageing affects the chronotype. According to the UK Biobank Study, race is one of the non-modifiable factors that causes Black British people to have a 1.4-times higher likelihood of having morning chronotype than White British people. Social determinants of an individual's chronotype include their way of life, surroundings and family. The circadian clock system may be altered by increased exposure to artificial light at night compared to natural sunshine. In an urban setting, crowding and noise may also disturb sleeping habits. Working hours are crucial for predicting chronotype, as it can be observed that shift workers are more likely to be "certainly evening-type" people and that unemployed individuals are less likely to be "moderately morning-type" people (Suzana Almoosawi et al. 2019a). The effect of food or dietary habits on the peripheral circadian clocks has an impact on chronotype as well. In a Japanese observational research, it was shown that eating foods high in tryptophan, such as meat, bread or rice, fish, natto, and milk, is associated with increased morningness in children aged 0 to 8, but not in children aged 8 and up. Boys of the morning chronotype used to eat more fruits and vegetables than boys of the later chronotypes, although girls of both chronotypes consumed almost the same amounts of these foods (B. Y. M. Yu et al., 2020). Adolescents with evening chrono types were observed to consume more stimulants such coffee, energy drinks, sugar-sweetened beverages, and alcohol and less dairy (Suzana Almoosawi et al., 2019b). The risk of developing chronic illnesses rises as this eating pattern persists from adolescence through adulthood, highlighting the link between irregular meal schedules and the development of cardiometabolic disorders. Adults with morning chronotypes have regular eating habits, whereas adults

with evening chronotypes report consuming a lower percentage of their calories from protein and carbohydrates, a higher percentage of their calories from sucrose, fats and oils, especially saturated fats, and alcohol, and a lower percentage of their calories from vegetables, eggs, and dairy products. This results in an inadequate intake of various vitamins and minerals, including calcium, magnesium, zinc, the B complex vitamins, and vitamin V. Suzana Almoosawi et al.,2019b). Lower BMI is linked to chronotype and early meal time. Early chronotype was linked to lower BMI, larger test meal perceived fillingness, and lower seeking but not liking for high-fat food, whereas early meal timing was linked to lower hunger, greater test meal perceived fillingness, and lower liking and desire for high-fat food. 44 of the 50 individuals who were enrolled in the study—who were between the ages of 18 and 25—completed it. They were not vegetarians, didn't skip breakfast, weren't on a diet, and didn't have any medical issues that would have been influenced by the study's criteria (Kristine Beaulieu et al., 2020)

Circadian Misalignment

Circadian stability is essential for our body's optimal operation (Basnet, 2019) Despite possessing a master circadian clock that is genetically well-regulated, we often engage in activities that distort the circadian clock and the typical rhythm of the light-dark cycle (Suzana Almoosawi et al., 2019b) Circadian misalignment can occur between the central clock and behavioural factors (such as feeding-fasting, wake-sleep, activity-rest), which is known as "central clock-behavioral misalignment," or between the master clock and environmental factors (such as the light-dark cycle) "behavioural inconsistency. It arises from a phase change in the oscillation of the activity- and circadian-regulated physiological systems. In a recent study, it was discovered that chronic disruption of the day-night cycle, one of the most fundamental circadian (daily) rhythms, causes mice to exhibit physiological and behavioural changes that are similar to those seen in people who work shifts or experience jet lag, including weight gain, impulsivity, slower thinking, and other changes (Potter GDM et. al, 2016) Additionally, when there is an imbalance between the body's main clock and the peripheral clocks, it is referred to as "a misalignment inside. Given that humans have a daily rhythm, circadian misalignment can seriously impact the body's normal metabolism. (Carliana Mota and Aparecida Crispim, 2019). The biggest zeitgeber for peripheral circadian clocks and metabolism-related organs like the liver seems to be feeding patterns (Mason et al., 2020; Kim et al., 2015). Even "regular" work hours can

cause a smoother imbalance of circadian rhythm and sleep deprivation, especially among evening chronotypes, although shift work and jet lag clearly affect the circadian system and sleep. This is due to the fact that many people set alarms to wake them up when they would normally be asleep (Potter GDM et. al, 2016). Unusual photoperiod (polar regions), circadian rhythm sleep (wake disorders [non-24-h sleep-wake disorders], senescence, disease states [Alzheimer's disease, Smith-Magenis syndrome, Parkinson disease], and pregnancy, menopause, mental health issues, or medications] are additional causes of circadian disruption. Jetlag or fast time zone transition syndrome (extreme drowsiness and a lack of daytime alertness in those who fly between time zones), shift work sleep problem, and others are common circadian rhythm disorders (people who frequently rotate shifts or work at night), symptoms of a delayed sleep phase (DSPS) Advanced sleep phase disorder (ASPD). People go to sleep sooner and wake up earlier than expected, people have trouble getting up in time for work, school, or social activities, Because the circadian clock is regulated by the light-dark cycle over a 24-hour period, non-24-h sleep-wake disorder and non-24-h sleep-wake disorder (dramatically reduced sleep length and quality at night and issues with tiredness during daytime hours) afflict those who are completely blind (Pavol Vorc 2019). Consuming food at varied time points throughout the day due to social or personal schedules, is believed to be physiologically improper from an evolutionary perspective and hastens the process of circadian misalignment. Chronic disrupted biological clocks lead to intolerable levels of glucose, insulin, and fat metabolism (Sans-Fuentes MA et. al, 2009, Stankiewicz AJ et. al, 2017, Potter GDM et. al, 2016), according to research. Desynchrony can lead to metabolic syndrome or even diabetes mellitus because glucose homeostasis depends on the daily cycle of light and darkness (Poggiogalle E et. al, 2017, Sassone-Corsi P et. al, 2016, Potter GDM et. al, 2016]. It has been established that there is a correlation between the degree of circadian disruption and the severity of illness [McKenna HT et. al, 2017].

Non-Communicable Diseases

According to the World Health Organisation (WHO), non-communicable diseases (NCDs), also known as chronic illnesses, have a tendency to last a long time and are caused by a mix of genetic, physiological, environmental, and behavioural factors. Diabetes, cancer, chronic respiratory conditions including asthma and chronic obstructive pulmonary disease, and cardiovascular illnesses are the four primary

categories of NCDs. Noncommunicable diseases (NCDs) account for 41 million annual fatalities, or 71% of all fatalities worldwide. 15 million of them, between the ages of 30 and 69, pass away from an NCD. Around 5.87 million (60%) of all fatalities in India are attributable to non-communicable diseases (NCDs), with diabetes accounting for 1.6 million of those deaths. (World Health Organization, 2015)

Type 2 Diabetes Mellitus

The International Diabetes Federation (IDF) estimates that 9.3% (463 million) persons had diabetes in 2019, and that by 2045, that number will have risen to 10.9%. (700 million).

In India, there were 77 million diabetics in 2019, and by 2045, that number is projected to rise to 134.2 million. 2019 according to International Diabetes Federation. The second-highest proportion of adult diabetics in the world reside in India. Approximately one in eleven persons today have diabetes mellitus, with type 2 diabetes accounting for 90% of cases (T2DM). (Zheng et al. 2018) According to NFHS-5 (2019–20), about 16.8% of the adult male population and 14.6% of the adult female population in the 22 States/UTs over the age of 15 are projected to have diabetes. In Gujarat, diabetes affects 15.8% of women and 16.9% of men, who require medication to lower their blood sugar levels. While in Vadodara, where 16.6% of women and 15.1% of men have diabetes and take medication, women are more likely to have the disease. (NFHS-5,2019-20)

Diabetes mellitus is a metabolic condition with numerous etiologies defined by persistent hyperglycemia and changes in the metabolism of carbohydrates, fats, and proteins as a result of problems with insulin production, action, or both (Definition, Diagnosis and Classification of Diabetes Mellitus and Its Complications, WHO, 1999). About 90–95% of all instances of diabetes are Type 2 Diabetes Mellitus, also known as Non-Insulin Dependent Diabetes Mellitus (NIDDM), which is distinguished by two main insulin-related abnormalities: insulin resistance and dysfunction of the islets of pancreatic -cells. Muscle, the liver, adipose tissue, and other peripheral tissues become less sensitive to insulin as a result of insulin resistance. Multiple organs' regular functions are disrupted by unchecked or improperly identified hyperglycemia, which can result in immediate or long-term consequences. (Banday et al., 2020b)

The factors that may lead to development of diabetes can be both modifiable and nonmodifiable.

The non-modifiable factors are:

i) AGE: Type 2 diabetes often develops in middle age and grows sharply after that.

ii) SEX: South East Asia has a higher prevalence of diabetes among males.

iii) IMMUNE MECHANISMS: In response to specific environmental triggers, the body's own insulin-producing cells may be attacked by cell-mediated immunity and humoral immunity.

Modifiable factors include:

i) SEDENTARY LIFESTYLE: A sedentary lifestyle is a significant risk factor for the onset of type 2 diabetes mellitus because it modifies how insulin interacts with its receptors and contributes significantly to the disease.

ii) DIET: Saturated fat-rich diets increase the likelihood of developing impaired glucose tolerance. Polyunsaturated fatty acid consumption is linked to a lower incidence of type 2 diabetes. Saturated fatty acid consumption is reduced whereas unsaturated fatty acid ingestion improves insulin sensitivity and glucose tolerance.

iii) DIETARY FIBER: Consuming a lot of fibre lowers blood sugar levels and impairs glucose tolerance.

iv) ALCOHOL: Drinking too much alcohol increases the risk of type 2 diabetes mellitus by harming the liver and pancreas and encouraging fat.

v) OBESITY: The risk of diabetes rises with rising BMI, waist circumference, and waist-hip ratio. In addition to being a risk factor for type 2 diabetes, central obesity is a significant contributor to insulin resistance. Losing weight increases insulin sensitivity and lowers the chance that poor glucose tolerance would progress to type 2 diabetes mellitus. (Park, 2015)

Along with the nutritional shift and the decline in habitual physical activity and energy expenditure, obesity and type 2 diabetes have become more common (Misra A et al.2011, Gulati S et al. 2014). For many South Asians, an unconventional diet with higher overall carbohydrate intake, reduced fibre, and higher levels of saturated fats, trans fats, sugar, and salt has replaced the traditional frugal diet rich in fibre and low in fat (Singh PN et al. 2014, Subedi YP et al. 2013, Gujral UP et al. 2013, Upreti SR et al. 2016, Gulati S et al. 2017). In observational studies with children and adults, it has been shown that skipping breakfast increases with age and is associated with a significant risk of being overweight (OW) and obese (OB), cardiometabolic risk, and a

bad diet plan. Adult short-term intervention trials produced mixed findings. In groups of young people who participated in randomised controlled trials (RCTs) or intervention longitudinal trials lasting longer than two months, the aim of this systematic review was to summarise the relationship between skipping breakfast and body weight, metabolic characteristics, and nutritional quality. When using multi-level approaches, interventions were effective in lowering the prevalence of skipping breakfast. In contrast to RCTs, which had minimal impact, two longitudinal investigations found a significant prevalence of OW/OB in breakfast skippers. A lower-quality nutritional intake was seen in breakfast skippers, according to ten research. This review sheds light on the idea that skipping breakfast is a modifiable marker of the risk of OW/OB and bad dietary practises in kids and teenagers. It is necessary to conduct additional long-term multi-level intervention studies to better understand the connections between breakfast, dietary quality, chronotypes, and cardiometabolic risk in young people. (Ricotti et al. 2021)

Table 2.2: Hormones affect the energy metabolism and are involved in regulating blood glucose levels-

Hormone	**Action**	**Tissue of Origin**	**Metabolic effect**	**Effecton blood Glucose**
Insulin	To regulate the metabolism of carbohydrates and fats by allowing the absorption of glucose from the blood. Fat isstored and is notused for providing energy.	Pancreatic β cells	Helps entering glucose into cells; Stores glucose as glycogen, or converts to Fatty Acids; synthesizes Fatty Acids and proteins; Suppresses breakdown of proteins into Amino Acids, and adipose tissue into Free Fatty Acids.	Lowers

Glucagon	Increases the glucose concentration inblood by breaking down the stored liver glycogen into glucose.	Pancreatic α cells	Releases glucose from glycogen; Synthesizes glucose from amino acids or fatty acids.	Raises
Somatostatin	Inhibits the release of numerous secondary hormones. It inhibits insulinand glucagon secretion.	Pancreatic δ cells	Suppresses release of glucagon from α cells; suppresses release of Insulin, PTH, gastrin & secretin.	Lowers
Epinephrine	Increases blood flow to muscles,output of the heart, pupil dilation, and blood sugar level during fight-or- flight situation.	Adrenal medulla & neurons	Releases glucose from glycogen; Releases Fatty Acids from adipose tissue.	Raises
Cortisol	Released in response to stress and lowblood-glucose	Adrenal cortex	Enhances gluconeogenesis; Acts as Insulin antagonist.	Raises

Diagnosis of Diabetes-

To diagnose diabetes, medical practitioners often utilise the fasting plasma glucose (FPG) test or the HbA1C test. When you have fasted for at least eight hours, you can assess your blood glucose level using a fasting plasma glucose (FPG) test.

A blood test called the HbA1C shows your average blood glucose levels over the previous three months. Random Plasma Glucose (RPG) is a test that can identify diabetes without having to fast, and it is occasionally used by medical experts.

Diagnostic criteria for Diabetes by American Diabetic Association

Diagnosis	Fasting blood Glucose (FBG)	Random Plasma Glucose (RPG)	HbA1c (%)
Normal	<100 mg/dl		<5.7%
Prediabetes	100-125 mg/dl		5.7 to 6.4%
Diabetes	>=126 mg/dl	>200mg/dl	>6.4%

Association of Diabetes and Triglycerides

Dyslipidemia is very common in patients with type 2 diabetes (T2DM). According to previous studies, elevated triglyceride (TG) and decreased high-density lipoprotein cholesterol (HDL-c) are characteristic features of diabetic dyslipidemia [Verges B., 2015; Haffner SM., 2003]. Patients with diabetes have an increased risk of cardiovascular disease (CVD), and low-density lipoprotein cholesterol (LDL-c) is an independent risk factor for CVD. Studies have shown that the TG/HDL-c ratio can be used to predict insulin resistance in Caucasian and Chinese Han populations [Zhou M et al., 2016; Chiang JK et al., 2011; Salazar MR et al., 2012], reflecting the close relationship among TG, HDL-c, and insulin resistance. Lipotoxicity can not only induce insulin resistance but also impair beta cell function. Both chronic hyperglycemia (glucotoxicity) and chronic hyperlipidemia (lipotoxicity) can impair islet beta cell function [Unger RH., 1995]. It has also been suggested that lipotoxicity damages islet beta cell function only under high-glucose conditions (glucolipotoxicity) [Prentki M et al, 2013; Poitout V et al., 2008; Poitout V et al., 2010].

Association of Diabetes and Chrononutrition

A physiological process that occurs during the day called glucose metabolism has a circadian rhythm. Humans have a daytime peak in their glucose tolerance, which then steadily drops throughout the day, peaking at night. Changes in insulin sensitivity, insulin production, and glucose consumption at particular times of the day lead to the circadian rhythmicity that is observed in glucose metabolism. (Henry et al., 2020; Suzana Almoosawi et al., 2019a) A person's chrononutrition (circadian rhythm) and its impact on diabetes are known to interact in a well-established way. With the existing recommendations for primary lifestyle adjustments (i.e. modification to dietary

patterns) having a limited influence in reducing the occurrence of these metabolic disorders, the rate of diagnosis of obesity and type 2 diabetes mellitus continues to rise. The fact that the majority of adults may not be able to follow current dietary recommendations is one of the reasons why nutritional practises have not changed. Indeed, long-term dietary adjustments are difficult since there is constant access to nutrient-poor, energy-dense food. In order to reverse some of the negative impacts on circadian biology brought on by our modern lifestyle, there is an urgent need for improvements in the delivery of evidence-based food therapies. We examine dietary regimes that shift the timing of food intake to intentionally change the feeding-fasting cycle in light of the growing understanding that the length of time food is ingested during a day has substantial impacts on several physiological and metabolic systems. This type of chrono-nutrition works to optimise metabolism by aligning nutrient intake with the acrophases of metabolic cycles to increase whole-body insulin sensitivity and glycemic management, which in turn has a good effect on metabolic health. (Hawley et al. 2020)

However, some lifestyle choices and environmental circumstances might disturb the circadian pattern of glucose metabolism. These factors are:

A) Sleep: The sleep-wake cycle is the most effective way to synchronise the organism with its circadian clock since sleep regulates metabolism. 2019 (Drăgoi et al.). Numerous food and behavioural elements that might have an impact on health are present in the urban environment. The amount of time spent engaging in activities like excessive internet, television, and phone use throughout the day causes a gradual decline in the amount of time allotted for sleeping enough, as exposure to light during the "biological night" affects the sleep activity by impacting the duration and quality of sleep. Negative health impacts have been directly linked to insufficient sleep. Serin & Acar Tek Tek, 2019; Pot, 2018). Lack of sleep makes people more likely to choose unhealthy foods that are heavy in fat and energy and to eat more often. (Garcez et al., 2021) People who don't get enough sleep tend to consume more fat, meat, refined carbohydrates, sugary foods, and alcohol while eating less carbohydrate, protein, dairy products, rice, vegetables, eggs, minerals like potassium, calcium, magnesium, iron, and zinc, and vitamins like vitamin A and D, thiamine, riboflavin, and folate. (2018) (Toktaş, Erman, et al.) Leptin levels were discovered to be low and high ghrelin levels were identified in those who had decreased sleep duration, which was directly associated to increased appetite and might result in a high BMI. This suggests that the

balance between the satiety and hunger hormones has been disturbed. 2020 (Berendsen et al.). Obesity, reduced glucose tolerance, elevated postprandial plasma glucose, and diabetes can all result from the degeneration of the sleep-wake cycle, even in healthy persons. (Serin & Acar Tek, 2019) Short sleep duration has been proven to dramatically increase the chance of acquiring obesity and diabetes, as has eating supper late at night and consuming more calories in the late evening. (Berendsen et al., 2020). 172 diabetics and 188 healthy controls participated in a research that was done in Oman. According to the study, Type 2 Diabetes Mellitus and nighttime sleep duration of less than 6 hours are positively correlated. (Al-Abri et al., 2016)

B) Hormones: Hormones are essential for regulating metabolism and for identifying metabolic diseases and illnesses. Leptin and ghrelin are two hormones that have an impact on how the body regulates the energy balance. Insulin and glucagon help to control blood sugar levels, while growth hormone, thyroxine, and cortisol raise blood sugar levels. Melatonin hormone controls sleep in the body (Qaid & Abdelrahman, 2016) In addition to being impacted by sleep, food, and general lifestyle habits, the way that certain hormones work varies according to the light and dark cycle. Circadian disruption affects an organism's hormonal rhythms and metabolism adversely, which can result in obesity, insulin sensitivity, diabetes, impaired glucose and lipid homeostasis, and reversed melatonin and cortisol cycles (Kim et al., 2015).

i) Melatonin- An indoleamine with the chemical name N-acetyl-5-me-thoxytryptamine, melatonin is an evolutionary hormone whose release is timed to the cycle of light and dark (S. Sharma et al., 2015b). Its secretion from the pineal gland is significantly suppressed by the SCN during the light phase and increased during the dark phase. By exposing the eyes to light, the pineal gland activates or deactivates, producing and releasing the melatonin hormone. Melatonin secretion sets the circadian rhythm in life and begins approximately three months of age. (Kodali, 2017) Strong circadian rhythmicity is demonstrated by melatonin. Melatonin hormone levels are higher at night and decrease in the morning. Between 11:00 pm and 5:00 am, melatonin release reaches its peak, with a 3 to 10 fold rise in blood concentration. (Serin & Acar Tek, 2019). Human sleep is significantly regulated by melatonin (Kim et al., 2015) The melatonin hormone's primary function is to maintain the biological clock and regulate body rhythm. (Serin & Acar Tek, 2019) Because melatonin receptors are found on several peripheral organs, melatonin keeps the circadian rhythm in check. (S. Sharma et al., 2015b) Melatonin affects the release of glucagon and insulin. The regulation of

glucose-induced insulin release is particularly influenced by these fluctuating melatonin levels. Two distinct Gi-protein-coupled melatonin receptors, MT1 and MT2, which are found in the alpha, beta, and gamma cells of the islets of Langerhans in the pancreas and can regulate the insulin production, mediate these functions. Type 2 diabetes may arise as a result of receptor signalling desynchronization or mutations that alter insulin production. (Peschke et al., 2015). The presence of light prevents melatonin production, which disturbs sleep. (Zisapel, 2018) Sleep deprivation lowers insulin secretion and sensitivity. (Kodali, 2017) Within the Nurse's Cohort Health Research cohort, a case-control study was done in which 370 women with type 2 diabetes mellitus from the years 2000 to 2012 were chosen as cases and another 370 women were chosen as controls using risk-set sampling. By linking the melatonin secretion to lifestyle factors, sleep quality, indicators of inflammation, and endothelial dysfunction, the study demonstrated that reduced melatonin production was independently connected with an increased risk of developing type 2 diabetes mellitus. (McMullan et al., 2013). Melatonin administration results in a morning increase in glucose tolerance and insulin sensitivity and a nighttime reduction in insulin sensitivity. Reduced glucose tolerance was seen after sleep deprivation, supporting the theory that melatonin is essential for controlling blood glucose levels, maintaining homeostasis, and lowering the risk of type 2 diabetes mellitus. (S. Sharma et al.,2015b)

ii) Insulin- When blood glucose levels rise, the pancreatic islets of Langerhans generate insulin, a hypoglycaemic anabolic hormone that encourages the storage of energy in peripheral reserves. (Qaid & Abdelrahman, 2016) The body's level of insulin varies with the timing of meals. (Oda, 2015) Between 3:00 and 5:00 a.m. at night, during regular body metabolism, insulin sensitivity and insulin production sharply decline. (Serin & Acar Tek, 2019) Insulin synchronises the clocks of the liver and adipose tissue, highlighting its entrainment in both metabolic syndrome-related organs. (Oda, 2015). With a high blood glucose level toward the conclusion of the inactive phase, shortly before waking up - part of the "dawn phenomenon" - blood glucose is likewise subject to circadian regulation via the SCN (using the hypothalamus as a "relay"). The liver is exporting glucose into the blood at this moment, and tissues, particularly skeletal muscle, are enhancing their absorption (disposal) of glucose. This is all done to prepare you for action. This implies that insulin sensitivity and glucose tolerance are often at their highest early in the morning, along with the fact that insulin levels are at their lowest. Insulin and glucagon work together as an energy regulator between the

fasted and fed states due to their antagonistic effects. (Drăgoi et al., 2019) The pancreas' circadian clock controls how much insulin is secreted and how it reacts to blood glucose levels. (Johnston et al., 2016) Increased beta cell reactivity, insulin sensitivity, and glucose tolerance occur when circadian clocks are in balance. In healthy people, glucose tolerance exhibits circadian rhythmicity, which is greater in the morning and leads to poor glycemic control in the evening and at night. (Paoli et al., 2019) This demonstrates how eating the same thing in the morning and the evening results in different postprandial glucose concentrations and insulin secretions (Kessler & Pivovarova-Ramich, 2019). Alterations to the circadian rhythm decrease the activity of the beta cells, causing them to produce more glucose and insulin, as well as less glucose tolerance and less sleep (Arola-Arnal et al., 2019) Sleep deprivation is significantly linked to the development of glucose intolerance, insulin resistance, lower insulin sensitivity, increased inflammation, and eventually Type 2 Diabetes Mellitus, according to several epidemiological research. (Mirghani et al., 2020; Suzana Almoosawi et al., 2019a). According to a research, a week of extended sleep can restore glucose tolerance and insulin release that had been decreased by circadian misalignment over the previous three weeks together with sleep restriction. 2016 (Johnston et al.) In individuals who lead nocturnal lifestyles, acute or chronic sleep deprivation may produce insulin resistance at the level of cell signalling, which results in insulin resistance, glucose intolerance, and raises the risk of type 2 diabetes mellitus. (Kim et al., 2015)

iii) Leptin- Leptin is released by adipocytes and has a role in controlling food intake by acting on the hypothalamus to reduce hunger. (Noble & Smith, 2015) Leptin and ghrelin, hormones that control hunger and appetite, have receptors in the suprachiasmatic nucleus. (Drăgoi et al., 2019) It is a key regulator of energy balance, and leptin resistance, which characterises body obesity, causes hyperleptinemia. Obesity and diabetes mellitus are two metabolic diseases that result from impaired leptin signalling. (Ramos-Lobo & Donato, 2017). The SCN has direct control over leptin secretion from adipose tissue, which peaks at midday (the busiest time of the day) and troughs around midnight. After just a few days of circadian misalignment, leptin production is suppressed, which causes glucose levels to rise and raises the risk of obesity and diabetes (Serin & Acar Tek, 2019). (Johnston et al., 2016) With 10 days of forced desynchronization, leptin levels in healthy subjects fell by 17%. (Anothaisintawee et al., 2018) The irregular time of meal intake is associated with

changes in satiety signals and lower serum leptin levels, which increase hunger and lead to irregular eating patterns, particularly at night, and lower energy expenditure (Azmi et al., 2020; Arola-Arnal et al., 2019). The timing of carbohydrate and fat ingestion impacts the leptin blood levels on average. (Kessler \s& Pivovarova-Ramich, 2019) According to Kim et al. (2015), leptin levels were shown to be at their lowest during sleep deprivation and circadian disturbance, which increases hunger and raises BMI (Berendsen et al., 2020). It can also cause severe insulin resistance, which is directly linked to hyperglycemia. (Ramos-Lobo & \sDonato, 2017)

iv) Ghrelin- Developed from the stomach of rats, ghrelin is a 28-amino acid peptide. (Lindqvist and others, 2020) Human stomach A-like cells release ghrelin, which has orexigenic and adipogenic effects that lead to an increase in food intake and body weight and play a significant role in energy balance. (Muhammad et al.2017) Ghrelin is mostly produced in the stomach, although it is also secreted in minor amounts by the pancreas and intestine. Additionally, it was discovered that ghrelin cells, which make up the fifth kind of islets of Langerhans cells and account for less than 1% of total islets of Langerhans cells, were present. (Lindqvist and others, 2020). The morning is when ghrelin levels are at their lowest and follows a circadian rhythm. (ArolaArnal et al.2019) The Suprachiasmatic Nucleus regulates hunger and satiety signals via the hypothalamus and possesses leptin and ghrelin receptors in the heart and adipose tissue. (Drăgoi et al., 2019). The timing and frequency of meals have an impact on the release of ghrelin from the stomach, which is not centrally regulated. The longer the time since the last meal, the greater the ghrelin level. It is probably controlled by the stomach's peripheral clock, with release being amplified during the active period. Along with increasing food intake, it also stimulates stomach emptying and gastric acid production. Additionally, ghrelin increases taste perception, olfactory sensitivity, and locomotor activity in response to food rewards. (Poher et al., 2018) Ghrelin levels modestly rose after 3 weeks of limited sleep and circadian misalignment. (Anothaisintawee et al., 2018) Lack of sleep raises ghrelin levels, which enhances feelings of hunger and suppresses feelings of fullness. This increases appetite both during the day and at night, raising BMI. (Garcez et al., 2021; Azmi et al., 2020; Berendsen et al., 2020). The glucose metabolism is impacted by ghrelin's stimulation of glucagon production. (Poher et al., 2018) Total plasma ghrelin levels have been observed to be greater in lean people and lower in obese people. (Ahmed et al., 2017)

Ghrelin's diabetogenic effects are therefore observed in obese people. (Mani et al., 2019)

v) Cortisol- The major glucocorticoid produced in the zona fasciculata of the adrenal cortex is cortisol. In reaction to a biological stress, it is released. The circadian rhythmicity of cortisol is demonstrated by its levels rising in the early morning (peaking at around 8 a.m.) and gradually falling in the evening and also during the first stages of sleep. (D. Y. Lee et al., 2015) The SCN exerts significant circadian control over glucocorticoids (cortisol in humans), which peak at the beginning of the activity period (upon waking). The tissue or organ and the presence of other hormones, notably insulin, affect how this cortisol acts. The peripheral clock in the pancreas' active phase, which may be synchronised to the SCN, substantially regulates how much insulin is released. Nevertheless, the availability of glucose continues to be the primary factor in the release of insulin, with insulin levels normally being at their lowest towards the conclusion of the inactive period. When the hypothalamic-pituitary-adrenal (HPA) axis is active, the hypothalamus releases corticotropin-releasing hormone (CRH) and the anterior pituitary gland is stimulated to release adrenocorticotropic hormone (ACTH). In reaction to stress, ACTH then encourages the adrenal gland to produce cortisol. (Joseph & Golden, 2017) Lack of sleep has been linked to an increase in cortisol owing to the hypothalamic-pituitary-adrenal HPA axis' inability to regulate itself. This overabundance of glucocorticoids can have significant negative consequences on the body. (Hirotsu et al., 2015). In a trial with just 4 hours of sleep every night for six straight days, the efficacy of glucose and the immediate insulin response decreased by 30%. (Hirotsu et al.2015) The islets of Langerhans of the pancreas become dysfunctional as a result of circadian rhythm disturbance or sleep deprivation, which disrupts the cortisol cycle and eventually promotes the development of insulin resistance, glucose intolerance, and Type 2 Diabetes Mellitus. (Briançon-Marjollet et al. 2015)

C) Meal timings & Meal consumption

The time of meals has a significant impact on the circadian rhythm of the peripheral organs, which controls metabolic processes and is essential for metabolic health (Kessler & Pivovarova-Ramich, 2019; Réda et al., 2020). Regular meal times can alter how the master circadian clock and peripheral clocks communicate, which can cause glucose intolerance (Henry et al., 2020) While the final meal of the day promotes lipogenesis and the formation of adipose tissues, the first meal of the day modifies the

circadian rhythm of the peripheral clocks. Consuming breakfast improves the quality of the diet throughout the day. (Azmi et al., 2020) Breakfast consumption of a meal high in carbohydrates suggests a preventive effect against the onset of diabetes and metabolic syndrome. (Kessler & Pivovarova-Ramich, 2019) Breakfast protein consumption reduces ghrelin levels, enhances satiety, and promotes feelings of fullness. (Azmi et al., 2020) Overweight/obesity can result from people skipping breakfast since they ate more calories at lunch, snacks, and dinner, as well as more calories and carbohydrates. (S. Almoosawi et al., 2016) The thermal impact of foods is significantly influenced by the time of meals. When compared to eating in the evening and at night, eating in the morning has a greater rate of diet-induced thermogenesis. (Serin & Acar Tek, 2019) Skipping breakfast causes postprandial insulin levels to rise, promotes fat oxidation and inflammation, and may compromise glucose homeostasis. (Paoli et al., 2019) The risk of acquiring type 2 diabetes mellitus is increased in those who skip breakfast and eat at unsuitable times despite receiving hunger signals as a result of a disturbed biological clock.

The risk of acquiring type 2 diabetes mellitus is increased in those who skip breakfast and eat at unsuitable times despite receiving hunger signals as a result of a disturbed biological clock. Men who miss breakfast had a 21% higher chance of getting Type 2 Diabetes Mellitus than men who eat breakfast, according to a 16-year follow-up cohort research conducted in the USA. In those with type 2 diabetes mellitus, skipping breakfast increases insulin resistance. People with Type 2 diabetes mellitus who skipped breakfast later chronotyped exhibited worse glycemic control and higher HbA1c levels. (Henry and others, 2020) Late eating was linked to lower glucose tolerance, lower resting energy expenditure, and lower food thermal impact. (Azmi et al.,2020) After eating a late-night meal, postprandial hyperglycaemia was observed during the sleep hours, lowering glucose tolerance. A cohort research found that older men and women who ate a lot of calories at supper had a 2 times higher prevalence of type 2 diabetes mellitus. A cohort research showed a connection between eating supper late and a rise in HbA1c in those with diabetes. These studies show that timing of meals is just as important to glucose metabolism as what you eat and how much of it you consume. (Henry et al., 2020) The amount, type, and pace at which dietary carbohydrates are digested influence postprandial glucose levels and the insulin response. (Henry et al., 2020)

According to epidemiological research, eating more carbs than lipids in the morning

can help ward against type 2 diabetes mellitus. Reducing the total sugar and saturated fat level of supper was found to directly enhance glycemic response in a randomised crossover experiment that evaluated two isocaloric meals that only differed in total sugar and saturated fat content. When ingested in the evening, green tea with catechins lowers postprandial plasma glucose levels, whereas a prospective cohort research has found that those who drink coffee at lunch have a protective effect against diabetes. These significant claims put forth the idea that the dietary components, as determined by the time of ingestion, are related to the peripheral circadian clocks. (Henry et al.,2020)

Recent research has revealed that extending the time spent eating each day may hasten the development of chronic diseases. The diet known as time-restricted eating (TRE) places further restrictions on this daily food window. It can be a dietary strategy that will likely enhance health indicators. TRE caused a reduction of fat mass and an average 3% weight loss. Additionally, this fat loss was seen without any calorie limitation. It's interesting that TRE generated positive metabolic effects without causing weight reduction, indicating an intrinsic effect based on the circadian clock and feeding schedule realignment. Based on chrononutrition principles, TRE is a straightforward and highly-tolerated diet that produces a variety of positive health impacts. mechanisms and to determine how well they apply to human health. (Adafer et al. 2020)

D) Social Jetlag:

Social jetlag is a less well-known but more persistent circadian rhythm disturbance. People frequently utilise alarm clocks and/or medicine to match their sleep and wake hours with social commitments (such as work and school schedules) rather than with their naturally regulated sleep-wake timings, which is referred to as social jetlag (Wittmann et al., 2006; Roenneberg et al., 2012). According to several studies (Wittmann et al., 2006; Roenneberg and Merrow, 2007; Roenneberg et al., 2012; Rutters et al., 2014), social jetlag is quite common and is thought to affect physiological systems including blood pressure and glucose metabolism. In addition to raising heart rate and cortisol levels among the general population, social jetlag has been linked to higher body mass index (BMI) in overweight individuals (Roenneberg et al., 2012; Parsons et al., 2015). According to a population-based cohort study, social jetlag was linked to a two-fold higher risk of the metabolic syndrome, diabetes mellitus, and prediabetes, particularly in people under the age of 61. These findings

support the notion that even little alterations in circadian misalignment are linked to undesirable health consequences, including metabolic syndrome and even diabetes and prediabetes. Therefore, possible social jetlag therapies, including straightforward behavioural adjustments like maintaining a normal sleep-wake cycle, may have positive impacts on the emergence of the metabolic syndrome and type 2 diabetes mellitus, particularly in younger (61 years) individuals (Koopman A et al., 2017).

E) Physical Activity:

In the treatment of Type 2 Diabetes Mellitus, exercise is crucial. People are encouraged to exercise every day or every other day in order to achieve the current physical activity standards, which call for 75 minutes of vigorous intensity exercise or at least 150 minutes of moderate activity each week (Henson et al.2020) Exercise is a type of physical activity that involves deliberate, methodical, and repetitive body motions that are carried out to enhance or preserve overall bodily fitness. Exercise enhances sleep quality, preventing chronic illnesses brought on by lack of sleep. (Cai et al., 2017). Exercise significantly alters body composition because it increases fat oxidation, which lowers visceral and subcutaneous fat while maintaining lean body mass. As insulin resistance has a circadian rhythm, aerobic exercise when done for the right amount of time and at the right intensity can lead to an improvement in glycemic control when done in the afternoon or evening. Among older persons with prediabetes, exercise also results in a decrease in appetite and in the consumption of carbohydrates, sugar, sweets, and desserts. (Parr et al., 2020) When people with diabetes exercise frequently, their blood sugar management, insulin resistance, and blood pressure all improve. (Cai et al., 2017) There is a connection between when you exercise and your health and the impact of meal time on glycemic management. Heden et al. indicated that when compared to exercising before the meal, people with Type 2 Diabetes Mellitus who exercised after eating had significantly lower blood glucose levels. When people with poor glucose tolerance engage in even brief bouts of exercise, their glucose absorption increases diabetes type 2 and glucose tolerance. According to studies, exercising for more than 150 minutes every week exercise lowers HbA1c by 0.89 percent. (Teo et al., 2018)

The above review of various literature shows a clear association between chrononutrition, chronotype, meal timing, meal composition, hormones, stress, sleep, social jet lag and physical activity.

METHODS AND MATERIALS

METHODS & MATERIALS

This chapter states the study design and discusses the methods and materials that are used to accomplish the stated objectives.

Sample Size: 227 subjects

- Required sample size was obtained using formula $n = (3.84)\ pq / L^2$,

(Sample size for estimation of proportion) at 5% level of significance.

- p = 15.9% (average of high blood sugar in men and women as 15.1% and 16.6% respectively, as per NFHS-5, Vadodara district factsheet), and q = 1 – p.
- Absolute precision (L) was taken as 5%.
- Design effect was taken as 1.
- Thus, the required sample size was 206
- Considering 10% attrition, the total sample was calculated as 227.

Sampling Technique: The sample size will be selected through Random Sampling.

Study design: This study is a Cross-section Study, based in Urban Vadodara.

Inclusion Criteria:

- Both Men and Women
- 35-60 years
- Those who have been diagnosed with Type 2 Diabetes Mellitus from past 0-5 years.
- Having controlled diabetes.
- Subjects without secondary complications.
- Subjects on oral hypoglycaemic drugs
- Willingness to participate.

Exclusion Criteria:

- Subjects with poor compliance for follow up at the clinic.

A total of 227 participants will be enrolled in the study.

Written informed consent will be taken from the subjects who agree to participate in the study.

The following information will be collected through the structured questionnaire:

- Personal information,
- Diet information,
- Consumption of ultra-processed foods,

- Chronotype,
- Physical activity,
- Screen time,
- Stress,
- Sleep,
- Social Jetlag,
- Anthropometric data
- Biochemical parameters

The following data will be collected through the personal interview technique.

- **Personal Information**: The personal information including name, age, gender, education qualification, occupation and type of family will be collected from the participants.

  Education qualification will be classified into 7 categorized according to kuppuswamy scale.

Table 3.1: Educational Qualification Categorization:

Category
Illiterate
Primary School
Secondary School
Higher Secondary
Diploma
Graduate
Post-Graduate

Source: (MODIFIED KUPPUSWAMY SCALE | PSM Made Easy)

The occupation will be categorised according to National Occupation Classification into the following categories:

Table 3.2: Occupation categories according to National Classification:

Occupational Categories:
Business owner/ self employed
Professionals
Government / Civil service
Manager/ Supervisor
Clerks
Sales / Service workers
Agriculture and fishery worker
Home-maker
Retired

Source: National classification of occupation (Ii, 2015)

- **Diet Information** will be collected using a 24-hour dietary recall for 3 days. According to National Cancer Institute, The A 24-hour dietary recall is a structured interview that captures the detailed information about all foods and beverages consumed by the respondent in the past 24 hours, most commonly, from midnight to midnight the previous day. The 3 days 24-hour diet recall will be converted into raw ingredients and then quantified using the Dietcal software developed by Ms. Gurdeep Kaur, Chief Dietitian at AIIMS, New Delhi.

- **Glycaemic Index of Meals** was calculated using the following formula:

$$Average\ Dietary\ GI = \left\{\sum_{x=1}^{n}(GI_x \text{ X } g_x)\right\}/G$$

Source: (Journal of the American Academy of Nutrition and Dietetics, 2012)

where GIx is the GI for food x, and n is the number of foods eaten per day; gx represents available carbohydrate in gram weight of food x; and G is the total available carbohydrate eaten per day. The GI values derived for day 1, day 2 & day 3 were then averaged.

- **Consumption of Ultra-processed foods** information will be collected using the food frequency questionnaire. According to National Cancer Institute, a food frequency questionnaire (FFQ) is an advanced form of checklist of finite list of foods and

beverages which collects the information about how often the specific food is consumed over a specific period by the respondent.

- **Chronotype** will be assessed using the Horne and *Ostberg Morningness-Eveningness* Questionnaire. There are 19 questions in the questionnaire to determine *morningness-eveningness* in human circadian rhythms. Scoring ranges from 16-86. Scores from 16 to 30 indicates "Definitely Evening", 31 to 41 indicates "Moderate Evening", 42 to 58 indicate "Intermediate types", 59 to 69 indicates "Moderate Morning" and 70 to 86 indicates "Definite Morning".

- **Physical Activity:** The Physical activity will be assessed using the Global Physical activity Questionnaire (GPAQ). The Global Physical Activity Questionnaire was developed by WHO for physical activity surveillance in countries. It collects information on physical activity as well as sedentary behaviour and comprises of 16 questions. The domains are: 1) Activity at work 2) Travel to and from places and 3) Recreational activities. Information on type of activity and duration of activity was obtained from the GPAQ questionnaire and the Exercise Energy Expenditure (EEE) was calculated using the following formula EEE=Time (hour) × RMR/24 × MET.

- **Sitting Time:** Sitting time will be assessed using the thresholds defined in the study "Sitting time and all-cause mortality risk in 2012. The categories are as follows:

Table 3.3: Sitting hours and associated risk:

Category of Risk	Hours of Sitting
Low risk	< 4 hours/ day
Medium Risk	4-8 hours/ day
High Risk	8-11 hours/ day
Very High Risk	>11 hours / day

Source:(van der Ploeg et al.)

- **Stress:** Stress among the participants will be assessed using the perceived stress scale by Sheldon Cohen. The Perceived Stress Scale (PSS) is the most widely used psychological instrument for measuring the perception of stress. It is a measure of the

degree to which situations in one's life are appraised as stressful. Scoring of the PSS ranges from 0 to 40. Higher the scores, higher the perceived stress. Scores ranging from 0-13 are considered low stress, scores ranging from 14-26, moderate stress and scores ranging from 27-40 are considered as high perceived stress.

- **Sleep:** The Pittsburgh Sleep Quality index (PSQI) will be used to assess the sleep quality among participants. The PSQI contains 19 self-rated questions and 5 questions rated by the bed partner or roommate. The scoring is divided into 7 components which has a range of 0-3 points with "0" scoring indicating no difficulty, while scoring of "3" indicating severe difficulty. The score of the 7 components are then added and one "global" score is obtained that ranges from 0-21 where "0" indicates no difficulty and "21" indicates severe difficulties in all areas. A global score of 5 or more indicates poor sleep quality.

- **Social Jet lag:** The Munich Chronotype Questionnaire is a self-rated scale developed in ages 6 to > 65 years and focuses primarily on sleep timing and with 14 questions assesses the regularity of one's work schedule, number of workdays per week, sleep timing on workdays and work-free days, and alarm clock use on workdays and work-free days. Chronotype is estimated as the midpoint of sleep on work-free days minus half of the difference between sleep duration on work-free days and average sleep duration of the week to control for sleep debt (midpoint of sleep on work-free days, sleep-corrected, MSFsc). Thus, the MSFsc is in essence a subjective report of sleep timing. Importantly, MSFsc can only be calculated when individuals do not use an alarm clock on work-free days.

- **Anthropometric data** will be collected at the hospital which includes:

  Weight: The weight will be measured using Omron Full Body Sensor Body Composition Monitor and Scale Model HBF-224
  Height: The Height was measured using the heightometer.
  BMI: According to the NHLBI, BMI is calculated as weight in kilograms divided by the square of the height in meters (kg/m^2) and has been categorised into four groups according to the Asian-Pacific classification.
  BMI = Weight (in kg) / Height (m^2)

Table 3.4 BMI Asia-pacific classification:

Category	Asia Pacific BMI Cut-offs
Under weight	<18.5
Normal	18.5-22.9
Over-weight	23-24.9
Obese	>25

Waist Circumference: Waist circumference is measured at the midpoint between the lower margin of the least palpable rib and the top of the iliac crest, using a stretch-resistant. According to American Diabetes Association, the normal cut-off of waist circumference for Asian men was 85cm and 80 cm for Asian women.
Hip Circumference: Hip circumference Is measured around the widest portion of the buttocks, with the non-stretching tape parallel to the floor.

Waist-Hip Ratio: The Waist Hip Ratio is calculated by dividing the waist measurement by hip measurement. The formula is: *WHR= waist circumference / hip circumference. According to American Diabetes Association the* normal Waist-Hip Ratio for Indian men is 0.88 and for women it is 0.81.
Waist-Height Ratio: The Waist-Height ratio is calculated by dividing the waist measurement by height. 0.5 is the cut-off for Waist-Height Ratio that is accepted universally to measure central obesity in children above 6 years and adults.

The Body fat, Visceral fat and Skeletal muscle were measured using the Omron Full Body Sensor Body Composition Monitor and Scale (Model HBF-224) that estimates the body fat percentage by the Bioelectrical Impedance Method having weak electrical current of 50 kHz and less than 500 µA. Body tissues having high water content include muscles, blood, bones conduct electricity easily. While body fat doesnot store much water, therefore has little electric conductivity and higher resistance which slows the rate of travel of current and therefore helps to estimate the fat, visceral fat and muscle content of the body.

Body Fat: Body fat serves a vital role in storing energy and protecting internal organs. We carry two types of fat in our bodies: 1) essential fat which is stored in small amounts to protect the body and 2) stored fat which is stocked for energy during

physical activity. While too much body fat may be unhealthy, having too little fat can be just as unhealthy. Body fat was classified according the cutoffs provided by the omron heath care.

Table 3.5 Body Fat Percentage Classification:

Classification	Male	Female
Low (-)	5.0-9.9 %	5.0 – 19.9 %
Normal (0)	10.0 – 19.9 %	20.0 – 29.9 %
High (+)	20.0 – 24.9 %	30.0 – 34.9 %
Very High (++)	≥ 25.0 %	≥ 35.0 %

Source: (Omron health care)

Visceral Fat: Visceral fat is found in the abdomen and surrounding vital organs. It is different from the subcutaneous fat. Visceral fat can be seen through Magnetic Resonance Imaging (MRI). Too much visceral fat is thought to be closely linked to increased levels of fat in the bloodstream, which may lead to conditions such as high cholesterol, heart disease and type 2 diabetes.

Table 3.6 Classification of Visceral Fat:

Category	Cut-off
Normal	<=9
High	10-14
Very High	>=15

Source: (Omron health care)

Skeletal Muscle: Skeletal muscles is attached to the skeleton and come in pairs -- one muscle to move the bone in one direction and another to move it back the other way. Increasing skeletal muscle will increase your body‟s energy requirements. Building skeletal muscle can help prevent “rebound” weight gain. The maintenance and increase of skeletal muscle is closely linked to resting metabolism rate.

Table 3.7: Classification of Skeletal Muscle:

Gender	**Age**	**Low (-) (%)**	**Normal (0) (%)**	**High (+) (%)**	**Very High (++) (%)**
Female	**18-39**	**< 24.3**	**24.3 – 30.3**	**30.4 – 35.3**	**≥ 35.4**
	40-59	**< 24.1**	**24.1 – 30.1**	**30.2 – 35.1**	**≥ 35.2**
	60-80	**< 23.9**	**23.9 – 29.9**	**30.0 – 34.9**	**≥ 35.0**

Male	**18-39**	**< 33.3**	**33.3 – 39.3**	**39.4 – 44.0**	**≥ 44.1**
	40-59	**< 33.1**	**33.1 - 39.1**	**39.2 – 43.8**	**≥ 43.9**
	60-80	**< 32.9**	**32.9 – 38.9**	**39.0 – 43.6**	**≥ 43.7**

Source: (Omron health care)

- The **Biological parameters** will be collected from the patient's case file which includes the following:

Fasting Blood Glucose: According to ADA, FPG is a test that measures the blood glucose level at one point after fasting for at least 8 hours.

Table 3.8: Classification of Fasting Blood Glucose:

Category	**Cut-off**
Normal	<100 mg/dl
Pre-diabetes	100-125 mg/dl
Diabetes	>=126 mg/dl

Source: (*Diagnosis | ADA*)

Random Blood Glucose: According to ADA, it is a blood test that can be done at any time of the day. Diabetes is diagnosed at blood sugar of **greater than or equal to 200 mg/dl.**

Post-prandial Blood Glucose: It is a blood test that is done after 2 hours of consuming any meal.

HbA1c: According to ADA, the HbA1C is a test that measures the average blood glucose of past 2-3 months.

Table 3.9: Classification of HbA1c:

Category	**Cut-off**
Normal	less than 5.7%
Pre-diabetes	5.7% to 6.4%
Diabetes	6.5% or higher

Blood pressure: According to American Heart Association, blood pressure is a

pressure that pushes blood through arteries, veins and capillaries. The blood pressure is the result of two forces: 1) Systolic pressure occurs as blood pumps out of the heart and into the arteries that are part of the circulatory system. 2) Diastolic pressure is created as the heart rests between heart beats.

Table 3.10: Classification of Blood Pressure:

Category	**Systolic pressure (mm hg)**	**Diastolic pressure (mm hg)**
Normal	<120	<80
Elevated	120-129	<80
High BP (Stage 1)	130-139	80-89
High BP (Stage 2)	>=140	>=90

Source: (*Hypertension Guideline Resources | American Heart Association*)

Cholesterol: According to National Heart, Lung and Blood Institute (NHLBI) cholesterol is a waxy, fat-like substance made in the liver, and found in the blood and in all cells of the body.

LDL and HDL are two types of lipoproteins. They are a combination of fat (lipid) and protein. The lipids need to be attached to the proteins so they can move through the blood. LDL and HDL have different purposes:

Low Density Lipoprotein: LDL stands for low-density lipoproteins. It is sometimes called the "bad" cholesterol because a high LDL level leads to a build-up of cholesterol in your arteries and increases the risk for heart attack, stroke and peripheral artery disease. (PAD)

High Density Lipoprotein: HDL stands for high-density lipoproteins. It is sometimes called the "good" cholesterol because it carries cholesterol from other parts of your body back to your liver. Your liver then removes the cholesterol from your body.

Triglycerides: Triglycerides are a type of fat. They are the most common type of fat in your body.

Table 3.11: ATP III Classification of LDL, Total, and HDL Cholesterol (mg/dL)

TOTAL CHOLESTROL	
Desirable	<200 mg/dl
Border High	200-239 mg/dL
High	>=240 mg/dL
LDL CHOLESTROL	
Optimal	<100 mg/dL
Near Optimal	100-129 mg/dL
Borderline high	130-159 mg/dL
High	160-189 mg/dL
Very high	>=190 mg/dL
HDL CHOLESTROL	
Low	<40 mg/dL
High	>=60 mg/dL
TRIGLYCERIDES	
Normal	<150 mg/dL
Borderline High	150-199 mg/dL
High	200-499 mg/dL
Very high	>500 mg/dL

Source: (*High Blood Cholesterol ATP III Guidelines At-A-Glance Quick Desk)*

TG/HDL Ratio: The TG/HDL Ratio is also known as Castelli Index (CI) is suggested to be an excellent predictor of coronary artery disease (CAD) as proposed by Dr. William Castelli. A **TG**/**HDL ratio** of < 2 is considered as normal and the suggested target for TC/**HDL** is < 4.5.

TyG Index: The Triglyceride glucose index, which is derived from triglycerides (TGs), and fasting glucose levels is a simple surrogate marker of insulin resistance among adolescents compared with HOMA-IR (B Kang et al, 2017). The TyG cut off is <4.68

TyG index = [fasting TG (mg/dL) x fasting glucose (mg/dL)/2].

After collecting the above information, the Chrononutrition profile of the individuals will be assessed.

- **Chrononutrition Profile:** Chrononutrition profile will be assessed using the chrononutrition profile scoring method developed by Allison Christine Engwall. Six

chrononutrition behaviour cut-off scores are categorized into one of three 'chrononutrition behaviour cutoffs' for each chrononutrition behaviour (0=good, 1=fair, and 2=poor). These scores will then totalled to obtain Chrononutrition Profile score which represents one's chrononutrition profile. Scoring ranges from 0 to 12 with 0 indicating good chrononutrition status and 12 indicating poor chrononutrition status. (Prior, 2020)

Table 3.12: Chrononutrition behaviour descriptions and scoring cut-offs for the Chrononutrition Profile:

CHRONONUTRITION CUT-OFF	**DESCRIPTION**	**FORMAT**	**SCORING CUT-OFF (POOR, FAIR, GOOD)**
Eating Window	Duration between first eating event and last eating event	HH:MM	> 14:00 12:01 to 14:00 ≤ 12:00
Breakfast Skipping	Frequency of breakfast skipping	Days/Week	≥ 4 days/week 2-3 days/week 1 day/week or less
Evening Latency	Duration between last eating event and sleep onset	HH:MM	≤2:00 2:01 to 6:00 >6:00
Evening Eating	Risk of eating late in the waking day	HH:MM	≥23:00 20:00 to 22:59 < 20:00
Night Eating	Frequency of night eating	Days/Week	≥ 4 days/week 2-3 days/week 1 day/week or less
Largest Meal	Meal in which largest amount of food is eaten	Meal Name	Dinner/Supper Lunch Breakfast

(Source: Prior, 2020)

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The present investigation was undertaken to study the "Association of Chrononutrition with glycaemic control, body composition & social jet lag in people with Type 2 Diabetes Mellitus." This chapter presents the results and their discussions in eleven sections as mentioned in the "Chapter: Methods and Materials".

Section 4.1- Personal Information

Table 4.1.1: Personal details of the study participants

Variables	**Male**	**Female**
	N (%)	N (%)
Age Group		
35-39 years	13 (10.5)	14 (13.6)
40-44 years	12 (9.7)	22 (21.4)
45-49 years	29 (23.4)	24 (23.3)
50-54 years	33 (26.6)	13 (12.6)
55-60 years	37 (29.8)	30 (29.1)
Educational Qualification		
Illiterate	02 (1.6)	05 (4.9)
Primary School	27 (21.8)	32 (31.1)
Secondary School	21 (16.9)	08 (7.8)
Higher Secondary	25 (20.2)	13 (12.6)
Diploma	29 (23.4)	08 (7.8)
Graduate	18 (14.5)	37 (35.9)
Post-Graduate	02 (1.6)	-
Occupation		
Business owner/ self employed	43 (34.7)	05 (4.9)
Professionals	19 (15.3)	08 (7.8)
Government / Civil service	04 (3.2)	-
Manager/ Supervisor	01 (0.8)	02 (1.9)
Sales / Service workers	35 (28.2)	03 (2.9)
Home-maker	05 (4.0)	85 (82.5)
Retired	17 (13.7)	-

Table 4.1.1 provides the personal information of 227 participants. It can be noted that majority of male (29.8%) and female participants (29.1%) were between the ages of 55 and 60, with 23.3% women between the ages of 45 and 49 and 26.6% male between the ages of 50 and 54.

Male participants' education ranged from illiterate (1.6%) to post graduation (1.6%) with most participants having a diploma (23.4%) or high school education (25%). Female participants' education ranged from illiterate (4.9%) to secondary school and diploma (7.8%) with most participants being a graduate (35.9%) or primary school education (31.1%).

Majority (82.5%) of females participants were home-makers while only (1.9%) were managers/supervisors and none were government/civil service workers or retired. Maximum number of male (34.7%) were business owner/ self employed followed by sales/service workers (28.2%) and professionals (15.3%).

Section 4.2- Anthropometric measurements

Table 4.2.1: Anthropometric Profile of people with diabetes

Variables	**Cut-off**	**Mean** ± SD	**N (%)**	**Cut-off**	**Mean** ± SD	**N (%)**
	Male			**Female**		
Number of Participants	**124**			**103**		
Waist Circumference						
Normal	≤ 85	80.8 ± 3.8	13 (10)	≤ 80	74 ± 2.8	19 (18)
High	>85	98.5 ± 6.9	111 (90)	> 80	95.6 ± 7.6	84 (82)
Waist-Hip Ratio						
Normal	≤ 0.88	0.8 ± 0.0	15 (12)	≤ 0.81	0.8 ± 0.0	16 (16)
High	> 0.88	0.9 ± 0.0	109 (88)	> 0.88	0.9 ± 0.0	87 (84)
Waist-Height Ratio						
Normal	≤ 0.5	0.5 ± 0.0	10 (8)	≤ 0.5	0.45 ± 0.0	1 (1)
High	> 0.5	0.6 ± 0.0	114 (92)	> 0.5	0.6 ± 0.0	102 (99)

Table 4.2.1 shows that only 10% of the male participants had a normal waist circumference with a mean value of 74 ± 3.8 while a majority (90%) of the male participants were in the high risk category with a mean value of 95.6 ± 6.9.

Majority female participants (82%) with a mean value of 95.6 ± 7.6 were in the high risk category of waist circumference. Majority (88%) of the male participants with a mean value of 0.9 ± 0.0 and 84% females with a mean value of 0.9 ± 0.0 were in the high-risk category of Waist-Hip ratio. Maximum male (92%) and female (99%) participants with a mean value of 0.6 ± 0.0 were under the high-risk category of Waist-Height ratio.

Table 4.2.2: BMI of people with diabetes

BMI	**Cut-off**	**Mean** ± SD	**N (%)**	**Cut-off**	**Mean** ± SD	**N (%)**
	Male			**Female**		
Number of Participants	**124**			**103**		
Under weight	<18.5	18.2 ± 0.5	7 (6.0)	<18.5	18.2 ± 0.0	3 (3)
Normal	18.5-22.9	20.4 ± 1.1	28 (23)	18.5-22.9	21.3 ± 1.1	25 (24)
Over-weight	23-24.9	23.8 ± 0.5	16 (13)	23-24.9	23.9 ± 0.6	10 (10)
Obese	>25	30.3 ± 3.1	73 (59)	>25	30.1 ± 3.2	65 (63)

Table 4.2.2 shows that the mean BMI in underweight category for 6% male participants was 18.2 ± 0.5 and among 3% female participants was 18.2 ± 0.0. The mean BMI in normal category for 23% male participants was 20.4 ± 1.1 and among 24% female participants was 21.3 ± 1.1. Overweight category had 13% male and 10% female

participants with mean BMI of 23.8 ± 0.5 and 23.9 ± 0.6 respectively. 59% male participants and 63% female participants in obese category had mean BMI of 30.3 ± 3.1 and 30.1 ± 3.2 respectively.

Table 4.2.3: Body composition of people with diabetes

Variables	**Cut-off**	**Mean** ± SD	**N (%)**	**Cut-off**	**Mean** ± SD	**N (%)**
	Male			**Female**		
Number of Participants	**124**			**103**		
Body Fat (%)						
Low (-)	5.0-9.9 %	6.7 ± 0.0	1 (1)	5.0 – 19.9 %	14.8 ± 1.8	4 (4)
Normal (0)	10.0 – 19.9 %	15.5 ± 2.0	14 (11)	20.0 – 29.9 %	27.4 ± 2.6	25 (24)
High (+)	20.0 – 24.9 %	21.5 ± 0.9	13 (10)	30.0 – 34.9 %	32.1 ± 0.9	9 (9)
Very High (++)	≥ 25.0 %	32.2 ± 4.5	96 (77)	≥ 35.0 %	36.4 ± 9.3	65 (63)
Visceral Fat						
Normal	<=9	5.4 ± 2.5	45 (36)	<=9	5.4 ± 2.5	33 (32)
High	10-14	11.2 ± 1.2	22 (18)	10-14	12.4 ± 1.4	40 (39)
Very High	>=15	20.9 ± 5.0	57 (46)	>=15	20.2 ± 5.2	30 (29)
Skeletal Muscle (%)						
Low (-)	< 24.1	20.8 ± 3.2	84 (68)	< 33.1	23.0 ± 3.1	67 (65)
Normal (0)	24.1 – 30.1	27.3 ± 1.7	26 (21)	33.1 - 39.1	26.4 ± 2.7	31 (30)
High (+)	30.2 – 35.1	31.8 ± 1.1	14 (11)	39.2 – 43.8	30.6 ± 1.2	5 (5)
Very High (++)	≥ 35.2	-	-	≥ 43.9	-	-

Participants were categorized based on Body fat % into low, normal, high and very high category according to the classification given by the Omron healthcare. Seventy seven percent male participants had a very high body fat % (mean fat % of 32.2 ± 4.5) followed by 10% male participants under the high body fat % category (mean fat % of 21.5 ± 0.9). Sixty-three percent female participants were classified under the very high fat % category with mean body fat % of 36.4 ± 9.3 while 9% female were

classified into high fat % category and 32% women were classified into normal fat % category having 32.1 ± 0.9 and 27.4 ± 2.6 as the mean body fat % respectively.

Visceral fat was categorised into normal, high and very high category according to the classification given by the Omron healthcare. Under the high category, 18% male had mean value of 11.2 ± 1.2 and 39 % female had mean value of 12.4 ± 1.4 followed by 46 % male and 29% female had mean visceral value of 20.9 ± 5.0 and 20.2 ± 5.2 under very high category and 36% male and 32% female participants had visceral fat under normal category.

Skeletal Muscle was categorised into low, normal, high and very high category according to the classification given by the Omron healthcare. Eighty-four percent male participants and 67 female participants had low skeletal muscle % with a mean of 20.8 ± 3.2 and 23.0 ± 3.1 respectively. Under the normal category, 26 male and 31 female participants had skeletal muscle % with mean of 27.3 ± 1.7 and 26.4 ± 2.7 respectively. While only 14 male and 5 female participants had skeletal muscle % under high category with a mean of 31.8 ± 1.1 and 30.6 ± 1.2 respectively.

According to a study conducted by Yun Hwan Oh et al., (2021), 1% increase in relative lean body mass lowered the risk of metabolic syndrome by 19-21%, while a 1% increase in relative appendicular skeletal mass reduced the risk of metabolic syndrome by about 38%. Furthermore, a 1% increase in relative Body Fat Mass raised the incidence of metabolic syndrome by 24-25%. This effect was more pronounced when the baseline Body Mass Index or Body Fat Mass Index was greater.

Section 4.3- Biological Parameters

Table 4.3.1: Duration of detection of diabetes among participants

Sr.no	Duration of detection of diabetes	N (%)
1	Less than 1 year	28 (12.3)
2	1 year	50 (22.0)
3	02 years	46 (20.3)
4	03 years	45 (19.8)
5	04 years	34 (15.0)
6	05 years	24 (10.6)

Table 4.3.1 shows the duration of detection of diabetes among 227 participants. Maximum participants were detected with diabetes in past 1 year (22%) followed by 2 years (20.3%) and only 10.6% of participants had diabetes since last 5 years.

Table 4.3.2: Blood glucose levels of study people with diabetes

Variables	**Cut off values**	**Mean** ± SD	**N (%)**	**Mean** ± SD	**N (%)**
		Male		**Female**	
Number of participants		124		103	
BLOOD GLUCOSE LEVELS:					
Fasting Blood Glucose (mg)					
Controlled	< 126	115 ± 9	55 (44)	107 ± 12	35 (34)
Uncontrolled	≥ 126	157 ± 32	68 (55)	169 ± 33	68 (66)
Post Prandial Blood Sugar (PP2BS) (mg)					
Controlled	< 160	134 ± 11	52 (42)	137 ± 13	22 (21)
Uncontrolled	≥ 160	207 ± 38	71 (57)	219 ± 35	81 (79)
HbA1C (%)					
Good Control	< 7	6.5 ± 0.2	3 (2)	6.6 ± 0.2	3 (3)
Fair Control	7-8	7.5 ± 0.3	61 (49)	7.6 ± 0.3	69 (67)
Poor Control	> 8	8.4 ± 0.2	60 (48)	8.3 ± 0	31 (30)

Table 4.3.2 categorises the participants based on glycaemic variability i.e. well controlled or uncontrolled blood sugar levels. Participants having fasting blood sugar level of <126 mg are classified under controlled category while participants having ≥ 126mg have uncontrolled fasting blood glucose levels. Controlled fasting blood glucose was seen among 44% male participants with a mean of 115 ± 9 and 34% female participants with mean of 107 ± 12. Fifty five percent male

participants and 66% female participants had uncontrolled fasting blood sugar levels with mean values of 157 ± 32 and 169 ± 33 respectively.

The 2 hour post prandial blood sugar level < 160mg is considered as controlled PPBSwhile level ≥ 160 is classified as uncontrolled PP2BS levels. Uncontrolled PPBS levels were seen among 57% male participants and 79% female participants with a mean of 207 ± 38 and 219 ± 32 respectively.

The HbA1c is classified into 3 categories. The HbA1c level of <7% is considered as good control while 7-8% is considered as fair control and >8% is considered as poor control. Majority of participants both male (49%) and female (67%) had fair controlled HbA1c levels with a mean of 7.5 ± 0.3 and 7.6 ± 0.3 respectively followed by 48% male and 30% female participants with a mean of 8.4 ± 0.2 and 8.3 ± 0 respectively for poor controlled HbA1C levels. Only 2% male participants (6.5 ± 0.2) and 3% female participants (6.6 ± 0.2) had good controlled HbA1C levels. According to a study with 4 trials on 27,049 participants conducted by Sophia Zoungas et al.,(2017), the primary outcomes during the follow-up period of 5 years, 1626 kidney events, 795 eye events and 7598 nerve events were recorded in poor glucose control.

Table 4.3.3: Blood pressure levels of people suffering from diabetes (mmHg)

Variables	Male	Female
Blood Pressure (Average of 3 readings)	**N (%)**	**N (%)**
Normal Blood pressure (<120 mm Hg / <80 mm Hg)	24 (19.4)	26 (25.2)
Elevated Blood pressure (120-129 mm Hg / <80 mm Hg)	46 (37.1)	33 (32.0)
High BP (Stage 1) (130-139 mm Hg / 80-89 mm Hg)	35 (28.2)	30 (29.1)
High BP (Stage 2) (>=140 mm Hg />=90 mm Hg)	19 (15.3)	14 (13.6)

Table 4.3.3 shows that 37.1 % male and 32.0% female had Elevated blood pressure. Twenty eight point two percent male and 29.1% female had High blood pressure (stage 1) followed by 19.4 % male and 25.2 % female had normal blood pressure. While only 15.3% male and 13.6% female had High blood pressure (stage 2).

Table 4.3.4: Lipid profile of people with diabetes

Variables	**Cut off Values**	**Mean ± SD**	**N (%)**	**Mean ± SD**	**N (%)**
		Male		**Female**	
Number of participants		124		103	
LIPID PROFILE:					
TOTAL CHOLESTEROL(mg)					
Desirable	<200 mg/dl	134 ± 20	110 (89)	146 ± 24	92 (89)
Border High	200-239 mg/dL	202 ± 2	7 (6)	204 ± 4	11 (11)
High	>=240 mg/dL	286 ± 56	7 (6)	-	-
LDL (mg)					
Optimal	<100 mg/dL	87 ± 10	17 (14)	82 ± 15	17 (17)
Near Optimal	100-129 mg/dL	109 ± 6	7 (6)	112 ± 8	17 (17)
Borderline high	130-159 mg/dL	136 ± 5	41 (33)	139 ± 8	62 (60)
High	160-189 mg/dL	165 ± 4	53 (43)	162 ± 3	6 (6)
Very high	>=190 mg/dL	213 ± 0	4 (3)	-	-
HDL (mg)					
Low	<40 mg/dL	37 ± 2	100 (81)	37 ± 1	82 (80)
Normal	40-59 mg/dL	46 ± 5	12 (10)	49 ± 7	9 (9)
High	>=60 mg/dL	63 ± 2	12 (10)	63 ± 3	12 (12)
TRIGLYCERIDES (mg)					
Normal	<150 mg/dL	103 ± 22	102 (82)	107 ± 26	78 (76)
Borderline High	150-199 mg/dL	169 ± 13	18 (15)	170 ± 10	24 (23)
High	200-499 mg/dL	205 ± 10	4 (3)	200 ± 0	1 (1)
Very High	>500 mg/dL	-	-	-	-
TG/HDL					
Normal	≤ 2	1.6 ± 0.2	44 (36)	1.5 ± 0.3	9 (39)
High	> 2	3 ± 0.8	80 (64)	3 ± 0.6	63 (61)

Table 4.3.5: Insulin Resistance of people with diabetes

Variables	**Cut off values**	**Mean** ± SD	**N (%)**	**Median**
Number of participants	227			
INSULIN RESISTANCE				
TyG Index	≥ 4.68	8.9 ± 0.3	227 (100)	8.9

Table 4.3.4 presents the Lipid profile of 124 male participants and 103 female participants. It can be seen that 89% female participants have desirable cholesterol levels with mean of 134 ± 20 and 146 ± 24 respectively. Six percent male participants and 11% female participants with mean of 202 ± 2 and 204 ± 4 had border high cholesterol levels.

Forty-three percent male and 6% female participants with a mean of 165 ± 4 and 162 ± 3 have high LDL levels. Maximum female participants (60%) and 33% males have borderline high levels of LDL 139 ± 8 and 136 ± 5 respectively. Six percent males and 17% females have near optimal LDL levels.

Majority of male participants (81%) and female (80%) participants had low HDL levels with a mean of 37 ± 2 and 37 ± 1 respectively. Majority of male 82% and female participants 76% have normal triglyceride levels with a mean of 103 ± 22 and 107 ± 26 respectively. TG/HDL level was high among both male 64% and female 61% participants with a mean of 3 ± 0.8 and 3 ± 0.6 respectively.

Table 4.3.5 shows that all the participants of the study are insulin resistant with a mean value of TyG index 8.9 ± 0.3.

According to a study conducted by Moyad Jamal Shahwan et al.,(2019), A total of 23 percent of the 291 diabetic patients enrolled had hypercholesterolemia (TC 200) and 61.9% had hypertriglyceridemia. LDL-C values were abnormal (130) in 8.9% of patients, while HDL-C was less than 40 mg/dl in 54.3%. There was a statistically significant difference in abnormal HDL levels (40 mg/dl) between males (47.6) and females (59.3%). Patients with HbA1c values of 7.0% had substantially higher total cholesterol (TC) and aberrant LDL-C levels than patients

with HbA1c values of 7.0%. As a result, dyslipidemia is quite common among diabetics, particularly those with poorly managed diabetes. Insulin resistance is a crucial component to the pathophysiology of type 2 diabetes and is linked to metabolic abnormalities including dyslipidemia and hypertension. Impaired glucose tolerance, hyperglycemia, or type 2 diabetes can occur when insulin resistance is associated with -cell abnormalities in glucose-stimulated insulin production (Goldstein, 2002)

Section 4.4- Diet Information

Table 4.4.1: Type of food choice among people with diabetes

Sr.no	Type of food choice	N (%)
1	Vegan	-
2	Lacto-Vegetarian	132 (58.1)
3	Non-vegetarian	043 (18.9)
4	Lacto-ovo-Vegetarian	052 (22.9)

Table 4.4.1 details the food choice among the study subjects. It can be seen that 58.1% of the total participants were lacto-vegetarian while 22.9% were lacto-ovo vegetarian and 18.9% were non-vegetarian.

Table 4.4.2: Meal generally skipped among study population

Sr.no	Generally skipped meal	N (%)
1	Breakfast	82 (36.1)
2	Lunch	-
3	Dinner	-
4	No meal ever skipped	145 (63.9)

Table 4.4.2 shows that 63.9 % of the study population generally did not skip any meal while the rest 36.1% skipped the meal, which was generally the breakfast. According to Uemura et al., skipping breakfast raises the risk of Type 2 Diabetes Mellitus in both men and women regardless of lifestyle (2015).
There were 22 (11.3%) individuals who self-reported missing breakfast.

Breakfast skippers had considerably higher HbA1C readings, greater BMI, and delayed MSF than breakfast eaters. Even after controlling for age, gender, race, BMI, number of diabetic complications, insulin usage, depressive symptoms, perceived sleep debt, and percentage of daily calorie intake at supper, breakfast skipping was linked with higher HbA1C levels. The chronotype influenced the link between breakfast skipping and HbA1C in a study conducted by Sirimon Reutrakul et al., (2013).

Table 4.4.3: Most important meal of the day among study population

Sr.no	Important Meal	N (%)
1	Breakfast	013 (5.7)
2	Lunch	056 (24.7)
3	Dinner	158 (69.6)

Table 4.4.3 shows the preference for most important meal of the day on the basis of quantity. It can be seen that only 5.7 % of the total participants preferred breakfast as their main meal while 24.7 % had lunch as their main meal and 69.6 % had dinner as their main meal. According to a research by Bo et al. (2014), one-third of the study participants consumed most calories during supper, and after a 6-year follow-up period, those people found to be twice as likely to be obese. According to a research by Jakubowicz et al., high-calorie supper meals resulted in considerably higher serum glucose levels than high-calorie breakfast meals (2015).

Table 4.4.4: Participants Consulting Dietitian

Sr.no	Dietitian consultation	N (%)	Place of consultation		
			Online consultation (N)	Dietitian's Clinic (N)	Diabetes Clinic (N)
1	Yes	42 (18.5)	10	4	28
2	No	185 (81.5)`	-	-	-

Table 4.4.4 shows the number of participants that had consulted a dietitian

among the 227 participants. It can be seen that only 18.5% of the total participants had consulted a dietitian while 81.5% had never consulted a dietitian for diet advice.

Figure 4.4.1: Frequency of Consumption of Ultra-Processed Foods

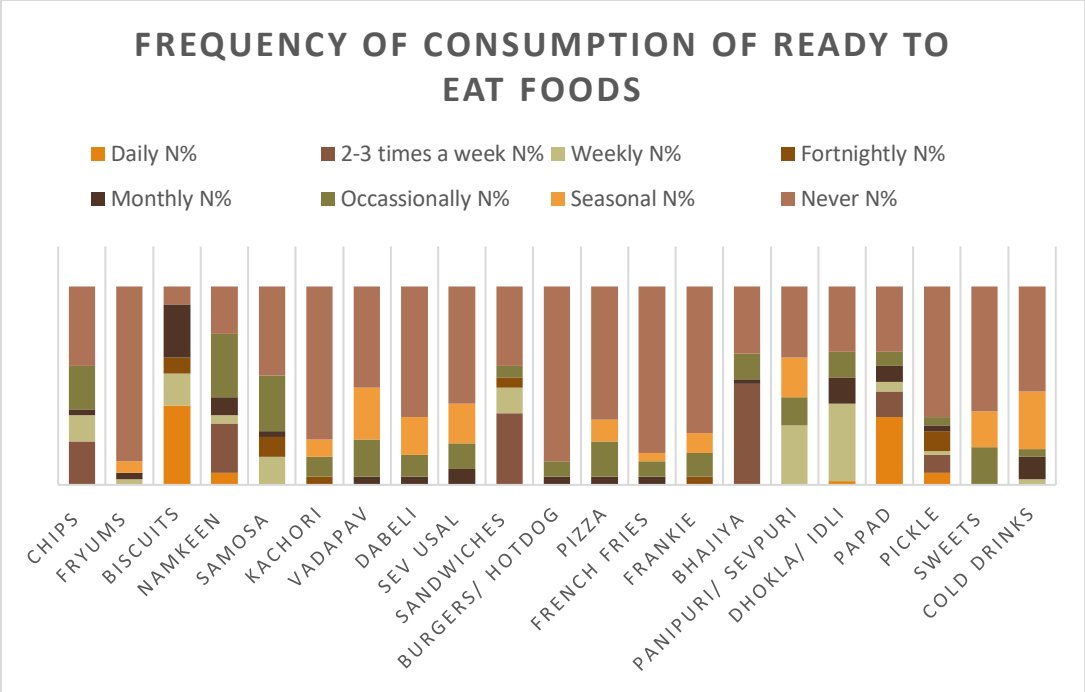


Figure 4.4.1, details the Consumption of ready-to-eat foods among study population.It can be seen that consumption of foods like biscuits were consumed by 40 % participants daily followed by 16 % 2-3 times a week. Consumption of papad and pickle was found to be daily among 34% and 6% participants respectively. Fried foods like bhajiya and namkeen were consumed on a weekly basis 51% and 25% of the participants. Weekly consumption among participants of sandwiches, chips, panipuri/sevpuri and dhokla/idli were found to be 36%, 22%, 30% and 39% respectively. Occassionally participants consumed sweets (19%), Frankie (12%), pizza (18%), sev-usal (13%), dabeli (11%), vadapav (19%), kachori (10%).

Burgers/ hotdogs, french-fries, colddrinks were not commonly consumed by the participants. Strong evident risk of developing chronic disease was seen among participants when fried foods were consumed more frequently according to Gadirajuet al., (2015). Fried-food consumption is associated with increased risk

of overweight/obesity according Qin et al., (2021) Frequent consumption of fried food was significantly associated with increase in Type 2 diabetes mellitus incidence and was intervened with body weight, hypertension and hypercholesterolemia. Cahill et al., (2015) In a study conducted by Sista & Railla (2020) only a small group of participants (20%) preferred to have junk foods such as pizza, sandwich, samosa, burger, fries, etc., for dinner occasionally. Participants who practised mindful eatingconsumed less sweets and had lower fasting glucose levels.(Sista & Railla, 2020)

Section 4.5- Physical Activity

Table 4.5.1: Habit of performing exercise, time preference and time duration among people with diabetes

Habit of performing Exercise	Participants that perform any form of moderate intensity exercise ≥ 5times/week	Participants that do not perform any form of moderate intensity exercise ≥ 5times/week
N (%)	032 (14.1)	195 (85.9)
Duration of exercise	**N (%)**	-
< 30 minutes	13 (5.7%)	
30 minutes	7 (3.0%)	
> 30 minutes	12 (5.2%)	

The Physical activity was assessed using the Global Physical activity Questionnaire. Information on type of activity and duration of activity was obtained from the GPAQ questionnaire and the Exercise Energy Expenditure (EEE) was calculated using the following formula EEE=Time (hour) × RMR/24 × MET.

It can be clearly seen from data presented in Table 4.5.1 that only 14.1% participants performed moderate intensity exercise while 85.9% failed to perform any form of moderate intensity exercise throughout the day. It can be seen that maximum participants (5.7%) performed moderate intensity exercise for <30 minutes. In a research by Ghimire (2017), 46% of the patients with type 2 diabetes did not exercise. Exercise enhances metabolic indicators and has anti-inflammatory effects.

In those with type 2 diabetes, regular exercise improved body composition, physical fitness, and lipid and glucose metabolism. (Karstoft and Pedersen, 2016) It has been demonstrated that daily walking for at least 30 minutes significantly lowers the risk of T2D by around 50%. (Hamasaki, 2016).

Table 4.5.2: Categorisation of participants based on sitting duration

Category of Risk	**Male**	**Female**
	N (%)	**N (%)**
Low risk	-	-
Medium Risk	22 (17.7)	22 (21.4)
High Risk	51 (41.1)	23 (22.3)
Very High Risk	51 (41.1)	58(56.3)

Sitting for long period of time has a negative impact on overall health which includes excess body fat around waist, abnormal cholesterol levels, increased blood pressure and blood glucose levels. The sitting time (hours) has been categorised into the different risk levels. The categories are <4 hour of sitting time has lower health risk, 4-8 hours of sitting time has medium health risk, 8-11 hours has high risk and > 11 hours has very high risk on health. Table 4.5.2 shows the sitting hours throughout the day among study participants. It can be seen that 41.1% of male participants were at high risk followed by 41.1% at very high risk and 17.7 % at medium risk. 56.3% of female participants were at very high risk followed by 22.3 % having high risk and 21.4% at medium risk. Dempsey et al. (2016) found that adults with Type 2 Diabetes Mellitus experienced decreased acute postprandial glucose, insulin, C-peptide, and triglyceride responses when 8 hours of prolonged sitting time was broken up every 30 minutes with 3 minutes of brief bouts of Light Intensity Walking or Simple Resistance Activities. Stephens and colleagues' investigation on young, healthy men and women found that even one day of extended sitting reduced the body's ability to use insulin, compared to a day when sitting was replaced with standing and mild activity. (Owen Dempsey, et al., 2016)

Section 4.6- Screen Time

Table 4.6.1: Screen time duration and screen timing among study participants

Duration of screen time post dinner	**N (%)**	**Screen time post dinner**						
		07:30 Pm	08:00 pm	08:30 Pm	09:00 pm	09:30 Pm	10:00 Pm	10:30 Pm
< ½ hour/day	31 (13.7)	-	-	-	-	-	-	-
½ -1 hour/day	26 (11.5)	-	-	-	-	-	-	-
1-2 hours/day	102 (44.9)	005 (4.9)	007 (6.8)	002 (1.9)	050 (49.0)	022 (21.5)	005 (4.9)	019 (18.6)
>2 hours/day	68 (30.0)	003 (4.4)	013 (19.1)	009 (13.2)	035 (51.4)	026 (38.2)	014 (20.5)	017 (25.0)

Table 4.6.1 shows the screen timing and duration of Screen time among study participants. It can be seen that 30% of the participants had screen time of more than 2 hours post dinner and 44.9 % had 1-2 hours of screen time post dinner. Maximum participants had screen time post 9:00 pm in both categories. A study by Christensen et al. (2016) found that exposure to TV or smartphone displays, especially right before bed, had a deleterious effect on sleep. Poor sleep quality, lower sleep efficiency, and longer sleep onset latency were all linked to more screen time before bed and shorter sleep duration in people.

Section 4.7- Sleep quality

Table 4.7.1: Sleep quality among study subjects

Sleep Quality	**N (%)**
Mild sleep difficulty	033 (14.5)
Moderate sleep difficulty	187 (82.0)
Severe sleep difficulty	07 (3.1)

The Pittsburgh Sleep Quality index (PSQI) was used to assess the sleep quality among subjects. A global score of 5 or more indicates poor sleep quality. Table 4.7.1 shows that only 14.5 % subjects had mild sleep difficulty, 82.0 % subjects had moderate sleep difficulty and 3.1% subjects had severe sleep difficulty. Seventy nine percent subjects had short sleeping duration of less than 6 hours a day with sleeping time starting generally from 10:00pm /11:00pm and waking time between 4:00am to 5:00am. Sleeping for fewer than 6 hours has been linked to a higher risk of diabetes, cardiovascular disease, and hypertension than sleeping for 7-8 hours. Experimental sleep deprivation decreases both glucose tolerance and cellular insulin sensitivity. If these effects persist, it affects the pancreatic beta-ability cell's to function, which results in type 2 diabetes (Watson et al. 2015)

Section 4.8- Stress

Table 4.8.1: Stress among study population

Sr.no	Category	N (%)
1	Low stress	007 (3.0)
2	Moderate Stress	200 (88.1)
3	Perceived Stress (High Stress)	020 (8.8)

Stress among the participants was assessed using the perceived stress scale by Sheldon Cohen. Scores ranging from 0-13 are considered low stress, scores ranging from 14-26, moderate stress and scores ranging from 27-40 are considered as high perceived stress. It can be seen in Table 4.8.1 that only 3 % participants had low stress levels while 88.1 % participants suffered from moderate stress and 8.8% suffered from perceived stress (high stress). According to a study by Sendhilkumar et al. (2017), 35% of Type 2 Diabetes Mellitus patients reported having high or very high stress levels. Jobs, money problems, and a lack of exercise were all closely linked to stress in people. In a 12-year longitudinal research on women undertaken by Harris et al., moderate/high stress levels were linked to a 2.3-fold increase in the risk of diabetes (2017)

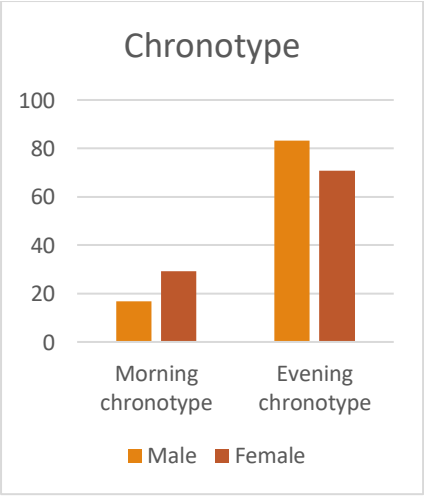
Section 4.9- Assessing Chronotype

Table 4.9.1: Chronotype of study population

Chronotype	**N (%)**
Definitely Morning	-
Moderate Morning	051 (22.4)
Moderate Evening	176 (77.2)
Definitely Evening	-

Chronotype was assessed using the Horne and *Ostberg Morningness-Eveningness* Questionnaire. Scores <= 41 indicate "evening types", scores >=59indicate "morning types" and scores between 42 and 58 indicate "intermediate types". Table 4.9.1 summarises the chronotype among 227 participants. It can be seen that Majority of the participants (77.2%) had moderate evening chronotype and 22.4% had moderate morning chronotype. Similar results were found in a research by Wennman et al. (2015), where the majority of participants (32%) were of a moderate evening type, followed by individuals who were of a moderate morning type (21%), a morning type (31%), and people who were of an evening type (16%). Intake of unhealthy foods and nutrients has been linked to evening type, which may indicate a higher risk of obesity in this group than in morning type. (2017) Maukonen et al. Hee Yu et al. found that compared to the morning chronotype, the evening chronotype was substantially related with metabolic syndrome and diabetes (2015).

Figure 4.9.1: Distribution of study participants by chronotype and gender



The Figure 4.9.1 shows the chronotype among 124 male participants and 103 female participants. Sixteen point nine percent male participants and 29.1% female participants were morning chrono typed while 83.1% male and 70.9% female had evening chronotype.

Table 4.9.2: Chronotype and dietary behavior of study participants

Parameters	**Morningness (n=51)**	**Eveningness (n=176)**	***p* value ***
Total Calorie Intake (kcal)	1673 ± 152	1767 ± 195	0.001
Total Carbohydrate (g)	185 ± 2.7	230 ± 5.9	0.000
Total Protein (g)	75 ± 2.8	57 ± 2.2	0.004
Total Fat (g)	29 ± 2.7	44 ± 3.2	0.000
Total Fibre (g)	30 ± 1.2	22 ± 1.1	0.002
Consumption of Cereals (g)	100 ± 5.7	143 ± 4.4	0.003
Consumption of Pulses & Legumes (g)	53 ± 4.0	24.8 ± 3.2	0.000
Consumption of Dairy Products (ml)	276 ± 150.1	266.8 ± 155.1	0.004
Consumption of Vegetables (g)	321.7 ± 14.1	200.7 ± 29.6	0.000
Consumption of Fruits (g)	130 ± 92.1	0.8 ± 11.3	0.000
Consumption of Nuts (g)	1.9 ± 2.7	0.0 ± 0.0	0.001
Consumption of Oils & Fats (g)	21.8 ± 2.0	37.3 ± 1.4	0.000
Consumption of Sugar (g)	7.1 ± 4.5	27.6 ± 1.6	0.001
p value is based on Independent Sample T-test *** p value < 0.05 is considered to be significant level**			

Table 4.9.2 shows the average of 3 days of composition of meals in terms of macronutrients and food groups segregated by chronotype of study participants (227). It can be clearly seen that the individuals who are evening type, have higher amount of calorie, carbohydrate and fat consumption contributed by significantly higher intake of sugar and oils & fats as compared to the morning type. The protein and fibre content was higher in the meals of morning type largely being contributed by cereals, pulses & legumes, vegetables and fruits. According to Muoz et al., (2017) the morningness group demonstrated a larger consumption at supper,

whereas the eveningness group consumed the majority of their calories and nutrients during breakfast and lunch. In a research by Toktaş et al. (2018), evening chronotype was linked to unhealthy eating behaviours, including high daily calorie, fat, and carbohydrate intakes, as well as low protein consumption at dinner.

Table 4.9.3: Association of chronotype with Glycaemic control

Parameters	**Morningness (n=51)**	**Eveningness (n=176)**	**β value**	***p* value***
HbA1c	7.1 ± 0.5	7.2 ± 0.6	0.4	0.000
FBS	154 ± 24	156 ± 25	0.3	0.000
PP_2BS	264 ± 26	265 ± 23	0.1	0.001
TyG	8.8 ± 0.3	9.1 ± 0.4	0.2	0.002
TG	114 ± 35	126 ± 38	0.4	0.001
Multiple regression analysis for Chronotype & Glycemic control **p value is based on Multiple linear regression analysis** *** p value < 0.05 is considered to be significant level**				

Morningness–eveningness shows the individual's preference for performing any activity and sleep throughout the day (Randler et al., 2016). Table 4.9.3 shows that significant association was found between eveningness and TyG index (β= 0.2, p=0.002), Triglyceride levels (β= 0.4, p=0.001) and Post-prandial plasma glucose (β= 0.1, p=0.001) and highly significant association between Fasting blood glucose (β= 0.3, p=0.000) and HbA1c (β= 0.4, p=0.000) which suggests that a circadian preference for eveningness was associated with poor glycaemic control and higher insulin resistance. In a cross-sectional research of 140 individuals with type 2 diabetes, Hashemipour et al., 2020 found that fasting blood glucose and HbA1c levels were higher in the evening group than the morning group. Evening chronotype was linked to higher HbA1c and worse glycemic control in T2DM patients (Index Medicus, Western Pacific Region, 2016). Similar findings suggest that experimental circadian misalignment in humans causes decreased glucose tolerance; the association between human clock gene polymorphisms and insulin resistance; the experimentally observed effects of night-time light exposure and sleep disturbance on glucose metabolism; and the association of insulin resistance with short sleep duration, long sleep duration, low

sleep quality, late chronotype, social jet lag, and shift work (Dirk Jan Stenvers et al., 2018).

Table 4.9.4: Association of chronotype with Glycaemic Index of Breakfast and Largest meal

Parameters	**Chronotype**		
	Morningness (N= 51) MEAN VALUE	**Eveningness (N= 176) MEAN VALUE**	***p* value***
Breakfast GI	30	45	0.01
Largest meal GI			
Breakfast	30	45	0.03
Lunch	41	57	0.02
Dinner	48	63	0.00
p value is based on Independent Sample T-test *** p value < 0.05 is considered to be significant level**			

Table 4.9.4 shows significant association was found between morningness and consumption of breakfast with lower glycemic index ($p < 0.01$). Consumption of largest meal at breakfast with lower glycemic index was significantly associated with morningness whereas consumption of largest meal at dinner was highly significantly associated with eveningness ($p < 0.00$).

Section 4.10- Assessment of Chrononutrition Profile

Table 4.10.1: Chrononutrition profile among people with type 2 diabetes

Chrononutrition Profile	**N (%)**
Good	07 (3.1)
Fair	112 (49.1)
Poor	108 (47.4)

Table shows the Chrononutrition profile among participants. After taking into consideration the six behaviours for assessing the chrononutrition profile it can be seen that 49.4 % of participants had fair chrononutrition profile while 47.4%

had poor chrononutrition profile and 3.1% had good chrononutrition profile.

Figure 4.10.1: Chrononutrition profile among people with type 2 diabetes

Figure 4.10.1(a): Eating window among participants

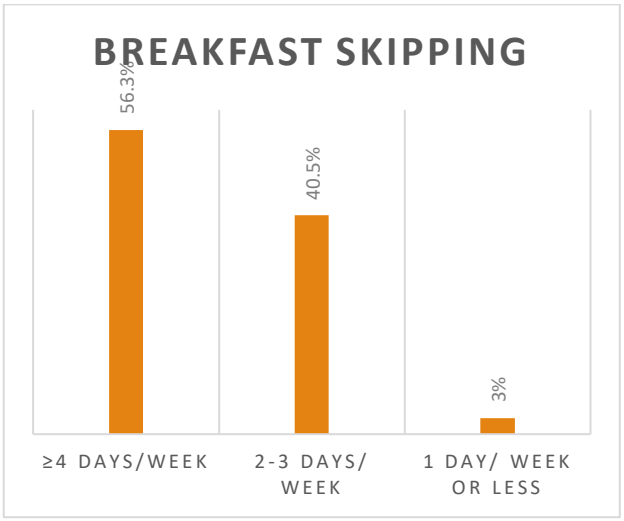


Figure 4.10.1(b): Breakfast Skipping among participants

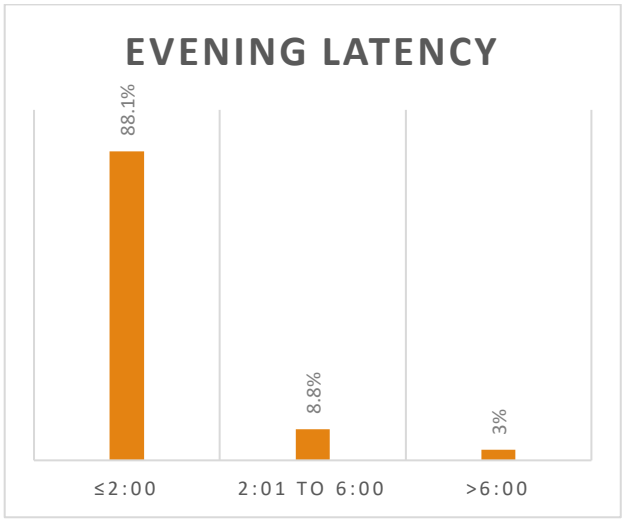


Figure 4.10.1(c): Evening latency among participants

Figure 4.10.1(d): Evening eating among participants

Figure 4.10.1(e): Night eating among participants

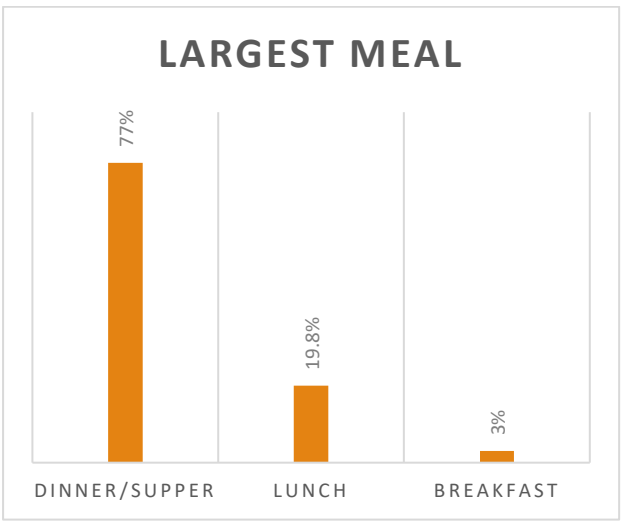


Figure 4.10.1(f): Largest meal among participants

Chrononutrition profile was assessed using the chrononutrition profile scoring method developed by Allison Christine Engwall. It has 6 indicators:

Eating Window includes duration between first eating event and last eating event. (HH:MM)

Breakfast Skipping includes frequency of breakfast skipping. (Days/Week)

Evening Latency includes duration between last eating event and sleep onset. (HH:MM)

Evening Eating includes risk of eating late in the waking day. (HH:MM)

Night Eating includes Frequency of night eating. (Days/Week)

Largest Meal includes meal in which largest amount of food is eaten. (Meal Name)

Scoring ranges from 0 to 12 with 0 indicating good chrononutrition status and 12 indicating poor chrononutrition status. Figure 4.10.1 shows the assessment of the Chrononutrition profile of participants. It can be seen in Figure 4.10.1(a) that maximum participants (50.2%) had poor duration between first eating event and last eating event, poor frequency of skipping breakfast for four or more days in a week Figure 4.10.1(b), poor duration between last eating event and sleep onset among

88.1% participants in Figure 4.10.1(c), poor risk of eating late in the waking day among 48% participants in Figure 4.10.1(d), fair frequency of night eating among 49.3% participants in Figure 4.10.1(e) and 77.0% participants were in poor category where dinner was the meal in which largest amount of food was eaten in Figure 4.10.1(f). More than 50% of participants in a cohort research by Jain Gupta et al. (2017) had a window for eating that lasted 15 hours or more. In a cohort study by Gill and Panda, more than half of the subjects' daily consumption time surpassed 14.75 hours (2015). The increased calorie intake and decreased sleep duration caused by the prolonged daily eating period directly raise the risk of developing metabolic disorders.

When overweight people who ate for more than 14 hours per day ate just for 10 to 11 hours per day, their body weight decreased, their energy level increased, and their sleep quality improved. 10 hours of eating window in metabolic syndrome increases weight reduction, decreases waist circumference, lowers body fat percentage and visceral fat, lowers blood pressure, atherogenic lipids, and also lowers levels of glycated haemoglobin, according to a research by Wilkinson et al. (2020)

Table 4.10.2: Association of Chrononutrition profile with Glycaemic Index of meals among participants with type 2 diabetes

Parameter	**Chrono nutrition profile**			***p* value ***
	Good (n=7)	**Fair (n=112)**	**Poor (n=108)**	
	MEAN			
Breakfast GI	29 ± 1	49 ± 0	50 ± 1	0.000
Lunch GI	37 ± 1	55 ± 1	58 ± 1	0.000
Dinner GI	45 ± 1	61 ± 1	64 ± 1	0.000
p value is based on One way ANOVA analysis *** p value < 0.05 is considered to be significant level**				

Table 4.10.2 shows the association between chrononutrition profile and dietary habits of the study population. Significant association was found between consumption of lower GI for breakfast (29 ± 1), lunch (37 ± 1) and dinner (45 ± 1) in participants with good chrononutrition profile ($p < 0.000$) and higher GI for breakfast (50 ± 1), lunch (58 ± 1) and dinner (64 ± 1) in participants with poor chrononutrition profile ($p < 0.000$) compared to the fair chrononutrition profile. Postprandial glucose (PPG) homeostasis is a key indicator of the risk of chronic illnesses, including type 2 diabetes and cardiovascular disease (Cavalot F et al., 2011). Since Jenkins et al. popularised the glycemic index (GI), low GI foods were advised to improve PPG and so control and avoid type 2 diabetes, obesity, and the risk of other cardiometabolic illnesses.

Table 4.10.3: Association of Chrononutrition profile with Body composition among participants with type 2 diabetes

Parameter	**Chrono nutrition profile**			***p* value ***
	Good (n=7)	**Fair (n=112)**	**Poor (n=108)**	
	MEAN			
Total Body Fat	24.4 ± 1.0	30.9 ± 1.1	34.3 ± 4.4	0.000
Skeletal Muscle	31.2 ± 0.4	25.4 ± 0.8	20.5 ± 1.5	0.000
Visceral Fat	4.5 ± 1.2	9.4 ± 1.1	15.3 ± 1.6	0.000

p value is based on One way ANOVA analysis
*** p value < 0.05 is considered to be significant level**

Table 4.10.3 shows the association between chrononutrition profile and body composition of the study population. Highly significant association was found between higher body fat % (34.3 ± 4.4) and visceral fat (20.5 ± 1.5) and lower skeletal muscle % (15.3 ± 1.6) in participants with poor chrononutrition profile ($p < 0.000$) compared to the fair chrononutrition profile. Good chrononutrition profile was significantly associated with lower body fat % (24.4 ± 1.0) and visceral fat (4.5 ± 1.2) and higher skeletal muscle % (31.2 ± 0.4).

Table 4.10.4: Association of Chrononutrition profile with Biological parameters among participants with type 2 diabetes

Chrono nutrition profile	Biochemical parameters				
	FBS	**PP_2BS**	**HbA1C**	**DBP**	**SBP**
Eating window	p=0.04	p=0.02	p=0.01	p=0.02	p=0.03
Breakfast skipping	p=0.00	p=0.01	p=0.05	p=0.01	p=0.02
Evening latency	p=0.01	p=0.02	p=0.02	p=0.03	p=0.04
Evening eating	p=0.03	p=0.01	p=0.01	p=0.01	p=0.02
Night eating	p=0.03	p=0.01	p=0.00	p=0.02	p=0.02
Largest meal	p=0.00	p=0.01	p=0.01	p=0.00	p=0.01
p value is based on Chi-square test					
*** p value < 0.05 is considered to be significant level**					

Chrono nutrition profile	Biochemical parameters				
	TOTAL CHOLESTEROL	**LDL**	**HDL**	**TG**	**TG/HDL**
Eating window	p=0.02	p=0.04	p=0.01	p=0.00	p=0.03
Breakfast skipping	p=0.01	p=0.00	p=0.04	p=0.02	p=0.02
Evening latency	p=0.02	p=0.01	p=0.01	p=0.03	p=0.01
Evening eating	p=0.01	p=0.03	p=0.02	p=0.02	p=0.0
Night eating	p=0.02	p=0.03	p=0.03	p=0.04	p=0.04
Largest meal	p=0.01	p=0.00	p=0.01	p=0.00	p=0.01
p value is based on Chi-square test					
*** p value < 0.05 is considered to be significant level**					

Chrono nutrition profile	BIOCHEMICAL PARAMETERS									
	FBS	**PP_2BS**	**HbA1C**	**DBP**	**SBP**	**TOTAL CHOLESTEROL**	**LDL**	**HDL**	**TG**	**TG/HDL**
Eating window	**MEAN & MEDIAN**									
>14:00 (N= 114)	145.9	192.1	7.1	83	127	165.3	123.8	49.6	117.2	2.5
	138	191.0	7.3	80	128	148.5	114.0	49.0	111.5	2.5
12:01 to 14:00 (N= 99)	140.2	183.4	7.1	79	127	147.3	113.1	46.8	116.4	2.4
	133.0	188	7.0	80	126	132.0	110.0	44.0	113.0	2.3
≤12:00 (N= 12)	138.5	184.2	7.0	79	126	149.1	111.4	48.3	114.1	2.4
	122.0	194.5	6.9	80	122	132	109	48.0	99.0	2.3

Breakfast skipping										
≥4 days/week (N=128)	146.4 138.0	191.6 191.0	7.1 7.3	82 80	134 123	156.2 151.0	119.1 109.0	50.8 53.0	117.7 113.0	2.5 2.4
2-3 days/ week (N=92)	139.0 130.0	185.4 188.0	7.1 7.2	79 80	126 127	148.8 132.0	113.2 110.0	49.6 49.0	114.8 111.0	2.4 2.3
1 day/week or less (N=7)	132.1 122.0	162.4 169.0	7.2 7.4	79 80	126 127	149.3 132.5	112.4 109.5	46.3 43.5	113.7 99.0	2.3 2.3
Evening latency										
≤2:00 (N=200)	153.7 144.5	193.3 189.5	7.2 7.4	82 80	134 123	156.2 151.0	124.5 116.0	50.8 53.0	131.8 133.0	2.6 2.5
2:01 to 6:00 (N=20)	142.3 133.0	187.5 191.0	7.2 7.4	79 80	127 128	151.0 140.0	119.1 109.0	50.2 51.5	115.1 111.0	2.4 2.3
>6:00 (N=7)	132.1 122.0	162.4 169.0	7.1 7.2	76 75	122 123	148.9 132.0	111.5 109.0	48.0 47.0	114.7 99.0	2.3 2.3
Evening eating										
≥23:00 (N=109)	146.5 138.0	191.8 191.0	7.1 7.3	79 80	127 127	150.8 135.0	118.9 112.0	49.7 49.0	123.5 121.0	2.5 2.4
20:00 to 22:59 (N=85)	140.6 129.0	187.6 181.0	7.1 7.2	79 80	126 128	148.4 132.0	113.0 110.0	49.8 50.0	116.3 112.0	2.5 2.4
<20:00 (N=33)	139.3 138.0	183.6 188.0	7.2 7.4	78 80	126 123	148.6 134.0	111.0 109.0	45.9 43.0	114.2 110.0	2.4 2.3
Night eating										
≥4 days/week (N=108)	145.9 136.0	192.4 191.0	7.2 7.4	82 80	134 127	156.2 151.0	119.1 109.0	50.8 53.0	117.1 113.0	2.5 2.5
2-3 days/ week (N=112)	140.8 134.5	183.6 186.0	7.1 7.2	79 80	126 127	150.2 134.0	114.3 110.0	49.7 49.0	116.1 111.5	2.4 2.3
1 day/week or less (N=7)	132.1 122.0	162.4 169.0	7.1 7.2	79 80	124 123	147.9 132.0	111.1 109.0	46.8 44.0	114.7 99.0	2.3 2.3
Largest meal										
Dinner/ Supper (N=175)	147.7 140.0	189.8 205.0	7.2 7.4	82 80	134 123	157.1 147.0	119.1 109.0	50.8 53.0	117.7 112.0	2.4 2.5
Lunch (N=45)	142.2 133.0	187.6 191.0	7.1 7.2	78 79	127 127	156.2 151.0	113.3 110.0	48.8 47.0	114.7 99.0	2.4 2.3
Breakfast (N=7)	132.1 122.0	162.4 169.0	7.1 7.2	79 80	125 128	147.0 132.0	112.6 110.0	46.2 43.0	112.4 112.0	2.3 2.3

Table 4.10.4 shows the association between chrononutrition profile indicators and biochemical parameters. Significant association was found between eating window and FBS (P < 0.04), LDL (P < 0.04), TG/HDL (P < 0.03), Systolic blood pressure (P < 0.03), Diastolic blood pressure (P < 0.02), PP2BS (P < 0.02) and Total cholesterol (P < 0.02) while highly significant association was found between eating window and HbA1c (P < 0.01), HDL (P < 0.01) and TG (P < 0.00). Breakfast skipping was significantly associated with HbA1c (P < 0.05), HDL (P < 0.04), TG (P < 0.02), TG/HDL (P < 0.02) and SBP (P < 0.02) while breakfast skipping was highly associated with PP2BS (P < 0.01), DBP (P < 0.01), Total cholesterol (P < 0.01), LDL (P < 0.00) and FBS (P < 0.00). Evening latency was significantly associated with FBS, PP2BS, HbA1c, DBP, SBP, Total cholesterol, LDL, HDL, TG and TG/HDL. Significant association was found between evening eating and FBS (P < 0.03), LDL (P < 0.03), HDL (P < 0.02), TG (P < 0.02) and SBP (P < 0.02) while a highly significant association was found between PP2BS (P < 0.01), HbA1C (P < 0.01), DBP (P < 0.01), Total cholesterol (P < 0.01) and TG/HDL (P < 0.00). Night eating was significantly associated with TG (P < 0.04), TG/ HDL (P < 0.04), FBS (P < 0.03), HDL (P < 0.03), LDL (P < 0.03), DBP (P < 0.02), SBP (P < 0.02) and total cholesterol (P < 0.02) while night eating was highly associated with PP2BS (P < 0.01) and HbA1c (P < 0.00). TG/HDL (P < 0.01), HDL (P < 0.01), Total cholesterol (P < 0.01), SBP (P < 0.01), HbA1c (P < 0.01) and PP2BS (P < 0.01) showed a significant association while FBS (P < 0.00), DBP (P < 0.00), LDL (P < 0.00) and TG (P < 0.00) showed a highly significant association with the largest meal thatwas consumed. This suggests that indicators of chrononutrition profile, individuals with Eating window [>14:00], Breakfast skipping [≥4 days/week], Evening latency [≤2:00], Evening eating [≥23:00], Night eating [2-3 days/ week] & Largest meal [Dinner/Supper] had a poor glycemic control, poor lipid profiles along with higher atherogenic indices.

Section 4.11- Assessing Social jetlag

Table 4.11.1: Social jetlag of study population

Social Jetlag	**N (%)**
≥2 hrs	218 (96)
1-2 hrs	07 (3.1)
<1 hr	02 (0.9)

The Munich Chronotype Questionnaire is a self-rated scale focuses primarily

on sleep timing and with 14 questions assesses the sleep timing on workdays and work-free days, and alarm clock use on workdays and work-free days. Social jetlag is found to be the discrepancy between the social (behavioural) and endogenous (circadian) time. Table 4.11.1 summarises the social jetlag among 227 participants. It can be seen that majority of the participants (96%) had ≥2 hrs of social jetlag followed by 1-2 hours of social jetlag (3.1%) and <1 hr of social jetlag (0.9%).

Table 4.11.2: Correlation between social jetlag and nutrient intake

Parameters	**Social Jet Lag**	
	R value	***p* value***
Carbohydrate	0.11	0.004
Protein	0.76	0.000
Fat	0.13	0.002
Fibre	-0.47	0.000
Pearson's correlation (r) between Social jet lag and total nutrient intake **p value is based on Pearson's Correlation analysis** *** p value < 0.05 is considered to be significant level**		

Table 4.11.2 shows the correlation between social jetlag and nutrient intake. There was a positive correlation and significant relationship between Social jetlag and higher carbohydrate (r=0.11, p=0.004), protein (r=0.76, p=0.000) and fat intake (r=0.13,p=0.002). Participants with social jetlag showed a highly significant association with lower fiber intake (r=-0.47, p=0.000).

Table 4.11.3: Correlation between social jetlag and body composition

Parameters	**Social Jet Lag**	
	R value	***p* value***
Total Body Fat	0.13	0.004
Skeletal Muscle	-0.11	0.002
Visceral Fat	0.13	0.002
Pearson's correlation (r) between Social jet lag and body composition **p value is based on Pearson's Correlation analysis** *** p value < 0.05 is considered to be significant level**		

Table 4.11.3 shows the correlation between social jetlag and body composition. There was a positive correlation and significant relationship between Social jetlag and higher total body fat % (r=0.13, p=0.004) and visceral fat (r=0.13, p=0.002). Participants with social jetlag showed a significant association with lower skeletal muscle mass % (r=-0.11, p=0.002).

Figure 4.11.1: Association between variation in meal timings on weekday and weekend and Glycemic control

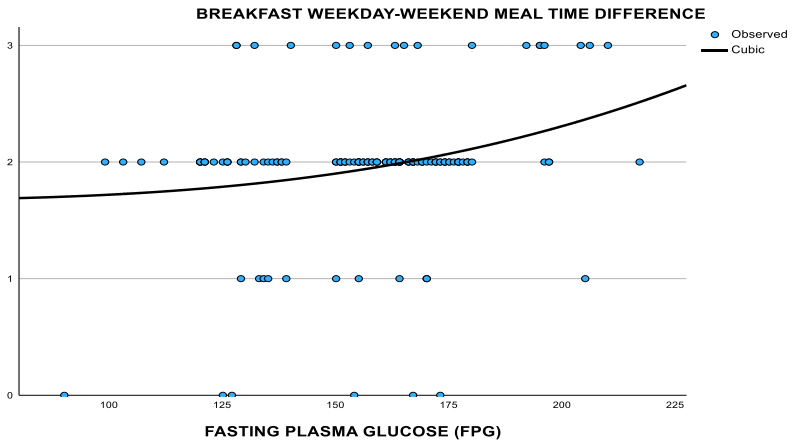


Figure 4.11.1(a): Association between variability of breakfast timings in weekday and weekend and Fasting Plasma Glucose

Figure shows the association between variability of breakfast timings in weekdays and weekends and Fasting plasma glucose. The graph highlights that higher the eating hours variability of breakfast in weekdays and weekends, higher is the fasting plasma glucose ($p < 0.01$).

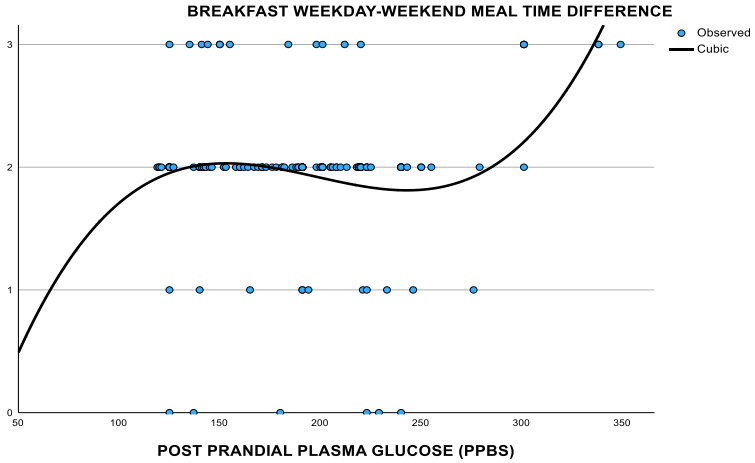


Figure 4.11.1(b): Association between variability of breakfast timings in weekday and weekend and Post prandial Plasma Glucose

Figure shows the association between variability of breakfast timings in weekdays and weekends and Post prandial plasma glucose. The graph highlights that higher the eating hours variability of breakfast in weekdays and weekends, higher is the post

prandial plasma glucose ($p < 0.04$).

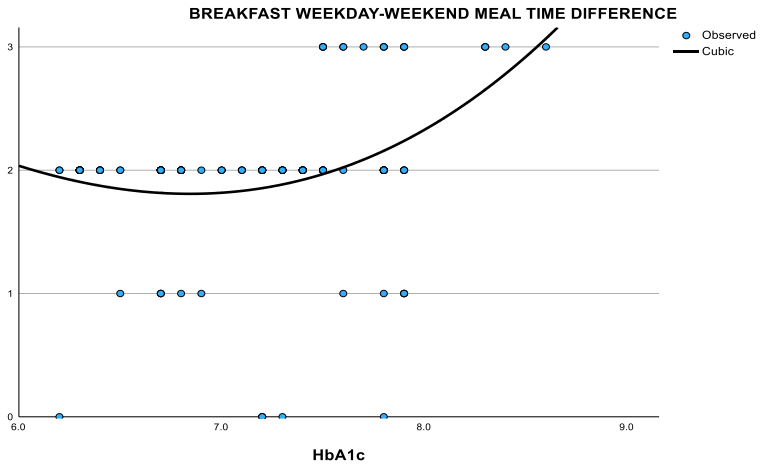


Figure 4.11.1(c): Association between variability of breakfast timings in weekday and weekend and HbA1c

Figure shows the highly significant association between variability of breakfast timings in weekdays and weekends and HbA1c. The graph highlights that higher the eating hours variability of breakfast in weekdays and weekends, higher is the HbA1c ($p < 0.00$).

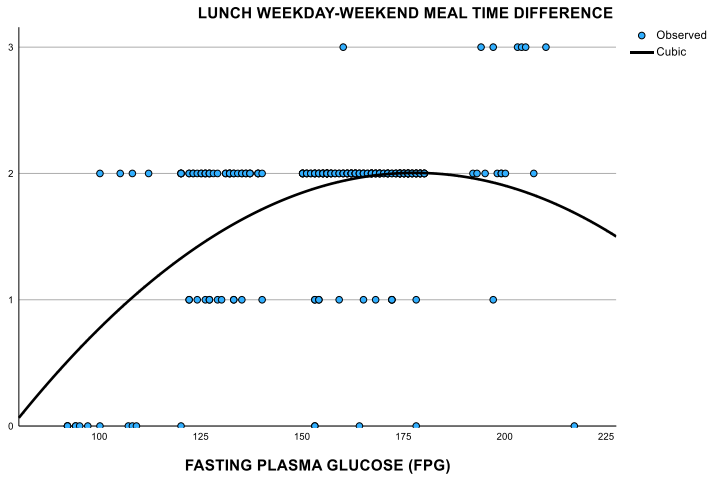


Figure 4.11.1(d): Association between variability of lunch timings in weekday and weekend and Fasting Plasma Glucose

Figure shows highly significant association between variability of lunch timings in weekdays and weekends and Fasting blood glucose. The graph highlights that higher the eating hours variability of lunch in weekdays and weekends, higher is the fasting blood glucose ($p < 0.00$).

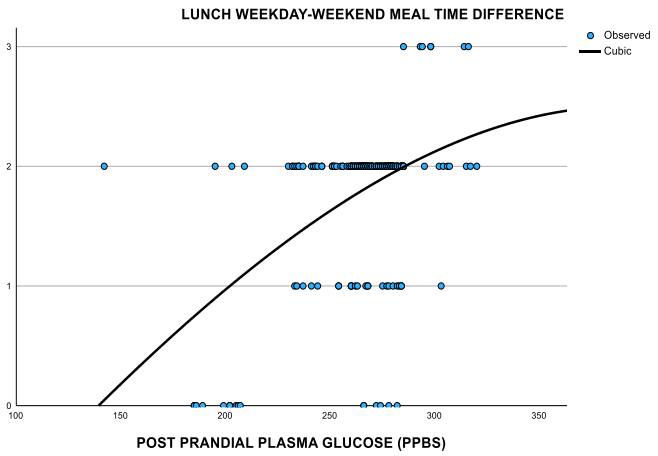


Figure 4.11.1(e): Association between variability of lunch timings in weekday and weekend and Post prandial Plasma Glucose

Figure shows highly significant association between variability of lunch timings in weekdays and weekends and Post prandial plasma glucose. The graph highlights that higher the eating hours variability of lunch in weekdays and weekends, higher is the post prandial plasma glucose ($p < 0.00$).

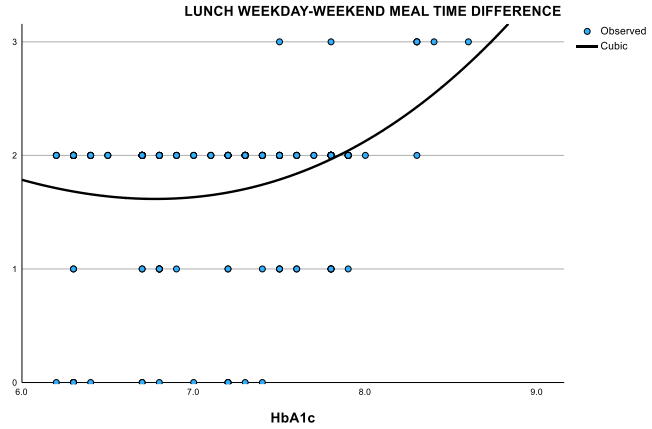


Figure 4.11.1(e): Association between variability of lunch timings in weekday and weekend and HbA1c

Figure shows highly significant association between variability of lunch timings in weekdays and weekends and HbA1c. The graph highlights that higher the eating hours variability of lunch in weekdays and weekends, higher is the HbA1c ($p < 0.00$).

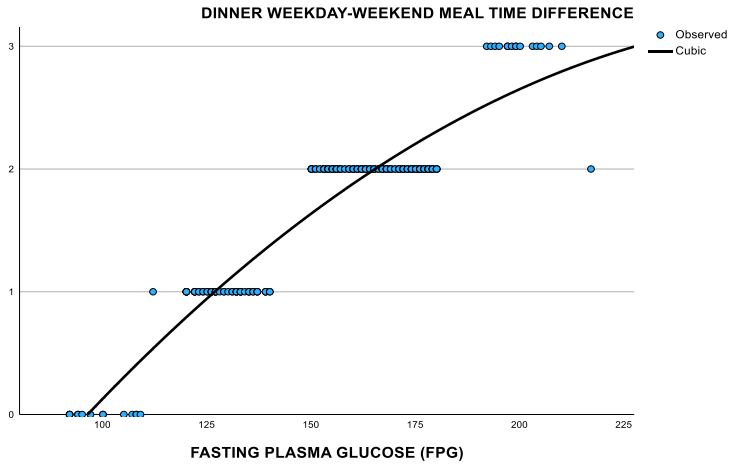


Figure 4.11.1(f): Association between variability of dinner timings in weekday and weekend and Fasting Plasma Glucose

Figure shows highly significant association between variability of dinner timings in weekdays and weekends and Fasting blood glucose. The graph highlights that higher the eating hours variability of dinner in weekdays and weekends, higher is the fasting

blood glucose (p < 0.00).

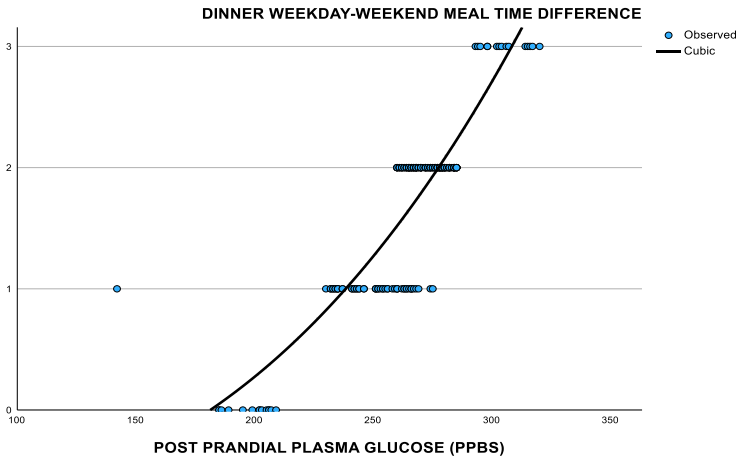


Figure 4.11.1(g): Association between variability of dinner timings in weekday and weekend and Post prandial plasma Glucose

Figure shows highly significant association between variability of dinner timings in weekdays and weekends and Post prandial plasma glucose. The graph highlights that higher the eating hours variability of dinner in weekdays and weekends, higher is the post prandial plasma glucose (p < 0.00).

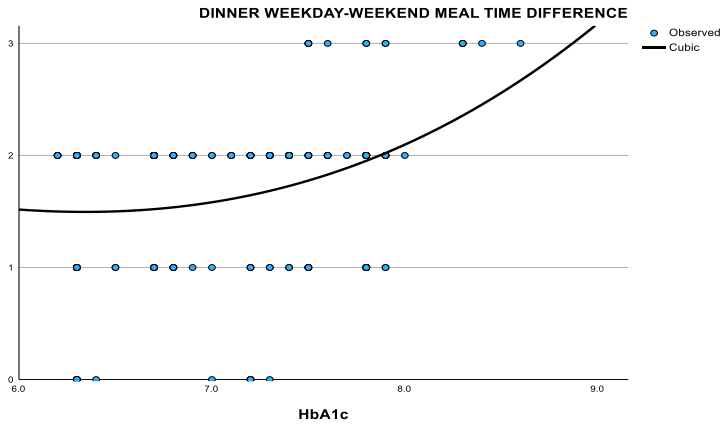


Figure 4.11.1(h): Association between variability of dinner timings in weekday and weekend and HbA1c

Figure shows highly significant association between variability of dinner timings in weekdays and weekends and HbA1c. The graph highlights that higher the eating hours variability of dinner in weekdays and weekends, higher is the HbA1c ($p < 0.00$).

Figure 4.11.1 shows that Variability of meal timings in weekday and weekend (breakfast, lunch and dinner) with a threshold of 2 hours of more was associated with a poor glycaemic control as assessed using cubic splines ($p < 0.000$).

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The purpose of the present study was to study the association between Chrononutrition and glycaemic control, body composition & social jet lag in people with Type 2 Diabetes Mellitus. The study involved 227 participants who were chosen from three diabetes clinics/hospital in the city of Vadodara. Data was gathered in 11 sections, including Personal information, diet information, consumption of ultra-processed foods, chronotype, physical activity, screen time, stress, sleep, social jetlag, anthropometric data were taken at the clinic, and biochemical parameters were taken from their case files.

Major findings of the Study

- **Personal information**

Maximum male (29.8%) and female participants (29.1%) are from age group of 55-60 years. The percentage of diploma holders in male (23.4%) and graduates in female (35.9%) are the highest among all education qualifications. Maximum number (82.5%) of females are home-makers and males (34.7%) are business owner/ self employed.

- **Anthropometric data and Biochemical parameters**

Prevalence of central obesity by higher waist circumference and high waist-hip ratio was higher in males than females. Majority of participants were obese (male = 59%, female= 63%). Seventy seven percent male and 63% female had very high body fat % while 46 % male had very high and 39 % female had high visceral fat with 68% males and 65% females having lower skeletal muscle %. Fifty five percent male and 66% female had uncontrolled fasting blood sugar levels while 79% male participants and 57% female participants had uncontrolled PP2BS levels and 49% percent male and 67 % female had fairly controlled HbA1c levels. Nineteen point four percent male and 25.2 % female had normal blood pressure. Eighty nine percent male and female participants had desirable cholesterol levels while 33 % male had high LDL levels and 60% female had borderline high LDL levels. Eighty one percent male and 80 % female participants had low HDL levels. Eighty two percent male and 76% female participants had normal triglycerides values and 64% male and 61% female had higher than recommended TG/HDL ratio which shows higher risk of suffering from cardiovascular diseases among participants. All the participants had TyG index more than the cut off value which indicated they were insulin resistant.

- **Diet information**

  Fifty eight point one percent of the total participants were lacto-vegetarian while 22.9% were lacto-ovo vegetarian and 18.9% were non-vegetarian. Breakfast was generally skipped by 36.1%. Only 5.7 % of the total participants preferred breakfast as their main meal. Maximum participants (81.5 %) had never consulted a dietitian.

- **Physical activity, sitting time, screen time, sleep and Stress**

  Only 14.1% participants exercised daily. Female participants had higher sitting time compared to the male participants. Screen time of 1-2 hours post dinner was seen among 44.9 % of the participants. Eighty two percent subjects had moderate sleep difficulty. Majority of the participants (88.1 %) suffered from moderate stress while 3.0 % participants had low stress levels and only 8.8% suffered from high stress.

- **Chronotype and Chrononutrition Profile**

  Majority of the participants (77.2%) had moderate evening chronotype followed by 22.4 % with moderate morning chronotype. Forty nine point one percent of participants had fair chrononutrition profile while 47.4% had poor chrononutrition profile and 3.1 % had good chrononutrition profile.

  Maximum participants (50.2%) had poor duration between first eating event and last eating event, frequency of skipping breakfast for four or more days in a week, poor duration between last eating event and sleep onset among 88.1% participants, poor risk of eating late in the waking day among 48% participants, frequency of night eating for 2-3 days a week among 49.3% participants and 77.0% participants are in poor category where dinner is the meal in which largest amount of food is eaten.

- **Social Jetlag**

  Maximum participants (96%) have ≥2 hrs of social jetlag followed by 1-2 hours of social jetlag (3.1%) and <1 hr of social jetlag (0.9%).

Conclusion:

The major conclusions that emerge from the present study are,

- Evening chronotype was more prevalent among male participants while majority of female participants showed morning chronotype.
- Higher BMI, body fat %, visceral fat, waist circumference, waist hip ratio, waist height ratio and lower skeletal Muscle was significantly associated with eveningness chronotype.
- Individuals having circadian preference for eveningness had higher HbA1c levels, fasting blood glucose and post-prandial blood glucose, triglyceride levels and TyG index.
- Poor dietary habits and irregular meal timings was seen in evening chronotyped individuals. Higher consumption of carbohydrates and fats and lower consumption of protein and fiber was seen in evening chronotyped individuals than the morning type. Less consumption of pulses and legumes, dairy products, fruits, vegetables and nuts and high consumption of cereals, oils and fats and sugar was seen in evening chronotype individuals. Evening chronotyped individuals consumed breakfast with a higher Glycemic Index as compared to morning type. Dinner was the largest meal and higher in GI in participants with a preference for eveningness.
- Fair chrononutrition profile was seen in majority of the participants followed by poor and good chrononutrition profile.
- Individuals having Poor Chrononutrition profile had higher body fat %, visceral fat and lower skeletal muscle %.
- An intake of Breakfast, Lunch and Dinner with a higher GI was seen among participants with a poor chrononutrition profile.
- As indicators of chrononutrition profile, individuals with Eating window [>14:00], Breakfast skipping [≥4 days/week], Evening latency [≤2:00], Evening eating [≥23:00], Night eating [2-3 days/ week] & Largest meal [Dinner/Supper] had a poor glycemic control, poor lipid profiles along with higher atherogenic indices.
- Majority of the participants had a social jetlag of ≥2 hrs which indicate a discrepancy in sleep time between weekdays and weekends.
- A variation in the breakfast, lunch and dinner time of weekday and weekend was seen among individuals with social jetlag. A higher carbohydrate, protein and fat intake and lower fibre.intake was seen among participants with social jetlag.

- Individuals with social jet lag had a higher body fat % and visceral fat and lower skeletal muscle %.
- Majority of the participants with a variation in the breakfast, lunch and dinner time of weekday and weekend of 2 or more eating hours had a poor glycaemic control.

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ANNEXURES

Annexure I

Ethical Approval Certificate

सत्यं शिवं सुन्दरम्
Estd. 1949

Institutional Ethics Committee for Human Research (IECHR)

FACULTY OF FAMILY AND COMMUNITY SCIENCES
THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA

Ethical Compliance Certificate 2022 – 2023

This is to certify that Ms. Gauri Jaimini's study titled, "**Chrononutrition and Its Association with Glycaemic Control, Body Composition & Social Jet Lag in People with Type 2 Diabetes Mellitus**" from Department of Foods and Nutrition has been approved by the Institutional Ethics Committee for Human Research (IECHR), Faculty of Family and Community Science, The Maharaja Sayajirao University of Baroda. The study has been allotted the ethical approval number **IECHR/FCSc/MSc/2022/38.**

Prof Mini Sheth
Member Secretary
IECHR

Prof Shagufa Kapadia
Chairperson
IECHR

Chair Person
IECHR
Faculty of Family & Community Sciences
The Maharaja Sayajirao University of Baroda

Annexure II

Consent Form (English)

This informed consent form is for People with Diabetes from Vadodara who we are inviting to participate in research, titled "CHRONONUTRITION AND ITS ASSOCIATION WITH GLYCAEMIC CONTROL, BODY COMPOSITION & SOCIAL JET LAG IN PEOPLE WITH TYPE 2 DIABETES MELLITUS".

Introduction:

I, Gauri Jaimini, am pursuing M.Sc. from Department of Foods and Nutrition of The Maharaja Sayajirao University Baroda. My research Project is titled "CHRONONUTRITION AND ITS ASSOCIATION WITH GLYCAEMIC CONTROL, BODY COMPOSITION & SOCIAL JET LAG IN PEOPLE WITH TYPE 2 DIABETES MELLITUS".

Over 77 million have now been diagnosed with diabetes in India. There are 729 diabetic individuals among a lakh population in Gujarat. I am going to give you information and invite you to be part of this research. Before you decide, you can talk to anyone you feel comfortable with about the research.

This consent form may contain words that you may not understand. Please ask me to stop as we go through the information and I will take time to explain. If you have questions later, you can ask me again.

Purpose of the research:

Diabetes is highly prevalent in India. We want to find the correlation of Type 2 Diabetes Mellitus with Chrono nutrition of an individual. We believe that you can help us by telling us about your diet patterns, sleep pattern, activity pattern and about health practices in general.

Type of Research Intervention:

This research will involve questionnaire which you will have to fill and will take half an hour to One hour.

We will need the following information from you:

Diet Information, Physical Activity data, Screen Time data, Data regarding Stress, Data related to Sleep, Data related to Social jetlag

Anthropometric data (Height, Weight, Waist Measurement, Hip measurement, Body composition) {Using questionnaire and interview method}

Biological Parameters {From your case file}

Participant Selection:

You are being selected to take part in this research because we want to understand the association of Chronotype, GI of meals, Insulin Resistance, Social jetlag and Diabetes Mellitus.

Voluntary Participation:

Your participation in this research is entirely voluntary. It is your choice whether to participate or not.

Procedures:

You need to fill out a questionnaire which will be provided and collected by Gauri Jaimini. You may answer the questionnaire yourself, or it can be read to you and you can say out loud the answer if you want me to write down.

If you do not wish to answer any of the questions included in the survey, you may skip them and move on to the next question. The information recorded will be confidential, your name will not be included on the forms, only a number will identify you, and no one else except research team will have access to your information.

Duration/Frequency:

We will need to meet twice during the entire course of research project for data collection.

Risks:
There is no perceived risk involved.
Benefits:
There will be no direct benefit to you, but your participation is likely to contribute toward better understanding.
Reimbursements:
You will not be provided any incentive to take part in the research.
Confidentiality:
We will not be sharing information about you to anyone outside of the research team. The information that we collect from this research project will be kept private. It will not be shared with or given to anyone except the Investigator, Research guide and Consultant Doctor.
Sharing the Results:
At the end of the study the relevant information will be shared with you.
Right to Refuse or Withdraw:
You do not have to take part in this research if you do not wish to do so. You may also stop participating in the research at any time even if you agreed earlier.
Whom to Contact:
If you have any questions, you can ask them now or later. If you wish to ask questions later, you may contact any of the following:
Gauri Jaimini (+91 7285816140; gaurijaimini99@gmail.com) and Dr. Suneeta Chandorkar (+91 9426366666; suneetachandorkar@gmail.com)

Certificate of Consent
I have been invited to participate in research about Chronotype, GI of meals, Insulin Resistance, Social jetlag and Diabetes Mellitus.
I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions I have asked have been answered to my satisfaction. I consent voluntarily to be a participant in this study.

Name of Participant_____ Signature of Participant _____ Date _

Statement by the researcher/person taking consent
I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the participant understands that the following will be done:

Anthropometric data Collection
Biological Parameters
Diet Information
Physical Activity data
Screen Time data
Stress data collection
Sleep data collection
Social jetlag data collection

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

A copy of this ICF has been provided to the participant.
Name of Researcher/person taking the consent_____

Signature of Researcher /person taking the consent_____
Date _____

Annexure III

Consent Form (Gujarati)

<u>સંમતિ ફોર્મ</u>

આ જાણકાર સંમતિ ફોર્મ વડોદરાના ડાયાબિટીઝવાળા લોકો માટે છે, જેને આપણે સંશોધનમાં ભાગ લેવા આમંત્રણ આપી રહ્યા છીએ, "ક્રોનોન્યુટ્રીશન અને ગ્લાયસિમિક કંટ્રોલ, બોડી કમ્પોઝિશન અને ટાઇપ 2 ડાયાબિટીસ મેલીટસવાળા લોકોમાં સોશિયલ જેટ લેગ સાથેનું જોડાણ" શીર્ષક છે.

પરિચય:
હું, ગૌરી જૈમિની, એમ.એસ.સી. ખોરાક વિભાગ અને મહારાજા સિયાજીરાઓ યુનિવર્સિટી બરોડાના પોષણથી. મારા સંશોધન પ્રોજેકટનું શીર્ષક છે “ક્રોનોન્યુટ્રિશન અને ગ્લાયકેમિક નિયંત્રણ, બોડી કમ્પોઝિશન અને ટાઇપ 2 ડાયાબિટીસ મેલીટસવાળા લોકોમાં સામાજિક જેટ લેગ” સાથે જોડાણ.
ભારતમાં હવે 77 મિલિયનથી વધુનું ડાયાબિટીઝ હોવાનું નિદાન થયું છે. ગુજરાતમાં લાખની વસ્તીમાં 729 ડાયાબિટીસ વ્યક્તિઓ છે. હું તમને માહિતી આપવા જઈશ અને તમને આ સંશોધનનો ભાગ બનવા આમંત્રણ આપું છું. તમે નક્કી કરો તે પહેલાં, તમે સંશોધન વિશે તમને આરામદાયક લાગે તે કોઇપણ સાથે વાત કરી શકો છો.
આ સંમતિ ફોર્મમાં એવા શબ્દો હોઇ શકે છે જે તમે સમજી શકતા નથી. કૃપા કરી મને માહિતીમાંથી પસાર થતાં જ રોકાવાનું કહો અને હું સમજાવવા માટે સમય લઇશ. જો તમને પછીથી પ્રશ્નો હોય, તો તમે મને ફરીથી પૂછી શકો છો.

સંશોધનનો હેતુ:
ભારતમાં ડાયાબિટીઝ ખૂબ પ્રચલિત છે. અમે કોઇ વ્યક્તિના ક્રોનો પોષણ સાથે ટાઇપ 2 ડાયાબિટીસ મેલીટસનો સહસંબંધ શોધવા માંગીએ છીએ. અમારું માનવું છે કે તમે તમારા આહારની રીત, sleep ંધની રીત, પ્રવૃત્તિની રીત અને સામાન્ય રીતે આરોગ્ય પધ્ધતિઓ વિશે અમને જણાવીને અમને મદદ કરી શકો છો.

સંશોધન હસ્તક્ષેપનો પ્રકાર:
આ સંશોધનમાં પ્રશ્નાવલી શામેલ હશે જે તમારે ભરવું પડશે અને અડધો કલાકથી એક કલાકનો સમય લાગશે.
અમને તમારી પાસેથી નીચેની માહિતીની જરૂર પડશે:
આહાર માહિતી, શારીરિક પ્રવૃત્તિ ડેટા, સ્ક્રીન ટાઇમ ડેટા, તાણ સંબંધિત ડેટા, ઊંઘથી સંબંધિત ડેટા, સામાજિક જેટલેગથી સંબંધિત ડેટા
એન્થ્રોપોમેટ્રિક ડેટા (ઊંચાઇ, વજન, કમર માપન, હિપ માપન, શરીરની રચના) પ્રશ્નાવલી અને ઇન્ટરવ્યૂ પધ્ધતિનો ઉપયોગ}
જૈવિક પરિમાણો તમારી કેસ ફાઇલમાંથી

સહભાગી પસંદગી:
તમને આ સંશોધનમાં ભાગ લેવા માટે પસંદ કરવામાં આવી રહ્યા છે કારણ કે અમે ક્રોનોટાઇપ, ભોજનની જીઆઇ, ઇન્સ્યુલિન પ્રતિકાર, સામાજિક જેટલાગ અને ડાયાબિટીસ મેલીટસના સંગઠનને સમજવા માંગીએ છીએ.

સ્વૈચ્છિક ભાગીદારી:
આ સંશોધનમાં તમારી ભાગીદારી સંપૂર્ણપણે સ્વૈચ્છિક છે. ભાગ લેવો કે નહીં તે તમારી પસંદગી છે.

કાર્યવાહી:
તમારે એક પ્રશ્નાવલી ભરવાની જરૂર છે જે ગૌરી જેમિની દ્વારા પ્રદાન કરવામાં આવશે અને એકત્રિત કરવામાં આવશે. તમે જાતે પ્રશ્નાવલિનો જવાબ આપી શકો છો, અથવા તે તમને વાંચી શકાય છે અને જો તમે મને લખવા માંગતા હોવ તો તમે મોટેથી જવાબ આપી શકો છો.
જો તમે સર્વેમાં સમાવિષ્ટ કોઇપણ પ્રશ્નોના જવાબ આપવા માંગતા નથી, તો તમે તેમને છોડી શકો છો અને આગલા પ્રશ્ન

પર આગળ વધી શકો છો. રેકોર્ડ કરેલી માહિતી ગુપ્ત રહેશે, તમારું નામ ફોર્મ્સ પર શામેલ કરવામાં આવશે નહીં, ફક્ત એક સંખ્યા જ તમને ઓળખશે, અને સંશોધન ટીમ સિવાય બીજું કોઈ તમારી માહિતીની .ક્સેસ કરશે નહીં.

અવધિ/આવર્તન:
ડેટા સંગ્રહ માટેના સંશોધન પ્રોજેક્ટના સમગ્ર કોર્સ દરમિયાન અમારે બે વાર મળવાની જરૂર રહેશે.
જોખમો:
તેમાં કોઈ જોખમ શામેલ નથી.

લાભો:
તમને કોઈ સીધો ફાયદો થશે નહીં, પરંતુ તમારી ભાગીદારી વધુ સારી રીતે સમજણમાં ફાળો આપે તેવી સંભાવના છે.
વળતર:
તમને સંશોધનમાં ભાગ લેવા માટે કોઈ પ્રોત્સાહન આપવામાં આવશે નહીં.

ગુપ્તતા:
અમે સંશોધન ટીમની બહારના કોઈપણને તમારા વિશેની માહિતી શેર કરીશું નહીં. અમે આ સંશોધન પ્રોજેક્ટમાંથી જે માહિતી એકત્રિત કરીએ છીએ તે ખાનગી રાખવામાં આવશે. તે તપાસનીસ, સંશોધન માર્ગદર્શિકા અને સલાહકાર ડ doctor ક્ટર સિવાય કોઈની સાથે શેર કરવામાં આવશે નહીં અથવા આપવામાં આવશે નહીં.
પરિણામો શેર કરી રહ્યા છીએ:
અભ્યાસના અંતે સંબંધિત માહિતી તમારી સાથે શેર કરવામાં આવશે.
ઇનકાર કરવાનો અથવા પાછો ખેંચવાનો અધિકાર:
જો તમે આમ કરવા માંગતા ન હોવ તો તમારે આ સંશોધનમાં ભાગ લેવાની જરૂર નથી. જો તમે અગાઉ સંમત થયા હોવ તો પણ તમે કોઈપણ સમયે સંશોધનમાં ભાગ લેવાનું બંધ કરી શકો છો.

જેનો સંપર્ક કરવો:
જો તમને કોઈ પ્રશ્નો હોય, તો તમે તેમને હવે અથવા પછીથી પૂછી શકો છો. જો તમે પછીથી પ્રશ્નો પૂછવા માંગતા હો, તો તમે નીચેનામાંથી કોઈપણનો સંપર્ક કરી શકો છો:
ગૌરી જૈમિની (+91 7285816140; gauijaimini99@gmail.com) અને Dr.સુનીતા ચન્ડોર્કર (+91 9426366666; suneetachandorkar@gmail.com)

સંમતિનો પ્રમાણપત્ર

મને ક્રોનોટાઇપ, ભોજનની જીઆઈ, ઇન્સ્યુલિન પ્રતિકાર, સામાજિક જેટલેગ અને ડાયાબિટીસ મેલીટસ વિશેના સંશોધનમાં ભાગ લેવા આમંત્રણ અપાયું છે.
મેં ઉપરોક્ત માહિતી વાંચી છે, અથવા તે મને વાંચવામાં આવી છે. મને તેના વિશે પ્રશ્નો પૂછવાની તક મળી છે અને મેં જે પ્રશ્નો પૂછ્યા છે તેનો જવાબ મારા સંતોષનો જવાબ આપવામાં આવ્યો છે. હું આ અભ્યાસમાં સહભાગી બનવા માટે સ્વૈચ્છિક રીતે સંમતિ આપું છું.

સહભાગીનું નામ _____
સહભાગીની સહી _____
તારીખ _____

સંમતિ લેતા સંશોધનકર્તા/વ્યક્તિ દ્વારા નિવેદન
મેં સંભવિત સહભાગીને માહિતી શીટને સચોટ રીતે વાંચી છે, અને મારી શ્રેષ્ઠ ક્ષમતાએ ખાતરી આપી છે કે સહભાગી સમજે છે કે નીચેના કરવામાં આવશે:

માનવશાસ્ત્ર
જૈવિક પરિમાણો
આહાર માહિતી
ભૌતિક પ્રવૃત્તિ -માહિતી
સ્ક્રીન ટાઇમ ડેટા
તણાવ -ડેટા સંગ્રહ
સ્લીપ ડેટા સંગ્રહ
સામાજિક જેટલેગ ડેટા સંગ્રહ

હું પુષ્ટિ કરું છું કે સહભાગીને અભ્યાસ વિશે પ્રશ્નો પૂછવાની તક આપવામાં આવી હતી, અને સહભાગી દ્વારા પૂછાતા તમામ પ્રશ્નોનો જવાબ યોગ્ય રીતે અને મારી શ્રેષ્ઠ ક્ષમતા માટે કરવામાં આવ્યો છે. હું પુષ્ટિ કરું છું કે વ્યક્તિને સંમતિ આપવા માટે દબાણ કરવામાં આવ્યું નથી, અને સંમતિ મુક્ત અને સ્વૈચ્છિક રીતે આપવામાં આવી છે.

આ આઇસીએફની એક નકલ સહભાગીને આપવામાં આવી છે.

સંમતિ લેતા સંશોધનકર્તા/વ્યક્તિનું નામ _____

સંમતિ લેતા સંશોધનકર્તા /વ્યક્તિની સહી _____

તારીખ _____

Annexure IV

QUESTIONNAIRE for "CHRONONUTRITION AND ITS ASSOCIATION WITH GLYCAEMIC CONTROL, BODY COMPOSITION & SOCIAL JET LAG IN PEOPLE WITH TYPE 2 DIABETES MELLITUS"

PERSONAL INFORMATION:

1) Name:
2) Age:
3) Sex:
4) Educational Qualification:
5) Occupation:

Occupational Categories:	Tick here
Business owner/ self employed	
Professionals	
Government / Civil service	
Manager/ Supervisor	
Clerks	
Sales / Service workers	
Agriculture and fishery worker	
Home-maker	
Retired	

6) Nature of Work:

Shift work	
Regular Work	

DIET INFORMATION:

7) You are:

Vegan	
Lacto-vegetarian	
Lacto-ovo vegetarian	
Non-vegetarian	

8) How many glasses of water do you drink daily? (200ml):

<6 glasses	
6-8 glasses	
>8 glasses	

9) Which meal do you generally skip? _____

10) Which is the most important meal of the day? _____

11) FREQUENCY OF CONSUMPTION OF READY TO EAT FOODS:

Name of the food items	*Daily (1)*	*2-3 Times a week (2)*	*Weekly (3)*	*Fortnightly (4)*	*Monthly (5)*	*Occasionally (6)*	*Seasonal (7)*	*Never (8)*
(a)CHIPS								
(b) FRYUMS								
(c) BISCUITS								
(d) NAMKEENS								
(e) SAMOSA								
(f) KACHORI								
(g) VADAPAV								
(h)DABELI								
(i)SEVUSAL								
(j)SANDWICHES								
(k)BURGERS/HOTDOG								
(l)PIZZA								
(m)FRENCHFRIES								
(n)FRANKIE								
(o)CHINESE FOOD								
(p)KHICHU								
(q)BHAJIYA								
(r)DHOKLA/IDLI								
(s)DOSA/UTTAPAM								
(t)PANI-PURI/ SEV PURI								
(u)CHORAFALI/ CHANAJOR GARAM								
(v)SWEETS								
(w)MILKSHAKES								
(x)COLD DRINKS								
(y)ENERGY DRINKS								
(z) OTHERS (name)								

12) 24- HOUR DIETARY RECALL:

Time	Meal	Ingredients	Raw amt. used for Family (gm) [A]	Cooked vol. for Family (ml) [B]	Vol. consumed by subject (ml) [C]	Raw amt. consumed by subject [D] D = A x C/B

13) Have you ever consulted a dietitian?

Yes	
No	

14) If yes, where have you consulted your dietitian?

Online	
Dietitian's private clinic	
Diabetes clinic	

15) Morning ness – Evening ness:

16.1) What time would you get up if you were entirely free to plan your day?	
Time	
1)5:00 – 6:29 am	
2)6:30 – 7:44 am	
3)7:45 – 9:44 am	
4)9:45 – 10:59 am	
5)11:00 – 11:59 am	
16.2) What time would you go to bed if you were entirely free to plan your evening?	
1)8:00 – 8:59 pm	
2)9:00 – 10:14 pm	
3)10:15 pm – 12:29 am	
4)12:30 – 1:44 am	
5)1:45 – 2:59 am	
6)3:00 am – 8:00 pm	
16.3) If there is a specific time at which you have to get up in the morning, to what extent do you depend on being woken up by an alarm clock?	
1)Not at all dependent	
2)Slightly dependent	
3)Fairly dependent	
4)Very dependent	

16.4) How easy do you find to get up in the morning (when you are not woken up unexpectedly)?	
1)Not at all easy	
2)Not very easy	
3)Fairly easy	
4)Very easy	
16.5) How alert do you feel during the first half hour after you wake up in the morning?	
1)Not at all alert	
2)Slightly alert	
3)Fairly alert	
4)Very alert	
16.6) How hungry do you feel during the first half-hour after you wake up in the morning?	
1)Not at all hungry	
2)Slightly hungry	
3)Fairly hungry	
4)Very hungry	
16.7) During the first half-hour after you wake up in the morning, how tired do you feel?	
1)Very tired	
2)Fairly tired	
3)Fairly refreshed	
4)Very refreshed	
16.8) If you have no commitment the next day, what time would you go to bed compared to your usual bedtime?	
1)Seldom or never later	
2)Less than one hour later	
3)1-2 hours later	
4)More than two hours later	
16.9) You have decided to engage in some physical exercise. A friend suggests that you do this for one hour twice a week and the best time for him/her is between 7:00 – 8:00 am. Bearing in mind nothing but	

your own internal "clock", how do you think you would perform?	
1)Would be in good form	
2)Would be in reasonable form	
3)Would find it difficult	
4)Would find it very difficult	
16.10) At what time of day do you feel you become tired as a result of need for sleep?	
1)8:00 – 8:59 pm	
2)9:00 – 10:14 pm	
3)10:15 pm – 12:44 am	
4)12:45 – 1:59 am	
5)2:00 – 3:00 am	
16.11) You want to be at your peak performance for a test that you know is going to be mentally exhausting and will last for two hours. You are entirely free to plan your day. Considering only your own internal "clock", which ONE of the four testing times would you choose?	
1)8:00 – 10:00 am	
2)11:00 am – 1:00 pm	
3)3:00 – 5:00 pm	
4)7:00 – 9:00 pm	
16.12) If you got into bed at 11:00 pm, how tired would you be?	
1)Not at all tired	
2)A little tired	
3)Fairly tired	
4)Very tired	
16.13) For some reason, you have gone to bed several hours later than usual, but there is no need to get up at any particular time the next morning. Which ONE of the following areyou most likely to do?	
1)Will wake up at usual time, but will NOT fall back asleep	
2)Will wake up at usual time and will doze thereafter	
3)Will wake up at usual time but will fall asleep again	
4)Will NOT wake up until later than usual	
16.14) One night you have to remain awake between 4:00 – 6:00 am in	

order to carry out a night watch. You have no commitments the next day. Which ONE of the alternatives will suite you best?	
1)Would NOT go to bed until watch was over	
2)Would take a nap before and sleep after	
3)Would take a good sleep before and nap after	
4)Would sleep only before watch	
16.15) You have to do two hours of hard physical work. You are entirely free to plan your day and considering only your own internal "clock" which ONE of the following times would you choose?	
1)8:00 – 10:00 am	
2)11:00 am – 1:00 pm	
3)3:00 – 5:00 pm	
4)7:00 – 9:00 pm	
16.16) You have decided to engage in hard physical exercise. A friend suggests that you do this for one hour twice a week and the best time for him/her is between 10:00 – 11:00 pm. Bearing in mind nothing else but your own internal "clock", how well do you think you would perform?	
1)Would be in good form	
2)Would be in reasonable form	
3)Would find it difficult	
4)Would find it very difficult	
16.17) Suppose that you can choose your school hours. Assume that you went to school for five hours per day and that school was interesting and enjoyable. Which five consecutive hours would you select?	
1)5 hours starting between 4:00 – 7:59 am	
2)5 hours starting between 8:00 – 8:59 am	
3)5 hours starting between 9:00 am – 1:59 pm	
4)5 hours starting between 2:00 – 4:59 pm	
5)5 hours starting between 5:00 pm – 3:59 am	
16.18) At what time of the day do you think that you reach your "feeling best" peak?	
1)5:00 – 7:59 am	
2)8:00 – 9:59 am	

3)10:00 am – 4:59 pm	
4)5:00 – 9:59 pm	
5)10:00 pm – 4:59 am	
16.19) One hears about "morning" and "evening" types of people. Which ONE of these types do you consider yourself to be?	
1)Definitely a "morning" type	
2)Rather more a "morning" type than an "evening" type	
3)Rather more an "evening" type than a "morning" type	
4)Definitely an "evening" type	

16) PHYSICAL ACTIVITY:

Questions	**Response**
Activity at work	
17.1) Does your work involve vigorous-intensity activity that causes large increases in breathing or heart rate like [carrying or lifting heavy loads, digging or construction work] for at least 10 minutes continuously?	1)Yes 2)No If no, go to question 20.4
17.2) In a typical week, on how many days do you do vigorous-intensity activities as part of your work?	Number of days: _____
17.3) How much time do you spend doing vigorous-intensity activities at work on a typical day?	Hours: Minutes_____
17.4) Does your work involve moderate-intensity activity that causes small increases in breathing or heart rate such as brisk walking [or carrying light loads] for at least 10 minutes continuously?	1)Yes 2)No If no, go to question 20.7
17.5) In a typical week, on how many days do you do moderate-intensity activities as part of your work?	Number of days: _____

17.6) How much time do you spend doing moderate-intensity activities at work on a typical day?	Hours: Minutes: _____
Travel to and from places	
17.7) Do you walk or use a bicycle (pedal cycle) for at least 10 minutes continuously to get to and from places?	1)Yes 2)No
17.8) In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places?	Number of days: _____
17.9) How much time do you spend walking or bicycling for travel on a typical day?	Hours: Minutes: _____
Recreational activities	
17.10) Do you do any vigorous-intensity sports, fitness or recreational (leisure) activities that cause large increases in breathing or heart rate like [running or football,] for at least 10 minutes continuously?	1)Yes 2)No
17.11) In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational (leisure) activities?	Number of days: _____
17.12) How much time do you spend doing vigorous-intensity sports, fitness or recreational activities on a typical day?	Hours: Minutes: _____
Physical Activity (recreational activities)	
17.13) Do you do any moderate-intensity sports, fitness or recreational (leisure) activities that causes a small increase in breathing or heart rate such as brisk walking (cycling, swimming, volleyball) for at least 10 minutes continuously?	1)Yes 2)No If no, go to question
17.14) In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (leisure) activities?	Number of days: _____

17.15) How much time do you spend doing moderate-intensity sports, fitness or recreational (leisure) activities on a typical day?	Hours: Minutes: _____
Sedentary behaviour	
17.16) How much time do you usually spend sitting or reclining on a typical day?	Hours: Minutes: _____

17) SCREEN TIME:

a. Screen time post Dinner:_____pm

b. Duration of Screen Time:

<1/2 hour/ day	
½ - 1 hour/ day	
1-2 hours/ day	
>2 hours/ day	

18) STRESS:

0 = Never 1 =Almost Never 2 = Sometimes 3 = Fairly Often 4 = Very Often

19.1) In the last month, how often have you been upset because of something that happened unexpectedly?	0	1	2	3	4
19.2) In the last month, how often have you felt that you were unable to control the important things in your life?	0	1	2	3	4
19.3) In the last month, how often have you felt nervous and "stressed"?	0	1	2	3	4
19.4) In the last month, how often have you felt confident about your ability to handle your personal problems?	0	1	2	3	4
19.5) In the last month, how often have you felt that things were going your way?	0	1	2	3	4
19.6) In the last month, how often have you found that you could not cope with all the things that you had to do?	0	1	2	3	4
19.7) In the last month, how often have you been able to control irritations in your life?	0	1	2	3	4
19.8) In the last month, how often have you felt that you were on top of things?	0	1	2	3	4
19.9) In the last month, how often have you been angered because of things that were outside of your control?	0	1	2	3	4
19.10) In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	0	1	2	3	4

19) SLEEP:

a. During the past month, when have you usually gone to bed at night?

USUAL BEDTIME_____

b. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

NUMBER OF MINUTES _____

c. During the past month, when have you usually gotten up in the morning?

USUAL GETTING UP TIME_____

d. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spend in bed.

HOURS OF SLEEP PER NIGHT _____

20.1) During the past month, how often have you had trouble sleeping because you...

	Not During the past month (1)	Less than one week (2)	Once or twice a week (3)	Three or more times a week (4)
i) Cannot get to sleep within 30 minutes				
ii) Wake up in the middle of night or early morning				
iii) Have to get up to use bathroom				
iv) Cannot breathe comfortably				
v) Cough or snore loudly				
vi) Feel too cold				
vii) Feel too hot				
viii) Had bad dreams				
ix) Have Pain				
x) Other Reasons, please describe				
xi) How often during the past month have you had trouble sleeping because of this?				

	1)Very good	2)Fairly good	3)Fairly bad	4)Very bad
20.2) During the past month how would you rate your sleep quality overall?				
	1)Not During the past month	2)Less than one week	3)Once or twice a week	4)Three or more times a week
20.3) During the past month, how often have you taken medicine to help you sleep?				
20.4) During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activities?				
	1)No problem at all	2) Only a very slight problem	3)Somewhat of a problem	4)A very big problem
20.4) During the past month, how much of a problem it has been for you to keep up enough enthusiasm to get things done?				
	1)Not During the past month	2)Less than one week	3)Once or twice a week	4)Three or more times a week
20.5) During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?				

20.6) If you have a roommate or bed partner, ask him/her how often in the past month you have had….				
	1)No bed partner or roommate	2)Partner/roommate in other room	3)Partner in same room but not same bed	4)Partner in same bed
a) Loud snoring				
b) long pauses between breaths while asleep				
c) legs switching or jerking while you sleep				
d) episodes of disorientation or confusion during sleep				

20) SOCIAL JETLAG:

MCTQ

21.1) I have a regular work schedule (this includes being, for example, a housewife or househusband):

Yes	
No	

21.2) If yes, how many days of the week? _____

(Is your answer "Yes, on 7 days" or "No", please consider if your sleep times may nonetheless differ between regular 'workdays' and 'weekend days' and fill out the MCTQ in this respect.)

(Please use 24-hour time scale (e.g. 23:00 instead of 11:00 pm)

WORKDAYS-

21.3) I go to bed at_____o'clock

21.4) I actually get ready to fall asleep at_____o'clock

21.5) I need_____minutes to fall asleep.

21.6) I wake up at_____o'clock.
21.7) After_____minutes I get up.
21.8) I use an alarm clock on workdays

Yes	
No	

21.9) If "Yes": I regularly wake up BEFORE the alarm rings:

Yes	
No	

FREEDAYS-

21.10) I go to bed at_____o'clock

21.11) I actually get ready to fall asleep at_____o'clock

21.12) I need_____minutes to fall asleep.

21.13) I wake up at_____o'clock.
21.14) After_____minutes I get up.
21.15) I use an alarm clock on workdays

Yes	
No	

21.16) If "Yes": I regularly wake up BEFORE the alarm rings:

Yes	
No	

21.17) I use an alarm clock on freedays

Yes	
No	

21.18) There are particular reasons why I cannot freely choose my sleep times on free days:

Yes	
No	

21.19) If yes,

Child(ren)/ Pet(s)	
Hobbies	
Others	

WORK DETAILS-

21.20) In the last 3 months, I worked as a shift worker

Yes	
No	

21.21) My usual work schedule starts at_____o'clock and ends at_____o'clock.

21.22) My work schedules are…

Very flexible	
Little flexible	
Rather inflexible	
Very inflexible	

21.23) I travel to work…

Within an enclosed vehicle (car, bus)	
Not within an enclosed vehicle (by foot, bike)	
Work at home	

21.24) For the commute to work, I need____hours and____minutes.

21.25) For the commute from work, I need____hours and____minutes.

TIME SPENT OUTDOORS-

21.26) On average, I spend the following amount of time outdoors in daylight (without a roof above my head):

on workdays:_____hours_____minutes
on free days:_____hours_____minutes

STIMULANTS-

	Per day	Per week	Per month
21.27) I smoke _____ cigarettes			
21.28) I drink _____ glasses of beer			
21.29) I drink _____ glasses of wine			
21.30) I drink _____ glasses of liquor/whiskey/gin etc.			
21.31) I drink_____cups of coffee			
21.32) I drink_____cups of black tea			
21.33) I drink_____cans of caffeinated drinks (soft-drinks)			
21.34) I take sleep medication_____times			

21) ANTHROPOMETRIC DATA

22.1) Weight (kg):

22.2) Height (cm):

22.3) Waist circumference(cm):

22.4) Hip circumference(cm):

22.5) Skeletal Muscle (%):

22.6) Visceral fat:

22.7) Body Fat (%):

22) BIOLOGICAL PARAMETERS:

a. At what age was your Diabetes detected for the first time? _____

b. Kindly fill up the following information from your clinic file:

c. Fasting Plasma Glucose (FPG): _____

d. Random Blood Glucose (RBG): _____

e. Post-Prandial Blood Sugar (PPBS): _____

f. HbA1c: _____

g. Blood Pressure: (3 readings) _____

h. Total Cholesterol: _____

i. LDL: _____

j. HDL: _____

k. TGs: _____

l. Are you suffering from any other health problem currently?

1)Yes 2) No

If yes, please mention along with its biological parameters_____