CHRONONUTRITION BEHAVIOR AND ITS ASSOCIATION WITH DIETARY INTAKE AND SLEEP QUALITY AMONG TYPE 2 DIABETES MELLITUS PATIENTS IN HOSPITAL PAKAR UNIVERSITI SAINS MALAYSIA(HPUSM)

by

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SCHOOL OF HEALTH SCIENCES

UNIVERSITI SAINS MALAYSIA

2025

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Dissertation submitted in partial fulfillment of the requirements for the degree of Bachelor of Health Science (Honours) (Dietetics)

JULY 2025

DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated and duty acknowledges. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at Universiti Sains Malaysia or other institutions. I grant Universiti Sains Malaysia the right to use the dissertation for teaching, research and promotional purposes.

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Nik Nur Farah Nasuha Binti Nik Zulkifli

Date: 1 JULY 2025

ACKNOWLEDGEMENT

Alhamdulillah, all praise to allah SWT for His blessings, guidance which enabled me to complete this journey successfully. Without His will and mercy, this journey would not have been possible.

I wish to express my deepest gratitude to my supervisor, Madam Nur-Fazimah Sahran, for her enthusiasm, insightful comments, invaluable suggestions, practical advice and endless support which have helped me tremendously throughout the process of my study and writing of this thesis. Without her guidance and relentless help, this thesis would not have been possible.

To my beloved parents, Nik Zulkifli Nik Sof and Wan Normah Mohd Nor as well as my family members, special thanks for the unwavering support, love, patience, constant prayer and continual encouragement in giving me strength to complete this whole journey.

Furthermore, I am also very much thankful to the sisters, staff nurses, pembantu perawatan kesihatan (PPK) of Klinik Pakar Perubatan (KPP), Klinik Rawatan Keluarga (KRK) and Klinik Dietetik Pesakit Luar in Hospital USM for their lending-hands and sharing some insightful knowledge in clinical setting during my study in those clinics.

Finally, I wish to express my sincere thanks to all friends and classmates for support and encouragement throughout the process of completing the study. Besides, I would like to express my thanks to all the respondents who took part in my study. Without their participation with understanding, I would not have completed this dissertation successfully.

CONTENT

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LIST OF ABBREVIATIONS

BMI	Body Mass Index
CHO	carbohydrate
CPQ	Chrononutrition Profile Questionnaire
HPUSM	Hospital Pakar Universiti Sains Malaysia
kcal	kilocalories
n	Total number of subjects
PSQI-M	Pittsburgh Sleep Quality Index Malay
SD	Standard Deviation
SPSS	Statistical Package for the Social Sciences
T2DM	Type 2 Diabetes Mellitus

TINGKAHLAKU KRONONUTRISI DAN PERKAITANNYA DENGAN PENGAMBILAN DIET SERTA KUALITI TIDUR DALAM KALANGAN PESAKIT DIABETES MELITUS JENIS 2 DI HOSPITAL PAKAR UNIVERSITI SAINS MALAYSIA(HPUSM)

ABSTRAK

Tingkahlaku krononutrisi merujuk kepada masa pengambilan makanan yang berinteraksi dengan ritma sirkadian badan dan memain peranan penting dalam pengurusan Diabetes Mellitus Jenis 2 (T2DM). Pola pemakanan yang tidak teratur dan tidak konsisten serta kualiti tidur yang lemah boleh memberi kesan negatif terhadap kawalan glukosa darah dan hasil kesihatan keseluruhannya, khususnya individu dengan T2DM. Tujuan kajian ini adalah untuk menentukan tingkahlaku krononutrisi dan hubungannya antara pengambilan diet dan kualiti tidur dalam kalangan pesakit T2DM di HPUSM. Seramai 103 pesakit T2DM telah direkrut dari Klinik Pakar Perubatan, Klinik Rawatan Keluarga dan Klinik Dietetik Pesakit Luar HPUSM berdasarkan kaedah persampelan bertujuan. Soal selidik tingkahlaku krononutrisi dinilai menggunakan Chrononutrition Profile Questionnaire versi Melayu (CPQ-M), pengambilan diet dinilai melalui kaedah ingatan diet 24-jam, manakala kualiti tidur dinilai menggunakan Pittsburgh Sleep Quality Index versi Melayu (PSQI-M). Berdasarkan kajian yang dijalankan min purata umur responden adalah 64.43 (12.59) tahun. Hampir keseluruhan peserta mempunyai tingkahlaku yang baik dengan purata waktu bangun tidur dan waktu tidur 5:41 (1.06) pagi dan 10:55 (1.42) malam. Di samping itu, majoriti peserta makan dalam julat rekomendasi dengan purata tenaga daripada sumber karbohidrat 54.43%, protein 17.45% dan lemak 28.17%. Hasil kajian turut mendapati seramai 101 (98.1%) subjek didapati mempunyai kualiti tidur yang rendah. Menurut analisis statistik uji *Independent One-way ANOVA* dari segi pengambilan diet, terdapat perbezaan yang signifikan dalam jumlah tenaga dan pengambilan makronutrien berkaitan dengan tingkahlaku makan waktu petang dan tempoh makan ($p < 0.05$). Analisis statisik uji *Pearson's Chi Square* menunjukkan terdapat hubungan yang signifikan secara statistik antara tingkahlaku makan lewat malam dengan kualiti tidur ($X^2 = 11.687$, $p = 0.03$) manakala tiada hubungan signifikan antara tingkahlaku krononutrisi lain. Kesimpulannya, tingkahlaku krononutrisi yang tidak baik,

mengambilan diet yang tidak menentu, serta kualiti tidur yang lemah merupakan isu penting dalam kalangan pesakit T2DM.

CHRONONUTRITION BEHAVIOR AND ITS ASSOCIATION WITH DIETARY INTAKE AND SLEEP QUALITY AMONG TYPE 2 DIABETES MELLITUS PATIENTS IN HOSPITAL PAKAR UNIVERSITI SAINS MALAYSIA(HPUSM)

ABSTRACT

Chrononutrition behavior is the timing of the food intake that interacts with body's circadian rhythm and plays an important role in managing Type 2 Diabetes Mellitus (T2DM). An irregular and inconsistent eating pattern with poor sleep quality can negatively impact the glycemic control and overall health outcomes among individual with T2DM. Aim of this study to determine the chrononutrition behavior and its association between dietary intake and sleep quality among T2DM patients in HPUSM. A total of 103 T2DM patients were recruited from clinics include Klinik Pakar Perubatan, Klinik Rawatan Keluarga and Klinik Dietetik Pesakit Luar based on inclusion criteria. Study subjects were selected through purposive sampling method. Questionnaires include sociodemographic data and biochemical data of subjects. Besides that, chrononutrition behavior was assessed using Chrononutrition Profile Questionnaire (CPQ-M) while dietary intake assessed through 24-hour diet recall and sleep quality assessed using Pittsburgh Sleep Quality Index Malay (PSQI-M). This study showed that mean age for T2DM patients in HPUSM was 64.43 (12.59) years old. Most of the subjects reported for having good chrononutrition behavior with mean wake time and bedtime was 5:41 (1.06) am and 10:55 (1.42) p.m. overall, most of the participant consume meal within recommended with of mean percentage energy intake from carbohydrate (CHO) was 54.43%, protei was 17.45% and fat was 28.17%. Moreover, sleep quality prevalence showed that 98.1% of the subjects had poor sleep quality. In terms of association between dietary intake and chrononutrition behavior, data were analyzed using *Independent One-way ANOVA* test, there are significant difference found in total energy and macronutrient

intake with evening eating behavior and eating window (p= <0.05). Data analyzed using Pearson Chi Square test showed that there was a statistically significant association between night eating behavior and sleep quality (X^2 =11.687, p = 0.03) but no significant association between other chrononutrition behavior. In conclusion, poor chrononutrition behavior and poor sleep quality were important among T2DM patients.

CHAPTER 1: INTRODUCTION

1.1 Background of study

Diabetes mellitus (DM) is a chronic metabolic condition defined by persistent hyperglycemia. It might be related to decreased insulin secretion, insulin resistance in the peripheral tissues, or both. According to the International Diabetes Federation (IDF), roughly 415 million people aged 20 to 79 had diabetes mellitus in 2015 (Rajeev et al.,2023).

Chrononutrition is a quickly increasing discipline of nutritional epidemiology that investigates the complicated interaction between temporal eating habits, circadian rhythms, and metabolic health to understand how meal timing measures affect health maintenance and chronic disease risk such as Type 2 Diabetes Mellitus (T2DM) (Oluwatimilehin et al.,2024). Irregular chrononutrition cycle may worsen the T2DM symptom. Apart from this, irregular and unhealthy dietary intake also might alter T2DM.

Research on the relationship between circadian rhythms and metabolic health are increasing in trend, especially in the context of chronic conditions such as type 2 diabetes mellitus (T2DM). Emerging evidence suggests that not just *what* we eat, but *when* we eat, may significantly influence glycemic control, metabolic regulation, and overall health outcomes in patients with T2DM (Mezitis & Bhatnagar, 2018; Sutton et al., 2018).

People living with T2DM often struggle with dietary management and sleep disturbances, both of which are critical components of effective disease management. Dietary intake patterns influenced by poor chrononutrition behaviors, such as late-night eating or irregular meal timing, may exacerbate insulin resistance and contribute to disrupted sleep quality (Radlicz & Mezitis, 2019; Sutton et al., 2018). Meanwhile,

impaired sleep further disrupts hormonal balance and appetite regulation, potentially creating a vicious cycle that complicates diabetes care (Seixas et al., 2019).

Understanding the association between chrononutrition behavior, dietary intake, and sleep quality among T2DM patients is crucial for developing holistic, lifestyle-based interventions. This study aims to explore these relationships, shedding light on how time-oriented eating patterns may serve as modifiable factors to improve both nutritional status and sleep health in individuals managing type 2 diabetes.

Dietary management include lowering energy intake, maintaining appropriate proportions of energy-generated nutrients, and selecting meals advised for T2DM patients. Adequate and high-quality meals that promote moderate glucose control and assist patients maintaining appropriate weights can help lower complications and enhance their quality of life. Excessive consumption of fast food, cereals, and carbs was found to have a positive statistically significant correlation with fasting glycemic levels. Additionally, interventional research demonstrated that meals low in calories and carbohydrates aid in regulating blood glucose and cholesterol levels. (Nguyen et al.,2019).

Inadequate sleep duration and poor sleep quality in persons with T2D would both be related with increased glycated hemoglobin (HbA1c) values and, consequently, chances of developing complications (Darraj, 2023).

1.2 Problem Statements

Previous research has shown that dietary pattern, poor sleep quality, and chrononutrition behavior may all highly associated with development of glucose metabolism; however, the connection between macronutrients and eating timing has not been thoroughly studied (Luján et al.,2024). Poor sleep quality is frequently found in this population, which may lead to increased stress, hormonal imbalances, and impaired glucose metabolism (Darraj, 2023). Furthermore, nutrition has important influence on the development and management of diabetes. There is strong evidence relate the dietary intake to diabetes development (Kheriji ,2022). Thus, understanding the association between chrononutrition behavior, food intake, and sleep quality in type 2 diabetes patients is important for developing innovative therapies to improve their management and overall well-being.

In addition, research has been proved that T2DM is often related to unhealthy and inappropriate dietary intake that may lead to poor glycemic control. Research indicated there is a substantial association between dietary intakes, nutrition knowledge, diabetes self- management behavior, and glycemic control among persons with T2DM (Shakil et al.,2024). The circadian mealtime pattern, as determined by chrononutrition behavior, is critical for regulating food intake and body metabolism to maintain optimal metabolic performance. Poor adherence to a healthy diet was found to be commonly associated with those with a late chronotype (Almoosawi et al.,2018)

Therefore, investigating the relationship between dietary intake and sleep quality with chrononutrition behavior may offer practicable interventions to address these concerns.

1.3 Significance of study

The study focuses on the importance of chrononutrition behavior impact among T2DM patients. Previous study has shown that chrononutrition behavior has an essential role in regulating circadian clocks, improving metabolic health, reducing the incidence of type 2 diabetes that may enhance overall health. Chrononutrition behavior interventions have also been demonstrated to enhance glucose metabolism, with potential advantages for blood sugar management (Henry Jeya et al.,2020). Understanding how these patterns affect dietary intake and sleep quality might contribute to essential information in dietary management and a holistic strategy for improved health outcomes in diabetic patients.

1.4 Research Question

1. What is the chrononutrition behavior among the T2DM patients in HPUSM?
2. How is dietary intake among the T2DM patients in HPUSM?
3. What is the sleep quality among the T2DM patients in HPUSM?
4. Does chrononutrition behavior associated with the dietary intake in T2DM patients in HPUSM?
5. Does chrononutrition behavior associated with sleep quality among T2DM patients in HPUSM?

1.5 Research Objectives

1.5.1 General objective:

To determine the association between chrononutrition behavior on the dietary intake and sleep quality among T2DM patients in Hospital Pakar Universiti Sains Malaysia (HPUSM)

1.5.2 Specific objectives:

1. To determine chrononutrition behavior among T2DM patients in HPUSM.
2. To assess dietary intake among T2DM patients in HPUSM.
3. To assess sleep quality among T2DM patients in HPUSM.
4. To examine association between chrononutrition behavior and dietary intake among T2DM patients in HPUSM.
5. To examine association between chrononutrition behavior and sleep quality among type 2 diabetes mellitus patients in HPUSM.

1.6 Research Hypotheses:

Hypothesis of association between chrononutrition behavior and dietary intake

H0 = There is no statistically significant association between chrononutrition behavior with dietary intake among T2DM patients in HPUSM.

HA= There is a significant association between chrononutrition behavior with dietary intake among T2DM patients in HPUSM.

Hypothesis of association between chrononutrition behavior and sleep quality

H0 = There is no statistically significant association between chrononutrition behavior with sleep quality among T2DM patients in HPUSM.

HA= There is a significant association between chrononutrition behavior with sleep quality among T2DM patients in HPUSM.

1.7 Conceptual Framework

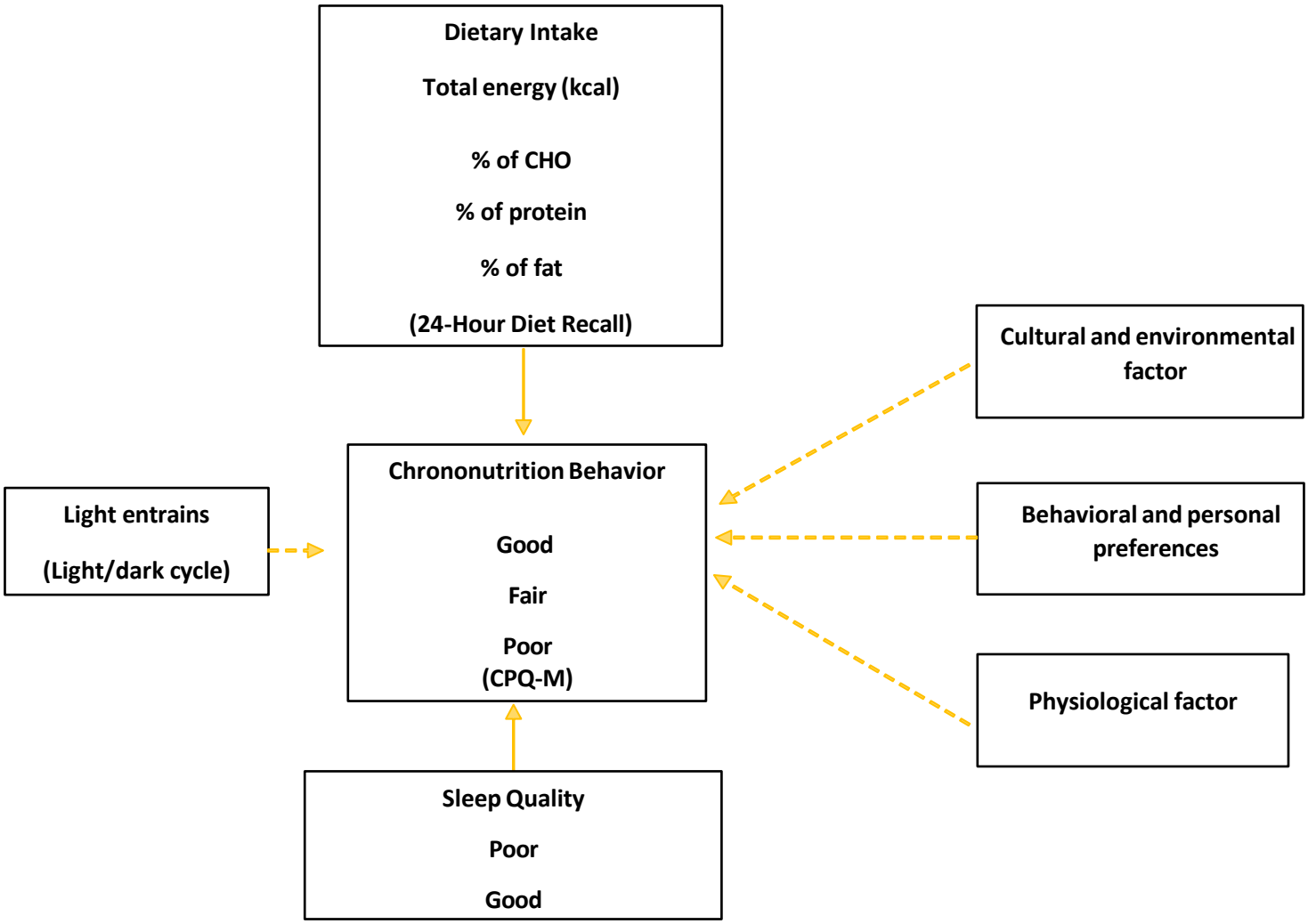

Figure 1: conceptual framework of chrononutrition behavior and its association with dietary intake and sleep quality among T2DM

Figure 1 shown that the chrononutrition behavior may affected by sleep quality and dietary intake of individual daily. In addition, chrononutrition behavior also may influenced by another cofounder factor such as cultural and environmental factor, physiological factor, behavior and preferences and light entrains but the present study only focused on the two a form mentioned factors which are dietary intake and sleep quality. From the chronobiological perspective, light entrains are crucial for chrononutrition behavior since, glucose metabolism in man has a circadian rhythm by diurnal variation in glucose tolerance that under normal circumstances peaks during day-light hours when food intake typically takes place and drops during night-dark hours when fasting typically takes place. Thus, light directly entrains the suprachiasmatic nucleus (SCN) immediately, whereas other non-photic zeitgebers (non-photic zeitgebers have been detected as well, including food, physical activity, and temperature (Schilperoort et al., 2020) have rhythmic fluctuations and entrain the SCN along with peripheral clocks within 24 hours. (Janse et al,2021).

CHAPTER 2: LITERATURE REVIEW

2.1 Type 2 Diabetes Mellitus in Malaysia

Type 2 diabetes is a chronic condition. It is characterized by elevated blood sugar levels. Type 2 diabetes develops when your cells reject insulin's typical impact of driving glucose from the blood into the cells. This condition is known as insulin resistance. As a result, glucose starts to accumulate in the bloodstream. In insulin-resistant patients, the pancreas recognizes increasing blood glucose levels. To keep blood sugar levels stable, the pancreas produces additional insulin. Insulin resistance worsens over time. In reaction, the pancreas produces more and more insulin. Eventually, the pancreas becomes "exhausted." It cannot meet the increasing demand for insulin (Harvard Health Publication,2024). Type 2 diabetes is characterized by insulin resistance and hyperinsulinemia, followed by a gradual reduction in pancreatic β cell ability to generate insulin. Type 2 diabetes is a complicated condition characterized by a combination of β-cell malfunction and insulin resistance. Even though 40-80% of β-cell function is lost at diagnosis, excellent glycemic management or remission can recover significant functional β-cell mass (Ahmad et al.,2022). A β-cell-centric hypothesis has been developed, which identifies abnormal β-cell function as the main issue in type 2 diabetes (Schwartz et al.,2016).

Diabetes statistics and data highlight the rising worldwide burden on individuals, families, and governments. According to the IDF Diabetes Atlas 2021, 10.5% of the adult population (20-79 years old) has diabetes, with nearly half of them uninformed of their illness. According to IDF, they predict at by 2045, one over eight individuals, or roughly around 783 million people, would have diabetes, increasing by 46%. Over 90% of patients with diabetes

have type 2 diabetes, which is caused by socioeconomic, demographic, environmental, and genetic variables. Diabetes affects roughly 537 million people aged 20 to 79 worldwide in 2021. The overall number of individuals living with diabetes is anticipated to increase to 643 million by 2030 and 783 million by 2045 (IDF,2023).

Malaysia has the highest diabetes rate in the Western Pacific area. Malaysia has the highest diabetes rate in the Western Pacific area. Malaysia is one of 38 nations and territories in the IDF Western Pacific area. Diabetes affects 537 million people worldwide, including 206 million in the Western Pacific Region; by 2045, this figure is expected to climb to 260 million (IDF,2023). In year 2019 diabetes prevalence increasing from 11.2% in year 2011 to 18.3%, representing a 68.3% of increasing (National Institutes of Health, Ministry of Health Malaysia,2020). In 2020, there were 1,698,683 registered patients and 902,991 active diabetic patients in the NDR. Nearly all patients included in the NDR were diagnosed with T2DM (99.33%) (Ministry of Health Malaysia. 2021, National Diabetes Registry Report, 2020).

Diabetes was the direct cause of 1.6 million deaths in 2021, accounting for 47% of all diabetes-related deaths under the age of 70. Diabetes contributed to an additional 530 000 renal disease deaths, and high blood glucose accounts for around 11% of cardiovascular deaths (World Health Organization,2024). Persistent hyperglycemia in uncontrolled diabetes mellitus can lead to a variety of acute and chronic problems. Diabetes mellitus is a primary cause of cardiovascular disease (CVD), blindness, renal failure, and lower-limb amputations. Acute consequences include hypoglycemia, diabetic ketoacidosis, hyperglycemic hyperosmolarity, and hyperglycaemic diabetic coma. Hovewer, chronic microvascular problems such as nephropathy, neuropathy, retinopathy, while chronic macrovascular complications are coronary artery disease (CAD), peripheral artery disease (PAD), and cerebrovascular disease are among

the complications that are often found among diabetic patients (Rajeev et al., 2023).

Furthermore, three methods of glycemic control that are commonly used in health setting to assess the quantity of glucose or sugar in the body such as fasting blood sugar (FBS), random blood sugar (RBS), and HbA1C. A blood glucose test and glycemic levels can aid in the diagnosis and severity of diabetes mellitus. HbA1c measures average plasma glucose levels during the past eight to twelve weeks. It may be done at any time of day and requires no preparations, such as fasting (Geneva, World Health Organization, 2011). Diabetes can be diagnosed with a HbA1c level of >6.3% (IFCC ≥ 45 mmol/mol) using an NGSP-certified technique standardized to the DCCT test (CPG Diabetes). The diagnostic value for T2DM is ≥7.0 mmol/L for fasting plasma glucose and ≥11.1 mmol/L for random blood glucose.

2.2 Chrononutrition behavior in Type 2 Diabetes Mellitus

Chrononutrition is the study of the interplay between biological cycles and nutrition, as well as the link between these elements and human health. Chrononutrition refers to the distribution of energy, meal frequency and regularity, eating length, and the relative relevance of these parameters in metabolic health and chronic disease risk. There were several studies done on animals and humans shown that the timing of meal consumption throughout the day can rapidly alter metabolic health and overall wellness (Alan et al., 2020).

In year 1986 Dr. Alain developed a concept of chrononutrition. It is a dietary regimen that follows our biological clock, which is characterized by fluctuations in metabolism

throughout the day. Six behavioral habits will influenced the individual chrononutrition behavior: eating at night, restricted time feeding, breakfast eating, timing of largest meal, time of evening eating and time between eating and sleep time. (Juliana et al., (2023). Later mealtimes and irregular eating, which are out of sync with the biological clock, are related with increased obesity, T2DM, and cardiometabolic risk factors (Franzago et al., 2023). In addition, chrononutrition behavior also may influence by cofounder such as cultural and environmental factor, physiological factor, behavioral and personal preferences and light entrains.

In humans, scheduled meal intake is regulated by the suprachiasmatic nucleus (SCN), which helps to synchronize circadian rhythms in peripheral organs, altering glucose metabolism. Dietary impacts on circadian rhythmicity obviously imply a link between elements such as mealtimes and nutrients (chrononutrition), which can contribute to circadian perturbance and affect the development of metabolic illnesses such as type 2 diabetes (Henry et al., 2020). Therefore, chrononutrition are vital in managing the blood glucose level in T2DM.

Based on the study conducted by Luján et al 2024, the higher prevelance in T2DM when the breakfast and dinner taken after 9.00 a.m. and after 9.00 p.m, respectively. In addition, this study also showed that the increase of T2DM when the individual consuming higher percentage of lipids during breakfast and higher percentage of carbohydrate intake during dinner.

2.3 Dietary Intake in Type 2 Diabetes Mellitus

Dietary intake refers to all meals and beverages eaten orally. Dietary supplements and condiments, which include energy and/or nutrients but are not considered foods, should be included in the diet. Omitting some products from dietary intake evaluations is often due to difficulty in identifying, quantifying, or understanding their composition (Ingrid HE Rutishauser). Short-term instruments of dietary intake such as 24 Hours Diet Recall seek to record recent or current dietary estimates, whereas long-term instruments seek to capture dietary data over a period of weeks to a year. Long-term or habitual dietary exposures are the most appropriate means of capturing dietary exposures in both research and population or sub-group monitoring, as most dietary recommendations are intended to be met over time to determine group or population adequacy and associations with health outcomes, respectively (Regan, 2022).

The Nutrition Division of Malaysia's Ministry of Health has been encouraging healthy eating habits among Malaysians to improve their quality of life. The healthy eating campaign includes campaigning for the food pyramid guideline and the most recent healthy meal consumption suggestion of 'quarter quarter half' plate sizes (Nutrition Department M of HM., 2020). The campaigns were based on Medical Nutrition Therapy for Type 2 Diabetes Mellitus (MNT T2DM, 2021) macronutrient guidelines. The MNT T2DM estimated that the typical macronutrient needs for an adult were 50-65% of total energy intake (TEI) from carbohydrate, 10-20% of TEI from protein, and 25-35% of TEI from fat (MNT T2DM, 2021). In general, there are no specific suggestions for macronutrient consumption among T2DM patients. The Malaysian Ministry of Health (MOH) suggests the following macronutrient consumption guidelines for T2DM patients: 45-60% carbohydrate, 15-20% protein, and 25-35% fat in TEI

(Pheng et al.,2020).

According to the study by Md Isa et al, T2DM patients mostly consumed carbohydrate and protein within the range of recommended nutritional intakes (MNT T2DM, 2021) for Malaysia but had a high fat intake compliance with recommended carbohydrate consumption (50-65% of TEI) among newly diagnosed, < 5 years, and > 5 years groups was 18.1%, 52.2%, and 29.7%, respectively. Protein consumption of more than 20% of TEI was similar across newly diagnosed, ≤ 5 years, and ≥ 5 years groups (18.5, 49.2, and 32.3% respectively). Furthermore, relatively few T2DM individuals ingested protein in levels below the necessary proportions. Although not significantly different, most T2DM patients ingested more fat than suggested (>30% of TEI) (Md Isa et al., 2023).

Measurement or assessment of dietary intake among T2DM patients are crucial, especially to assess their eating pattern and eating behavior that cause irregular blood sugar control. A healthy diet, that is, adequate and high-quality foods, promote moderate glycemic control, assist patients maintain healthy weights, reduce complications, and enhance their quality of life. Certain research conducted across the world shows that good dietary habits have statistically significant relationships with fasting glucose levels and HbA1c levels in diabetes individuals. Other research found that overconsumption of carbs, cereals, and fast meals was associated with higher fasting glycemic levels. Interventional studies also demonstrated that energy-reduced and low-carbohydrate diets can manage blood cholesterol and glucose levels (Nguyen et al.,2019)

2.4 Sleep quality in Type 2 Diabetes Mellitus

Sleep is a biological demand, and inadequate sleep and untreated sleep disorders are harmful to health, well-being, and public safety. Healthy People 2030 cover several sleep-related objectives with the purpose of improving people's health, productivity, well-being, quality of life, and safety by ensuring they receive adequate sleep (Kannan et al., 2021). Inadequate sleep can arise when there is inadequate time for it or when a disorder interferes with sleep quality. Sleep deprivation due to these disorders relates to impairments in cognitive and psychomotor function, including mood, thinking, focus, memory, learning, alertness, and response speed. Inadequate sleep is commonly linked with poor sleep quality due to several factors. Furthermore, studies have found links between insufficient sleep and a variety of health issues such as hypertension, type 2 diabetes, obesity, cardiovascular disease, and overall mortality risk. Insomnia, obstructive sleep apnea (OSA), and restless leg syndrome are all related with an elevated risk of morbidity and death (David et al.,2013)

In China, the population aged 65 and up increased to 8.2% in 2010, and it is predicted to reach 23.3% by 2050. Poor sleep quality has a significant influence on health, making it important to investigate its prevalence among China's elder population. Previous research on poor sleep quality in Chinese older persons found a prevalence ranging from 32.9% to 49.7% (Yun-Shu et al., 2017).

Nonrapid eye movement (NREM) sleep consists of three stages. Stage 1, also known as N1, occurs when a person initially falls asleep. This stage usually lasts from one to seven minutes. During N1 sleep, the body is not completely relaxed, but the body and brain functions

begin to decelerate with short movements. There are minor changes in brain activity related with falling asleep at this time. During stage 2, or N2, the body becomes more subdued, with a reduction in temperature, relaxed muscles, and slower breathing and heart rate. At the same time, brain waves exhibit a different pattern, and eye movements cease. Overall, brain activity decreases, but there are brief bursts of activity. Stage 3 sleep is also known as N3 or deep sleep, and it is more difficult to rouse someone up during this period. Muscle tone, pulse, and breathing rate drop during N3 sleep when the body relaxes even more (Sleep Foundation,2023).

Moreover, when someone is in sleeping mode then the brain activity will follow a distinct pattern that is known as delta waves. In this mode, stage 3 is also known as delta sleep or slow- wave sleep (SWS). Finally, the final stage is called rapid eye movement (REM), during REM stage the sleeping mode increases the brain activity to levels like those found when awake. At the same moment, the body experiences atonia, a brief paralysis of the muscles saving for the eyes and the muscles that govern respiration. Even if the eyes are closed, they may be seen moving fast, hence the stage's name. REM sleep is thought to be crucial for cognitive activities such as memory. REM sleep is notorious for producing the most vivid dreams, which is explained by the considerable increase in brain activity. Dreams can occur at any stage of sleep, although they are less prevalent and strong during NREM (Sleep Foundation,2023).

The National Sleep Foundation (2015) advises an average sleep duration between 7 to 9 hours for people aged 26 to 64 years. The recommended duration of sleep, however, declines with increasing age. According to increasing data, sleep deprivation is associated with an increased risk of T2DM. Sleep is essential for modifying endocrine, metabolic function, and sympathovagal balance, and deprivation has a deleterious influence on these systems. Studies conducted in Albania have shown poor sleep quality because of circadian rhythm disruption; for example, night shift work among nurses causes a significant increase in HbA1c and body

mass index (BMI) and influences certain gene expression in peripheral blood mononuclear cells that act as "peripheral clock genes". These alterations often emerge in people at risk of developing chronic metabolic disorders, particularly type 2 diabetes (Nor Fasehah et al.,2022)

In addition, some study poor sleep quality high association with T2DM. According to the Pittsburgh Sleep Quality Index (PSQI) score, Cappuccio et al's study found a statistically significant difference in how poor glycemic control and excellent glycemic control connect to sleep. Diabetic individuals with inadequate glycemic control experienced decreased sleep quality. This relationship might be explained by the fact that 50% of diabetes patients with poor glycemic control may suffer from severe diabetic neuropathy and osmotic diabetic symptoms, compromising their sleep quality by often using the restroom throughout the night (Safa et al.,2019)

2.5 Potential association of Chrononutrition and Dietary Intake

Dietary assessment methodologies varied widely, with most studies relying on food records and 24-hour recalls. Furthermore, the definition of eating events differed greatly. In most research, eating occasions consisted of pre-defined meal slots, and in some cases, survey participants self-reported the kind of eating occasion using a list of standardized meal and snack titles. Study by Sjoberg et al in 2003 combined food history with an interview with a dietetian. The questionnaire employed in the food history approach had a quantitative component and was separated into parts covering breakfast, lunch, dinner, and in-between meal eating times (Almoosawi et al,2016). Therefore, the concept of chrononutrition also important in access the meal timing and meal frequency apart from the circadian rythms in individual daily.

Food consumption regulates the circadian clock, notably the peripheral circadian clock in organs like the liver and gut (Damiola et al, 2000). In contrast, the central circadian clock, which is regulated by the dark-light cycle, has been shown to have an extended influence on food absorption. More precisely, tiny peptides cleaved in the colon from dietary protein have been demonstrated to be transported in a circadian manner (Qandeel et al., 2009)). Similar findings were reported for glucose (Iwashina et al., 2011) and lipid transport (Hussain & Pan, 2009). Circadian rhythms are cyclical endogenous processes that occur at about 24hour intervals. In the 1970s, researchers discovered suprachiasmatic nucleus in the human brain's anterior hypothalamus. The suprachiasmatic nucleus, commonly known as the master clock, synchronizes geophysical time by photic stimulation of retinal ganglion cells. In this manner, the suprachiasmatic nucleus may synchronize oscillators located inside the cells of most organs and tissues, therefore regulating various physiological processes (Almoosawi et al,2016).

The chrononutrition behavior and dietary intake are important to ensure the management of cardiovascular disease. Therefore, this aspect is highly associated with the risk of cardiovascular disease such as hypertension, diabetes mellitus, heart attack and obesity. Study reported that later feeding timing or late eating and circadian misalignment caused by mismatched eating habits and endogenous cycles might also affect appetite-regulating hormones, raising the risk of obesity and its metabolic consequences. Inverting behavioral cycles by ~12 hours can inhibit leptin, increase hunger and decrease energy expenditure. Overall, later feeding changes appetite-regulating hormones by lowering 24-hour blood leptin levels and raising the 24-hour ghrelin-leptin ratio, resulting in greater hunger. It is also linked to lower energy expenditure throughout the day, as well as alterations in gene expression that promote fat accumulation and obesity. Finally, the time of high-energy meals can influence fat formation and metabolism via the adipose tissue clock, potentially leading to dyslipidemia and

obesity. Study by Luján et al 2024 reported that, higher intake of lipid in breakfast may increase the risk of T2DM.

However, among Japanese people without obesity, skipping breakfast was related with 28% and 57% greater probabilities of developing metabolic syndrome and obesity, respectively, this cause by the habit of late-night meals (within 2 hours of bedtime). A cross-sectional study of healthy Korean individuals found that those who ate breakfast seldom were less likely to have increased blood triglycerides than those who ate breakfast regularly or often. (Raji et al.,2024). This might be explained by the fact that infrequent breakfast eaters consume more fat and less carbohydrates (Raji et al.,2024).

In the Korean NHANES dataset, night eating, defined as eating after 9:00 p.m., was related with 48% greater risks of metabolic syndrome in men exclusively, indicating that there may be gender variations in these correlations. However, increased nighttime eating has also been connected to cardiometabolic health (CMH) in women (Raji et al.,2024). For example, among 2650 women participating in the NHANES, each 10% increase in calorie consumption between 5:00 pm and midnight was related with a 3% rise in C-reactive protein (CRP). Consistent with these findings, a higher proportion of daily calories consumed at the self-identified largest evening meal ("dinner" and/or "supper" in an Automated Self-Administered 24 hour (ASA24) dietary record) was associated with higher blood pressure in a community-based cohort of 116 New York women (Raji et al.,2024).

Diet plays an important part in sustaining good health, and it has been proven that aligning food consumption with an individual's natural circadian clock promotes metabolic health. Innovative dietary techniques like time-restricted eating (TRE) have the potential to improve circadian alignment, resulting in a decrease in numerous metabolic risks.

2.6 Potential association of Chrononutrition and Sleep Quality

Irregular sleep, poor sleep quality, daytime sleepiness, and short and lengthy sleep durations have all been linked to higher all-cause and cardiovascular mortality, as well as a variety of cardiometabolic illnesses such as obesity, hypertension, and cognitive disorders such as depression and dementia. However, eating a nutritious diet rich in fruits and vegetables is linked to improved sleep quality and duration. Emerging data shows that the time and frequency of food consumption (chrononutrition) can impact health by resetting the body's circadian clock. Chrononutrition includes not only the types of meals eaten but also the timing, frequency, and distribution of food consumption throughout the day, all of which can have a substantial influence on metabolic processes and general health (Kim et al., 2024).

Consuming meals at night can interfere with sleep latency, length, and quality. Inadequate sleep length and poor sleep quality are well-established risk factors for metabolic disorders. Furthermore, new data suggests a link between eating habits, mealtimes, and metabolic health in people. Current data from animal studies and human research shows that eating during sleep hours might contribute to weight gain and poor metabolic health. Weight gain and obesity are more common among groups that move their activities to later hours, such as night or rotating shift workers, as well as certain young individuals, such as teens and college students who stay awake at night (Bahammam et al.,2023).

In addition, chrononutrition may be highly affected by poor sleep quality. This is because consistent research supports the concept that delayed bedtime might cause the skipping breakfast in the morning. Going to bed late is frequently related to waking up late, which might interfere with social obligations and limit breakfast eating. Studies showed a link between

skipping breakfast and shorter and poor sleep duration. Later bedtimes might be one possible explanation for these disparities in results (Saidi et al, 2024)

Moreover, the chrononutrition study by Yan et al found that later meal timings, including first, midway, and last meal timings, were related to poorer sleep quality. According to Chung et al, changes in sleep patterns and total sleep quality might alter the meal timing (chrononutrition). Additionally, according to a chronobiological study, the most important risk factors for the occurrence of disorders related to the metabolism of carbohydrates, which are accompanied by circadian dysfunction in the population evaluated, are the irrational distribution of food's energy value throughout the day, frequent meals, late breakfast and dinner, shifting bedtime, reducing the amount of time spent sleeping, and exposure to artificial lighting in the evening (Yuzhakova et al., 2020).

Thus, this study aims to explore the influence of sleep quality on the chrononutrition behavior. This is because the sleep quality might alter the morning latency, evening latency, eating window, skipping breakfast and timing of the largest meal taken.

2.7 Potential association of Chrononutrition, Dietary Intake and Sleep Quality on T2DM

As the prevalence of T2DM keeps expanding year by year, this disease is already known as major worldwide problem as it gives burden toward the country over the world. Therefore, some studies show that lifestyle habits, particularly dietary intake and sleep, have been recognized as major contributors to the onset and progression of the disease. Previous research also shown that food intake, poor sleep quality, and chrono nutrition may play an important role in the development of type 2 diabetes mellitus (T2DM) (Luján et al., 2024).

Chrononutrition components are important that need to be explored worldwide because this can introduce people to how the body works on the food intake in which the relation of food intake and body internal circadian rhythms. The timing of meal intake is a key factor in maintaining metabolic balance. Alternatively, a particular mealtime shift (e.g., increasing breakfast and decreasing supper calorie content) may restore clock gene expression in obese and diabetic animals, resulting in lower plasma glucose and triacylglycerol levels, as well as body weight. Recently, it was observed that a high-energy breakfast with a light dinner increased insulin sensitivity and lowered body weight, glucose excursions, and HbA1c among obese and diabetic individuals. Breakfast absence was also related with increased risk of type 2 diabetes, poor glycemic control, higher HbA1c, increased lipogenesis, visceral adiposity, and high blood pressure, as well as increased cardiovascular risk, despite the same daily calorie consumption in persons with type 2 diabetes (Jakubowicz et al.,2015).

Moreover, some studies have shown that body weight, blood pressure, and cholesterol levels may be affected by improper dietary choices and energy balance. Therefore, the help by

Health-care practitioners may help their patients to achieve healthier by individualizing their dietary treatments and providing ongoing support for improvement.

Apart from chrononutrition behavior and dietary intake, sleep quality also plays a crucial role in managing T2DM and reduce the risk. Multiple epidemiological sources give compelling evidence that these people are more prone to developing chronic illnesses such as obesity, type 2 diabetes when they deal with cardiometabolic difficulties, and sleep disturbances. One of the epidemiological cohort studies had identified that inadequate sleep duration as a risk factor for developing obesity and type 2 diabetes (Christina et al.,2021). Melatonin, a pineal hormone having antioxidative and anti-inflammatory characteristics, is a key player in the sleep cycle. Melatonin is mostly released during the absence of light, and its production decreases with age. According to studies, poor sleep hygiene is associated with hormonal changes such as the release of leptin, ghrelin, and melatonin. Recently, melatonin features related to glucose regulation were discovered, demonstrating that endogenous melatonin release directly promotes insulin secretion. However, study had indicated that exogenous ingestion of melatonin during the day increased insulin resistance (Rossy et al.,2024). According to research, the 25% rise in total calorie intake via many mechanisms highly associated with sleep deprivation.

Sleep deprivation can affect hunger hormones and activate reward-related brain areas in response to food cues. Dieting can considerably affect sleep physiology. Consuming an unhealthy diet heavy in saturated fat and sugar has been linked to poor sleep quality, disturbance of sleep patterns, and decreased slow-wave activity (Oussama et al,2024). Furthermore, the disturbance of chrononutrition, dietary intake and sleep quality may lead to further risk of T2DM.

CHAPTER 3: METHODOLOGY

3.1 Research design

This study cross sectional study in purpose to examine the relationship of chrononutrition behavior with dietary intake and sleep quality among T2DM patients in HPUSM.

3.2 Sampling Method

Study subjects were selected through non-probability sampling method, which purposive sampling was used. Eligible subjects will be identified based on inclusion and exclusion criteria.

3.3 Study Period

Data collection began after the ethical approval had been obtained from the Human Research Ethics Committee USM and director of Hospital USM. Data collection period ranges from March 2025 until the end of May 2025 on every weekday starting from starting from 7.30 am to 3 pm. Data entry and analysis started at the beginning of May 2025. The flow chart of the study was shown in Figure 2.0.