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Exploring the Impact of Meal Timing on Metabolic Health: A Narrative Review of Recent Findings

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ABSTRACT

Lifestyle modification is the frontline therapy for preventing and treating dysmetabolic diseases. Meal timing is a favorable dietary regimen for managing metabolic dysregulation. **Objectives:** To evaluate the impact of meal timing on metabolic output through the latest scientific findings. **Methods:** For this narrative review, various information retrieval databases were searched, including Google Scholar, PubMed, and Mendeley. Multiple combinations of keywords were used to identify relevant literature, such as "mealtime and metabolism," "circadian cycle," "intermittent fasting," "late eaters and metabolic health," and "appetite hormones and meal timing." Recent articles published between 2020 and 2025 in scientific journals were prioritized to provide the most up-to-date evidence. **Results:** Eating habits such as speed of eating, timing of eating meals, and meal frequency have now gained more attention because of their potential effect on metabolic health. Mismatched circadian rhythms are common in shift workers, social gatherings, eating, jet lag, and those who sleep late at night and wake late in the morning. Various observational research studies report that a greater portion of meals are taken in the latter half of the day, which increases the risk of metabolic diseases. The Randomized Controlled Clinical Trial proved that intermittent fasting, time-restricted feeding, and eating small and frequent meals improve insulin sensitivity and reduce weight. **Conclusions:** Skipping breakfast or eating late at night has adversely affected hormone regulation. Hence, lifestyle modification according to a circadian cycle result in preventing metabolic disorders.

INTRODUCTION

The term Metabolism is used for all chemical reactions that take place in cells and are crucial for the existence of life. Chemical reactions comprise both anabolic and catabolic processes. Anabolism generates complex molecules, and Catabolism generates simpler molecules. Maintaining cellular and body functions requires a continuous supply of energy through metabolism [1]. A circadian word derived from the Latin "Circa diem" means "around the day" [2]. Circadian rhythms are biological, visceral 24-hour cycles that regulate the body's physiological, metabolic, and behavioral processes. This system initiates wake and sleep episodes and also gives feeding and fasting signals to the body [3, 4]. Eating/Feeding is the daily rhythm that is commanded by a circadian system, which is the Central master clock present in the hypothalamic suprachiasmatic nucleus (SCN). It is modified by different environmental stimuli [5]. When a person's eating and sleeping behavior does not coincide with the circadian signal, it will cause a misalignment of the circadian cycle. Over the past few decades, researchers have focused more on gaining insight into altering meal timing and its influence on metabolic output. Research findings show that shift

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workers or Night duty staff also delay their morning meals and eat late at night, which disrupts the body's biological cycle and energy balance [3]. Humans are diurnal, and most of the physiological activity occurs in the daytime [6]. The body's circadian cycle regulates nutrient transport, utilization, and storage [7]. Various observational research studies reporting a greater portion of meals are taken in the latter half of the day, which increases the risk of metabolic diseases. According to the National Health and Nutrition Examination survey 2011-2015, most people take about 45 % of their daily energy intake in evening snacks and dinner, and it has a positive association with weight gain [6]. Consumption of food is transforming into energy that is used daily. Daily energy is classified into 3 ways: 1) Basal metabolic rate (60%), 2) Postprandial heat generation (10-15 %), 3) Physical activity (25-30 %). In a healthy population, there is a balance between food intake and physical activity [8]. Daily meal pattern is not only affected by biological factors and habits but also influenced by occupation and lifestyle, which leads to metabolic disruption and results in body weight change [9]. Many observational studies claim that over recent decades, eating patterns have changed and shifted towards skipping breakfast, eating throughout the day, prolonging the eating window for night shift working staff, and shorter sleep duration, which leads to metabolic disturbance in the body. Hence, proper mealtime is crucial for the metabolism of the body [10]. Availability of food, feelings of hunger and satiety, social gatherings, and convenience in making food all create hindrances in proper meal timing and eating patterns. If the consumption of meals is at the proper time (inherent time mechanism), then the circadian clock initiates a sensing pathway to maintain nutrient homeostasis, but if the consumption of meals occurs at a random time, the circadian clock is anticipated for new feeding time. Such disruption increases the risk of metabolic diseases (risk of obesity, type 2 Diabetes, and Chronic heart disease)[7].
This study aimed to evaluate the impact of meal timing on metabolic output through the latest scientific findings.

METHODS

Various information retrieval databases were used, including Google Scholar, PubMed, and Mendeley. To gather relevant literature for this narrative review, multiple keyword combinations were employed, including "Appetite-regulating hormone," "Circadian cycle," "Meal Timing," "Metabolic health," and "Time-restricted feeding." Articles included in this review were published in scientific journals between 2020 and 2025, written in English, and covered study designs such as cross-sectional studies, surveys, observational studies, randomized controlled trials, clinical trials, randomized crossover trials, and cohort studies. Articles published prior to 2020, non-English articles, and gray literature were excluded. Eating habits, such as meal timing, frequency, and speed, have recently attracted considerable attention due to their influence on metabolic health. Lifestyle modifications remain the frontline approach for preventing and managing metabolic disorders, and meal timing has emerged as a promising dietary strategy to regulate metabolic dysregulation. Evidence suggests that delayed evening feeding may adversely affect health by causing desynchronization between central and peripheral circadian clocks, particularly affecting gastrointestinal function and overall metabolism. All aspects of energy metabolism and appetite hormone regulation follow the body's circadian rhythm. Disruptions in eating patterns common among shift workers, individuals with late sleep-wake cycles, those traveling across time zones, or people engaged in social gatherings can lead to positive energy balance and weight gain. Conversely, consuming meals in alignment with endogenous circadian rhythms, such as early in the day, may reduce the risk of metabolic disorders, including obesity, hypertension, type 2 diabetes, dyslipidemia, and cardiovascular issues. Circadian rhythms involve physical, mental, and behavioral cycles over 24 hours. While light and dark are primary drivers, other factors such as dietary intake, food composition, psychological stress, physical activity, exposure to electronic devices, environmental and climatic conditions, and pharmacological or therapeutic interventions also modulate these rhythms. Proper alignment of food intake with circadian cues may therefore mitigate the risk of chronic metabolic diseases. Intermittent fasting, characterized by temporary abstinence from food through patterns such as alternate-day fasting or time-restricted feeding (e.g., 6 hours feeding and 18 hours fasting), has gained attention for its metabolic benefits. Evidence indicates that intermittent fasting promotes fatty acid metabolism to ketones, enhances thermogenesis, increases energy expenditure, and supports fat loss. Consequently, this dietary approach may benefit individuals with obesity, cardiovascular disorders, hypertension, and type 2 diabetes. Several studies have examined intermittent fasting as an intervention for weight management. A summary of key studies is provided in Table 1, which illustrates the positive impact of intermittent fasting on weight reduction and metabolic outcomes.

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Table 1: Studies Related to Intermittent Fasting Impact on Metabolism

Study Design	Target Population	Results	References
Randomized Controlled Trial (Turkey) Sample Size=70 Study period 12 weeks	Patient with metabolic syndrome, age 18 to 65 years, and BMI (Body Mass Index) 27 or more.	The IER Group (Intermittent Energy Restriction) significantly reduced weight (reduction of 5.5 kg), the CER group (Continuous Energy Restriction) significantly reduced weight by 4 kg, and insulin reduction.	[20]
Randomized Controlled Trial (China) Sample Size=101 Study period 3 weeks	Age 18-65 years. Pre-diabetes, and BMI (Body Mass Index) 23 or more.	The ADF group (Alternate Day Feeding) observed a more significant reduction in body weight. The TRF group (Time Restricted Feeding) least significant difference as compared to the ADF group. No significant difference was observed in blood glucose level, waist circumference, or LDL (Low-Density Lipoprotein) in both groups.	[21]
Quasi-experimental clinical trial (Aga Khan University Hospital) Sample Size=40 Study period 6 weeks	Age 20-70 years, Serum High Density Lipoprotein < 40 mg/dl (men) and Serum High Density Lipoprotein 50 mg/dl (women)	The IF group (Intermittent fasting) showed a significant reduction in Body Mass Index, Waist circumference, Low Density Lipoprotein, and a significant improvement in High Density Lipoprotein.	[22]
Randomized Controlled Trial Sample Size= 103, Study Period 26 weeks (Twice IF/week for first 4 weeks and Once IF/week for next 22 weeks) Intermittent Fasting: 24 hrs. Fasting with water only)	Age 21-70 years, with moderately elevated LDL-C (Low Density Lipoprotein Cholesterol) (without taking statins), with pre-diabetic (not taking anti-diabetic medicines), and elevated Blood Pressure (with taking anti-hypertensive medicines)	This IF regimen did not reduce LDL-C (Low-Density Lipoprotein Cholesterol) but significantly reduced HOMA-IR (Homeostatic Model Assessment of Insulin Resistance) & Metabolic Syndrome Score	[19]
Randomized Controlled Trial (Malaysia) Study period 12 weeks Sunnah Fasting 2 days per week (Consume a small meal before sunrise and a full meal after sunset)	Older males (Take a 300-500 kcal/ day diet with consumption of more healthy food)	Observed Weight loss approximates 3 %. Fat mass loss 6 -8 %	[23]

Breakfast is a kick-start to daily metabolism. It is considered the most crucial meal of the day that regulates energy metabolism. Despite this, skipping breakfast is common nowadays [24, 25]. According to various research studies, skipping breakfast is common among female, students in senior classes, and people who live in other cities [26]. In the last 4 decades, consumption of breakfast and lunch has been declining continuously. Many scientific research studies claimed that total calorie consumption in breakfast is inversely correlated with overweight/obesity and cardiovascular disease risk factors [27, 28] (Table 2).

Table 2: Influence of Skipping Breakfast on Metabolic Health

Study Design	Target Population	Results	References
Survey Study (Korea) Sample size=21193	Age 20-59 years Both gender	Regular Breakfast Eaters (56.4 %). The young adult population was significantly lower in this group. Irregular Breakfast Eaters have a higher abnormal metabolic outcome.	[25]
Cohort Study (United States of America) Sample size=9926 Study period 27 years	Age 20 years or older	Skipping breakfast shows higher cardiovascular and cerebrovascular disease mortality in MAFLD (Metabolic dysfunction associated with fatty liver disease), but not observed in the non-MAFLD group.	[29]
Survey-based (Brazil) Sample Size=776	Aged 18-65 years, Brazilian adults, both genders, and excluding night shift workers	Breakfast skippers had higher obesity than Breakfast eaters. Body Mass Index increased 0.74 kg/m2 for a delay of breakfast by every 1 hour from standard time.	[30]
Cross-Sectional Study (China) Sample size=70092	Chinese adult (having no cardiovascular disease and Cancer and with CRP (C-reactive Protein) concentration < 10 mg/l.	Serum CRP (C-reactive protein) was considerably higher in those individuals who skipped breakfast with poor diet quality.	[31]
Cross-sectional Study Sample Size= 112	3-12 years prepubertal children diagnosed with overweight/ obesity	There was no significant difference between the breakfast eater vs. breakfast skipper group in Growth Hormone, Cortisol, and Insulin-like growth factor-1, but total cholesterol, LDL-C (low density lipoprotein cholesterol), TGs (Triglycerides) were considerably higher in the breakfast skipper, and low HDL (High Density Lipoprotein) was observed in the breakfast skipper.	[32]

Glucose metabolism follows a circadian cycle, which peaks in the morning and declines in later days. Those who regularly skip breakfast and take more calories in the afternoon meal have peripheral tissues that do not manage glucose efficiently, which leads to a high post-prandial glucose level [33]. Skipping breakfast leads to more production of the ghrelin hormone, which

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encourages an individual's body to take more energy-dense food and leads toward overeating, which causes more fat storage and weight gain [34]. The modern lifestyle has a bad impact on people's health; most people consume high-energy food late at night or near bedtime. Late-night eating is classified in the literature as eating a meal after 10:00 pm or eating a meal 2 hours before bedtime, and if this activity is a minimum of 3 times per week, then it is considered late-night eating. This type of dietary change contradicts circadian rhythm, hence, increased risk of metabolic diseases (glucose intolerance, obesity, inflammation, and cardiac issues) and sleep disturbance [35, 36]. Epidemiological studies have highlighted that those who consume late-evening meals have a potentially negative impact on Cardio-metabolic health [37].

Table 3: Effect of Late-Night Eating on the Body's Metabolism

Study Design	Target Population	Results	References
Randomized Crossover Trial Sample Size=20	Age 18 -30 years, Healthy male/female	LD group (Late Dinner) had higher postprandial (4h) glucose and triglycerides levels than the RD group (Regular Dinner). There was no significant difference in morning fasting glucose and triglyceride levels in both groups. (Both groups' levels returned to normal in the fasting morning state.)	[38]
Randomized Crossover trial, Sample size=12	Age >20 years, non-smoker, and with no major disease.	The early dinner group (6:00 pm) had a significant decrease in postprandial respiratory quotient after breakfast, decreased blood glucose levels, and had a more positive effect on substrate oxidation than the late dinner group (9:00 pm)	[39]
Cross-sectional Study (Pakistan) Sample Size= 150	Age 18-30 years, University student, and late-night eaters.	95 % of participants usually consumed fried meals and confectionery items late at night. 75% headache, 66% sleep disorder, 63 % depression, 59 % stomach acidity, 29 % diarrhea, 25 % vomiting, and 21% piles.	[40]
Crossover Study, Sample size=8, and Study Period 3 days	Age 60 -70 years with body mass index < 30 kg/m2, Type 2 Diabetes HbA1c (Glycated Hemoglobin) 6.6 to 8.5 %, and not working at night.	By giving a test meal to both groups. Results showed that Postprandial glucose and insulin levels were high in the late -dinner group (21:00) as compared to the early-dinner group (18:00)	[41]
Prospective Observational Study	Patient age > 18 years with STEMI (ST-segment elevation myocardial infarction)	Skipping Breakfast (no food before lunch) with Late-night dinner (eating within 2 hours before bedtime) increases the risk of death four to five times more and re-attack of angina post 30 days of hospital discharge.	[42]

Small and frequent meal dietary habits are defined as the consumption of snacks or energy-giving beverages between main meals. It is still unclear whether consuming small and frequent meals or consuming a large meal has a greater potential benefit for metabolism or metabolic disorders [43]. But unhealthy snacking between main meals hurts an individual's health [44](Table 4).

Table 4: Importance of Eating Small and Frequent Meals in the Highlight of Research Studies

Study Design	Target Population	Results	References
Cross-sectional Study (Prospective study) Sample Size= 3009	Both male and female Aged between 47 and 68 years	Individuals with higher meal frequency (6 meals or >6 meals/day) had a lower risk of abdominal obesity than those with lower meal frequency (3 meals or < 3 meals/day).	[43]
Cohort Study (China) Sample Size= 8874 Study period 4 years Participants classification: Eating 2 meals/day Eating 3 meals/day Eating 4 meals/day	Community-dwelling people Age >45 years	Participants consuming 4 meals/day had lower risk factors associated with type-2 diabetes than those who ate 3 meals /day.	[11]
Cohort Prospective Study (European Prospective Investigation into Cancer) Sample Size= 14666	Age 45-75 years Resident of Norfolk	Results highlighted that lower total cholesterol and LDL-C (low-density lipoprotein cholesterol) had a difference of 0.25 mmol/l in those who ate more than 6 meals/day than those who consumed 2 meals/day after adjusting for confounding variables.	[45]
Parallel Study (Iran) Sample Size= 66	Both Male and Female Mean age 51.8 years With type 2 diabetes	Participants who consumed 6 meals/d had decreased HbA1c (Glycated Hemoglobin) compared to those who consumed 5 meals/d. Results also highlighted that there was no significant difference observed in low-density lipoprotein, high-density lipoprotein, total cholesterol, and fasting blood glucose levels.	[46]
Research Study Sample Size= 91 Study Period 3 days	46 participants in the 2 main meals group (2MMG) and 45 participants in the 3 main meals group (3MMG) Age 18-64 years With overweight/obese.	3 MMG were found to have higher median values of body weight, Total body water, BMR, and hip circumference in men. Renal urea nitrogen and total cholesterol levels were higher in 2 MMG women than in 3 MMG.	[47]

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Eating small and frequent meals spreads your whole day carbohydrate intake into smaller sections, which reduces the spike in insulin. Lower insulin spike requires fewer beta cells for insulin secretion [48]. A Small and frequent meal pattern brings less load to the liver and muscles and favors a more efficient oxidation process as compared to storing it in the form of fat. Hence, reduces ectopic lipid deposition [45]. Glucose metabolism in humans is under the control of the circadian rhythm. During the daytime, when a person usually consumes food, the body metabolizes glucose effectively, but the rate of metabolism of glucose is reduced during the night-dark hours. Various research studies on rodents and humans claimed that altered meal times can cause glucose intolerance because insulin and cortisol hormones (role in the metabolism of glucose) are regulated by the circadian system. Several studies have shown that glucose tolerance is more common in night shift workers [49]. The author Z Xie conducted a randomized controlled trial over a period of 5 weeks on healthy individuals. The author compared the insulin sensitivity response between two groups: one consisting of early-day eaters and the other a time-restricted feeding group. Their study results showed that improved insulin sensitivity was observed in the first group because, during the early part of the day, our body's biological clock aligns with our physiological mechanisms, causing muscles and adipose tissues to release more insulin in the morning than later in the day. Another author, Pavlou, conducted a randomized controlled trial for 6 months on adults with type 2 diabetes. Those who ate their meals earlier in the day (following a time-restricted eating regime without calorie counting) showed a comparable effect in reduction in body weight and HbA1c as the daily calorie restriction group [50]. Late-night snacking causes dysfunction of the circadian clock, disrupting lipid metabolism and leading to obesity. Various hormones, such as melatonin, leptin, and glucocorticoids, play a role in lipid metabolism and exhibit rhythmicity in a light/dark cycle. Mouse model research indicated that melatonin is considered a protective approach in the prevention of lipid metabolic disorders. Additionally, leptin regulates energy metabolism and its peak level at night [51]. The circadian cycle has an impact on protein metabolism. The anabolic activity of the protein is higher in the daytime; it might be effective to take protein in the daytime for muscle building. Taking protein close to bedtime might not be effective because of lower metabolic activity [52]. Yasuda performed 12 12-week randomized parallel trial on young adult that engaged in resistance training. There were two groups: one group (high protein intake in breakfast and also evenly distribution of protein all meals of day) and other group (on a skewed protein intake pattern: eating high protein in dinner) Their study outcomes showed that in group one where protein intake was evenly distributed in all day meals had increase muscle protein synthesis, increase muscle hypertrophy and its good for muscle building as compared to other group (skewed protein pattern)[53]. -Ghrelin: It was discovered in 1999 as a ligand for growth hormone. Ghrelin Hormone is released by the stomach. It is known as the "hunger hormone". It gives an appetite stimulus to the body. It releases more in the fasting state and decreases secretion after ingestion of food. The peak level of Ghrelin is in the evening according to the biological clock, so sleeping late at night, hunger sensation is at its peak level due to the ghrelin hormone [54]. Leptin: It was identified in 1994 as lipostat. The leptin hormone is secreted by white adipose tissues of the body. It is known as a "satiety hormone." It plays a key role in food intake and energy balance. The peak level of the leptin hormone is close to midnight. According to various intervention studies, the Concentration of leptin is higher in the morning in late eaters as compared to early eaters [14, 54] (Table 5).

Table 5: Peak Time of Digestive Hormones according to the Circadian Clock

Hormones	Peak Time
Ghrelin	At Night
Leptin	At Night
PYY (Peptide YY)	At Morning
Insulin	At Morning
GIP (Glucose-Dependent Insulinotropic Polypeptide)	At Morning
GLP1 (Glucagon-Like Peptide 1)	At Morning

Vujovic conducted a controlled crossover lab study. There were two groups: early eaters and late eaters, but both groups followed the same iso-caloric eating pattern. Their research findings exhibited that in the late eating group increase in 24-hour ghrelin secretion and a decrease in 24-hour leptin secretion, hence, it increased hunger feeling and less feeling of satiety [55]. Another author, Manoogian, highlighted in his review that various clinical trials supported the same evidence that those who rely on a narrow feeding regimen (one meal/day) have higher ghrelin production and leads toward glucose intolerance [56].

CONCLUSIONS

Recent studies have highlighted that intermittent fasting, time-restricted feeding, and eating small and frequent meals show different responses in individuals depending on their metabolism. Skipping breakfast or eating late at night has adversely affected hormonal regulation and increased the chances of obesity, which ultimately leads to metabolic diseases. Hence, lifestyle modification according to a circadian cycle result in preventing metabolic disorders.

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Authors Contribution

Conceptualization: SIT
Methodology: SIT, AM, IS
Formal analysis: SIT
Writing and Drafting: SIT, MH, IS, AR
Review and Editing: SIT, AM, MH, IS, AR

All authors approved the final manuscript and take responsibility for the integrity of the work.

Conflicts of Interest

All the authors declare no conflict of interest.

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REFERENCES

[1] Judge A and Dodd MS. Metabolism. Essays in Biochemistry. 2020; 64 (4): 607–647. doi: 10.1042/EBC20190041.

[2] Lewis P, Oster H, Korf HW, Foster RG, Erren TC. Food as a Circadian Time Cue—Evidence from Human Studies. Nature Reviews Endocrinology. 2020 Apr; 16(4): 213-23. doi: 10.1038/s41574-020-0318-z.

[3] Boege HL, Bhatti MZ, St-Onge MP. Circadian Rhythms and Meal Timing: Impact on Energy Balance and Body Weight. Current Opinion in Biotechnology. 2021 Aug; 70: 1-6. doi: .1016/j.copbio.2020.08.009.

[4] Tognini P, Samad M, Kinouchi K, Liu Y, Helbling JC, Moisan MP *et al.* Reshaping Circadian Metabolism in the Suprachiasmatic Nucleus and Prefrontal Cortex by Nutritional Challenge. Proceedings of the National Academy of Sciences. 2020 Nov; 117(47): 29904-13. doi: 10.1073/pnas.2016589117.

[5] la Fleur SE, Blancas-Velazquez AS, Stenvers DJ, Kalsbeek A. Circadian Influences on Feeding Behavior. Neuropharmacology. 2024 Sep; 256: 110007. doi: 10.1016/j.neuropharm.2024.110007.

[6] Davis R, Rogers M, Coates AM, Leung GK, Bonham MP. The Impact of Meal Timing on Risk of Weight Gain and Development of Obesity: A Review of the Current Evidence and Opportunities for Dietary Intervention. Current Diabetes Reports. 2022 Apr; 22(4): 147-55. doi: 10.1007/s11892-022-01457-0.

[7] Hawley JA, Sassone-Corsi P, Zierath JR. Chrono-Nutrition for the Prevention and Treatment of Obesity and Type 2 Diabetes: From Mice to Men. Diabetologia. 2020 Nov; 63(11): 2253-9. doi: 10.1007/s00125-020-05238-w.

[8] Yoshitake R, Park I, Ogata H, Omi N. Meal Timing and Sleeping Energy Metabolism. Nutrients. 2023 Feb; 15(3): 763. doi: 10.3390/nu15030763.

[9] Ogata H, Horie M, Kayaba M, Tanaka Y, Ando A, Park I *et al.* Skipping Breakfast For 6 Days Delayed the Circadian Rhythm of the Body Temperature without Altering Clock Gene Expression in Human Leukocytes. Nutrients. 2020 Sep; 12(9): 2797. doi: 10.3390/nu12092797.

[10] Thomas EA, Zaman A, Cornier MA, Catenacci VA, Tussey EJ, Grau L *et al.* Later Meal and Sleep Timing Predicts Higher Percent Body Fat. Nutrients. 2020 Dec; 13(1): 73. doi: 10.3390/nu13010073.

[11] Wang X, Hu Y, Qin LQ, Dong JY. Meal Frequency and Incidence of Type 2 Diabetes: A Prospective Study. British Journal of Nutrition. 2022 Jul; 128(2): 273-8. doi: 10.1017/S0007114521003226.

[12] Pellegrini M, Cioffi I, Evangelista A, Ponzo V, Goitre I, Ciccone G *et al.* Effects of Time-Restricted Feeding on Body Weight and Metabolism. A Systematic Review and Meta-Analysis. Reviews In Endocrine and Metabolic Disorders. 2020 Mar; 21(1): 17-33. doi: 10.1007/s11154-019-09524-w.

[13] Sletten TL, Cappuccio FP, Davidson AJ, Van Cauter E, Rajaratnam SM, Scheer FA. Health Consequences of Circadian Disruption. Sleep. 2020 Jan; 43(1): zsz194. doi: 10.1093/sleep/zsz194.

[14] Segers A and Depoortere I. Circadian Clocks in the Digestive System. Nature Reviews Gastroenterology and Hepatology. 2021 Apr; 18(4): 239-51. doi: 10.1038/s41575-020-00401-5.

[15] Ayyar VS and Sukumaran S. Circadian Rhythms: Influence on Physiology, Pharmacology, and Therapeutic Interventions. Journal of Pharmacokinetics and Pharmacodynamics. 2021 Jun; 48(3): 321-38. doi: 10.1007/s10928-021-09751-2.

[16] Ruan W, Yuan X, Eltzschig HK. Circadian Rhythm as a Therapeutic Target. Nature Reviews Drug Discovery. 2021 Apr; 20(4): 287-307. doi: 10.1038/s41573-020-00109-w.

[17] Acosta-Rodríguez VA, Rijo-Ferreira F, Green CB, Takahashi JS. Importance of Circadian Timing for Aging and Longevity. Nature Communications. 2021 May; 12(1): 2862. doi: 10.1038/s41467-021-22922-6.

[18] Vasim I, Majeed CN, DeBoer MD. Intermittent Fasting and Metabolic Health. Nutrients. 2022 Jan; 14(3): 631. doi: 10.3390/nu14030631.

[19] Bartholomew CL, Muhlestein JB, May HT, Le VT, Galenko O, Garrett KD *et al.* Randomized Controlled Trial of Once-Per-Week Intermittent Fasting for Health Improvement: The Wonderful Trial. European Heart Journal Open. 2021 Sep; 1(2): oeab026. doi: 10.1093/ehjopen/oeab026.

[20] Kunduraci YE and Ozbek H. Does the Energy Restriction Intermittent Fasting Diet Alleviate

DOI: https://doi.org/10.54393/df.v6i4.193

Metabolic Syndrome Biomarkers? A Randomized Controlled Trial. Nutrients. 2020 Oct; 12(10): 3213. doi: 10.3390/nu12103213.

[21] Hua CA, Xi CA, Yuelan QI, Michael Timothy NG. Intermittent Fasting in Weight Loss and Cardiometabolic Risk Reduction: A Randomized Controlled Trial. Journal of Nursing Research. 2022 Feb; 30(1): e185. doi: 10.1097/jnr.0000000000000469.

[22] Ahmed N, Farooq J, Siddiqi HS, Meo SA, Kulsoom B, Laghari AH *et al.* Impact of Intermittent Fasting on Lipid Profile–A Quasi-Randomized Clinical Trial. Frontiers in Nutrition. 2021 Feb; 7: 596787. doi: 10.3389/fnut.2020.596787.

[23] Hoddy KK, Marlatt KL, Çetinkaya H, Ravussin E. Intermittent Fasting and Metabolic Health: From Religious Fast to Time-Restricted Feeding. Obesity. 2020 Jul; 28: S29-37. doi: 10.1002/oby.22829.

[24] Lv L, Guo Y, Zheng Z, Li B. Blood Metabolites Mediate Effects of Breakfast Skipping on Heart Failure Via Mendelian Randomization Analysis. Scientific Reports. 2024 Aug; 14(1): 18957. doi: 10.1038/s41598-024-69874-7.

[25] Heo J, Choi WJ, Ham S, Kang SK, Lee W. Association between Breakfast Skipping and Metabolic Outcomes by Sex, Age, and Work Status Stratification. Nutrition and Metabolism. 2021 Jan; 18(1): 8. doi: 10.1186/s12986-020-00526-z.

[26] Sincovich A, Moller H, Smithers L, Brushe M, Lassi ZS, Brinkman SA *et al.* Prevalence of Breakfast Skipping among Children and Adolescents: A Cross-Sectional Population-Level Study. BioMed Central Pediatrics. 2022 Apr; 22(1): 220. doi: 10.1186/s12887-022-03284-4.

[27] Maugeri A and Vinciguerra M. The Effects of Meal Timing and Frequency, Caloric Restriction, and Fasting on Cardiovascular Health: An Overview. Journal of Lipid and Atherosclerosis. 2020 Jan; 9(1): 140-52. doi: 10.12997/jla.2020.9.1.140.

[28] Zeballos E and Todd JE. The Effects of Skipping a Meal on Daily Energy Intake and Diet Quality. Public Health Nutrition. 2020 Dec; 23(18): 3346-55. doi: 10.1017/S1368980020000683.

[29] Xie J, Huang H, Chen Y, Xu L, Xu C. Skipping Breakfast Is Associated with an Increased Long-Term Cardiovascular Mortality in Metabolically Dysfunctional-Associated Fatty Liver Disease (MAFLD) But Not MAFLD-Free individuals. Alimentary Pharmacology and Therapeutics. 2022 Jan; 55(2): 212-24. doi: 10.1111/apt.16727.

[30] Longo-Silva G, de Oliveira PM, Pedrosa AK, da Silva JR, Bernardes RS, de Menezes RC *et al.* Breakfast Skipping and Timing of Lunch and Dinner: Relationship with BMI and Obesity. Obesity Research & Clinical Practice. 2022 Nov; 16(6): 507-13. doi: 10.1016/j.orcp.2022.10.012.

[31] Zhu S, Cui L, Zhang X, Shu R, VanEvery H, Tucker KL, Wu S *et al.* Habitually Skipping Breakfast Is Associated with Chronic Inflammation: A Cross-Sectional Study. Public Health Nutrition. 2021 Jul; 24(10): 2936-43. doi: 10.1017/S1368980020001214.

[32] Blasetti A, Franchini S, Castorani V, Comegna L, Fornari E, Daniele F *et al.* Skipping Breakfast Is Associated with an Atherogenic Lipid Profile in Overweight and Obese Prepubertal Children. International Journal of Endocrinology. 2020; 2020(1): 1849274. doi: 10.1155/2020/1849274.

[33] Henry CJ, Kaur B, Quek RY. Chrononutrition in the Management of Diabetes. Nutrition and Diabetes. 2020 Feb; 10(1): 6. doi: 10.1038/s41387-020-0109-6.

[34] Wicherski J, Schlesinger S, Fischer F. Association between Breakfast Skipping and Body Weight—A Systematic Review and Meta-Analysis of Observational Longitudinal Studies. Nutrients. 2021 Jan; 13(1): 272. doi: 10.3390/nu13010272.

[35] Ucar C, Özgöçer T, Yıldız S. Effects of Late-Night Eating of Easily—Or Slowly—Digestible Meals on Sleep, Hypothalamo-Pituitary-Adrenal Axis, and Autonomic Nervous System in Healthy Young Males. Stress and Health. 2021 Oct; 37(4): 640-9. doi: 10.1002/smi.3025.

[36] Charlot A, Hutt F, Sabatier E, Zoll J. Beneficial Effects of Early Time-Restricted Feeding on Metabolic Diseases: Importance of Aligning Food Habits with the Circadian Clock. Nutrients. 2021 Apr; 13(5): 1405. doi: 10.3390/nu13051405.

[37] Madjd A, Taylor MA, Delavari A, Malekzadeh R, Macdonald IA, Farshchi HR. Effects of Consuming Later Evening Meal V. Earlier Evening Meal on Weight Loss During a Weight Loss Diet: A Randomized Clinical Trial. British Journal of Nutrition. 2021 Aug; 126(4): 632-40. doi: 10.1017/S0007114520004456.

[38] Gu C, Brereton N, Schweitzer A, Cotter M, Duan D, Børsheim E *et al.* Metabolic effects of Late Dinner in Healthy Volunteers—A Randomized Crossover Clinical Trial. The Journal of Clinical Endocrinology and Metabolism. 2020 Aug; 105(8): 2789-802. doi: 10.1210/clinem/dgaa354.

[39] Nakamura K, Tajiri E, Hatamoto Y, Ando T, Shimoda S, Yoshimura E. Eating Dinner Early Improves 24-H Blood Glucose Levels and Boosts Lipid Metabolism After Breakfast the Next Day: A Randomized Cross-Over Trial. Nutrients. 2021 Jul; 13(7): 2424. doi: 10.3390/nu13072424.

DOI: https://doi.org/10.54393/df.v6i4.193

[40] Jaffar HM, Ahsan W, Aqeel K, Sajjad R, Tariq M, Ahmed H *et al.* Effect of Late-Night Eating on Health: A Survey from University Students. Agricultural Sciences Journal. 2023 Aug; 5(2): 93-9. doi: 10.56520/asj.v5i2.276.

[41] Imai S, Saito Y, Kajiyama S, Nitta A, Miyawaki T, Matsumoto S *et al.* Late-Night-Dinner Deteriorates Postprandial Glucose and Insulin Whereas Consuming Dinner Dividedly Ameliorates Them in Patients with Type 2 Diabetes: A Randomized Crossover Clinical Trial. Asia Pacific Journal of Clinical Nutrition. 2020 Mar; 29(1): 68-76.

[42] Vieira Musse GN, Moreira T, Ayumi Kimura M, Pereira FW, Okoshi K, Garcia Zanati S *et al.* Skipping Breakfast Concomitant with Late-Night Dinner Eating Is Associated with Worse Outcomes Following ST-Segment Elevation Myocardial Infarction. European Journal of Preventive Cardiology. 2020 Dec; 27(19): 2311-3. doi: 10.1177/2047487319839546.

[43] SchwingshackI L, Nitschke K, Zähringer J, Bischoff K, Lohner S, Torbahn G *et al.* Impact of Meal Frequency on Anthropometric Outcomes: A Systematic Review and Network Meta-Analysis of Randomized Controlled Trials. Advances in Nutrition. 2020 Sep; 11(5): 1108-22. doi: 10.1093/advances/nmaa056.

[44] Almoraie NM, Saqaan R, Alharthi R, Alamoudi A, Badh L, Shatwan IM. Snacking Patterns Throughout the Life Span: Potential Implications on Health. Nutrition Research. 2021 Jul; 91: 81-94. doi: 10.1016/j.nutres.2021.05.001.

[45] Alkhulaifi F and Darkoh C. Meal Timing, Meal Frequency and Metabolic Syndrome. Nutrients. 2022 Apr 21; 14(9): 1719. doi: 10.3390/nu14091719.

[46] Abdollahi S, Kazemi A, de Souza RJ, Clark CC, Soltani S. The Effect of Meal Frequency on Biochemical Cardiometabolic Factors: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Clinical Nutrition. 2021 May; 40(5): 3170-81. doi: 10.1016/j.clnu.2020.12.038.

[47] Bakan S and Gezmen Karadağ M. The Effect of Meal Frequency on Body Composition, Biochemical Parameters and Diet Quality in Overweight/Obese Individuals. Journal of the American Nutrition Association. 2025 Apr; 44(3): 245-55. doi: 10.1080/27697061.2024.2422476.

[48] Song J, Oh TJ, Song Y. Individual Postprandial Glycemic Responses to Meal Types by Different Carbohydrate Levels and Their Associations with Glycemic Variability Using Continuous Glucose Monitoring. Nutrients. 2023 Aug; 15(16): 3571. doi: 10.3390/nu15163571.

[49] Mason IC, Qian J, Adler GK, Scheer FA. Impact of Circadian Disruption on Glucose Metabolism: Implications for Type 2 Diabetes. Diabetologia. 2020 Mar; 63(3): 462-72. doi: 10.1007/s00125-019-05059-6.

[50] Pavlou V, Cienfuegos S, Lin S, Ezpeleta M, Ready K, Corapi S *et al.* Effect of Time-Restricted Eating on Weight Loss in Adults with Type 2 Diabetes: A Randomized Clinical Trial. Journal of the American Medical Association Network Open. 2023 Oct; 6(10): e2339337-. doi: 10.1001/jamanetworkopen.2023.39337.

[51] Li Y, Ma J, Yao K, Su W, Tan B, Wu X *et al.* Circadian Rhythms and Obesity: Timekeeping Governs Lipid Metabolism. Journal of Pineal Research. 2020 Oct; 69(3): e12682. doi: 10.1111/jpi.12682.

[52] Smith HA and Betts JA. Nutrient Timing and Metabolic Regulation. The Journal of Physiology. 2022 Mar; 600(6): 1299-312. doi: 10.1113/JP280756.

[53] Yasuda J, Tomita T, Arimitsu T, Fujita S. Evenly Distributed Protein Intake Over 3 Meals Augments Resistance Exercise–Induced Muscle Hypertrophy in Healthy Young Men. The Journal of Nutrition. 2020 Jul; 150(7): 1845-51. doi: 10.1093/jn/nxaa101.

[54] García AS, Moreno AG, Castillo ZR. The Role of Ghrelin and Leptin in Feeding Behavior: Genetic and Molecular Evidence. Endocrinología, Diabetes y Nutrición (English ed.). 2021 Nov; 68(9): 654-63. doi: 10.1016/j.endien.2020.10.009.

[55] Vujović N, Piron MJ, Qian J, Chellappa SL, Nedeltcheva A, Barr D *et al.* Late Isocaloric Eating Increases Hunger, Decreases Energy Expenditure, and Modifies Metabolic Pathways in Adults with Overweight and Obesity. Cell Metabolism. 2022 Oct; 34(10): 1486-98. doi: 10.1016/j.cmet.2022.09.007.

[56] Manoogian EN, Chow LS, Taub PR, Laferrère B, Panda S. Time-Restricted Eating for the Prevention and Management of Metabolic Diseases. Endocrine Reviews. 2022 Apr; 43(2): 405-36. doi: 10.1210/endrev/bnab027.