Available online: https://journal.ipb.ac.id/index.php/jgizipangan
ISSN 1978-1059 EISSN 2407-0920
J. Gizi Pangan, July 2026, 21(2):137-146
DOI: https://doi.org/10.25182/jgp.2026.21.2.137-146

Systematic Review Article

Interactions among Chrononutrition, Vitamin D, and Sleep in Infertility: A Scoping Review

Shahirah Ayuni Anwar[1], Nur Islami Mohd Fahmi Teng[1*], Norsham Juliana[2]
[1]Faculty of Health Sciences, Universiti Teknologi Mara, Cawangan Selangor, 42300 Bandar Puncak Alam, Selangor, Malaysia
[2]Faculty of Medicine and Health Sciences, Universiti Sains Islam Malaysia, 71800 Nilai, Negeri Sembilan, Malaysia

ABSTRACT

The purpose of this scoping review was to examine and compile the available data about the relationship between infertility and eating habits, vitamin D, and sleep. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) served as the review's guide. Using PubMed, Scopus, Web of Science, and ScienceDirect, a thorough search of the literature was carried out, encompassing research published from each database's creation to October 2025. The keywords and search phrases encompassed chrononutrition, timing of meals, night eating, late-night eating, vitamin D, sleep, and infertility. Studies were deemed eligible if they included human subjects and utilized either observational or interventional methodologies, with reported outcomes related to fertility. From the initial 420 records screened, 19 studies met the inclusion criteria. Overall, the evidence suggests that irregular eating patterns, such as consuming more calories late at night and skipping breakfast, are associated with menstrual irregularities, anovulation, and poorer semen quality. In addition, inadequate sleep, both in terms of quality and duration, has been associated with lower reproductive hormone levels and decreased chances of conception. Adequate vitamin D levels, on the other hand, were generally associated with improved outcomes in assisted reproductive technologies as well as better semen parameters. Nevertheless, differences in study design and assessment methods across the included studies made it difficult to perform a meta-analysis. Overall, the evidence points towards a potential role of circadian alignment achieved through consistent meal timing, sufficient sleep, and optimal vitamin D status in supporting reproductive health. Despite promising associations, the current evidence is predominantly observational. Future longitudinal and interventional studies are needed to elucidate causal mechanisms and inform chrono nutritional strategies for optimizing fertility outcomes.

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Article History:
Received 22-01-2026
Revised 19-03-2026
Accepted 13-04-2026
Published 30-07-2026

Keywords:
chrono nutrition, eating behaviour, meal timing, late night eating, infertility, sleep quality, vitamin D

***Corresponding Author:**
tel: +6032584540
email: nurislami@uitm.edu.my

INTRODUCTION

Infertility is a growing global concern that affects a significant proportion, with one in every six people (about 17.5 %) of the adult population worldwide will experience infertility at some point in their lifetime, with implications for both physical and emotional well-being (WHO 2023).

Chrono nutrition is grounded in the concept that the body's internal biological clock, governed by circadian rhythms, plays an important role in regulating key physiological processes such as metabolism, hormonal balance, and reproductive function (Johnston *et al.* 2016). Disruptions to this timing for example, consuming meals at biologically inappropriate hours like late at night may negatively affect metabolic health and contribute to obesity and hormonal disturbances, which are recognised risk factors for infertility (Ni *et al.* 2019).

Time-Restricted Eating (TRE), a form of chrononutrition where food intake is confined to specific daily periods, has gained attention for its possible benefits on reproductive and metabolic

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health (Manoogian *et al.* 2019). Several studies suggest that aligning eating patterns with the body's circadian rhythm can enhance insulin sensitivity, reduce inflammation, and support hormonal balance, all essential factors for fertility (Li *et al.* 2021).

Vitamin D has been identified as a pleiotropic hormone with significant roles beyond skeletal health, particularly in reproductive physiology. It exerts its effects via the Vitamin D Receptor (VDR), which is widely expressed in reproductive tissues such as the ovaries, endometrium, and placenta testes, and hypothalamus, the physiologically active form, 1,25-dihydroxyvitamin D (calcitriol), exerts both genomic and non-genomic effects (Lerchbaum & Rabe 2014). However, evidence on the relationship between vitamin D status and reproductive outcomes remains inconsistent, particularly among women undergoing Assisted Reproductive Technology (ART).

This comprehensive review aims to systematically categorise the existing evidence on chrononutrition practices and their association with infertility. It specifically analyses the interplay between meal time, meal frequency, vitamin D levels, and sleep quality with circadian rhythms to affect reproductive health outcomes.

METHODS

This approach comprises five main stages: (1) defining the research question; (2) identifying relevant studies; (3) selecting studies based on eligibility criteria; (4) charting the data by extracting key information from the literature; and (5) collating, summarizing, and reporting the findings.

Identify research question

This scoping review addresses the research questions: "What is the current evidence on the association between chrononutrition, eating behaviour, sleep, and vitamin D in relation to infertility among men and women of reproductive age?"

Search strategies

A protocol was developed for the review following the principles of PRISMA Extension for scoping review (Tricco *et al.* 2018). This study conducted a scoping review of esteemed databases, including PubMed, Scopus, Web of Science, and ScienceDirect.

A thorough literature search was carried out. The terms "chrononutrition," "meal timing," "circadian rhythm," "time-restricted eating," "breakfast skipping," "late-night eating," and "night eating" were associated with eating habits and circadian behaviors. These were mixed with phrases related to reproductive health, including "ovulation," "fertility," "infertility," "sperm quality," and "reproductive outcomes." There were also other terminology pertaining to biological and behavioral issues, such as "sleep," "sleep quality," "circadian disruption," "vitamin D," and "25-hydroxyvitamin D." The keywords were combined and the search was refined using the boolean operators "AND" and "OR." The inclusion of "night eating" and "late-night eating" ensured that research on eating habits during the night and their possible effects.

Study selection

The selection criteria were determined collaboratively by researchers working in pairs. The data extracted by each reviewer were subsequently compared, and any discrepancies were resolved through discussion to ensure consistency in the study selection process. First, to ensure the acquisition of relevant, recent data, the inclusion criteria for this review were applied between August and October 2025, with no restrictions on publication year, although only studies published in English were considered. Next, studies were eligible if they were human-based investigations adopting either observational (cross-sectional, cohort, case-control) or interventional (randomized controlled trial, quasi-experimental) designs. Eligible populations included women and/or men of reproductive age, regardless of fertility status, provided that outcomes related to reproductive function were reported. Studies were rejected if they utilised exclusively animal models, unless experimental results were directly applied to elucidate mechanistic processes pertinent to human fertility.

Review studies, whether systematic or narrative, that synthesise research on these subjects were included. Review studies were selected solely to delineate conceptual frameworks, summarise existing knowledge, and indicate research gaps, excluding data extraction or quantitative synthesis. Articles that did not meet the inclusion criteria were eliminated during the eligibility assessment.

Data charting

After identifying appropriate titles and abstracts, full-text articles were obtained from the corresponding databases.

Data charting was initially conducted by a single researcher and subsequently validated by a second researcher collaborating in pairs. A structured data extraction table was created to collect both general and study-specific information from the chosen articles. The extracted information comprised: author(s), publication year, nation, sample characteristics (sample size, study design, study population, and age), the studied factor, fertility outcomes, and principal findings such as shown in Figure 1.

Collating, summarising, and reporting the results

The extracted data were collated and synthesized using a descriptive and narrative approach, in line with scoping review methodology. Study characteristics and key findings were first mapped in tabular form (Table 1) to provide an overview of the study design, population, exposures, and fertility-related outcomes across the included literature.

The included studies were then grouped according to the main factors examined, namely chrononutrition and eating behaviours, sleep and circadian-related factors, and vitamin D status, in relation to fertility and reproductive outcomes.

RESULTS AND DISCUSSION

A total of 424 articles were identified across the four chosen databases through the search strategy. Cross-checking led to the removal of 95 records that were found to be duplicates, leaving 329 articles in the screening phase. At this stage, the eligibility of each study was screened using its title and abstract to identify studies related to chrononutrition and fertility-related outcomes.

A total of 249 articles were excluded at this stage, primarily due to irrelevance. Out of the 80 screened publications, 22 were excluded since they had no fertility outcome, 21 only focused on general health and nutrition for pregnancy and 18 low quality articles. In total, 19 papers were deemed eligible and were incorporated into the literature review. It reviewed different chrononutrition variables, including meal timing, night eating, time-restricted feeding, and the role of vitamin D and sleep quality with infertility.

The included literature consisted of 19 articles, including twelve primary research studies and seven review papers that provided supporting secondary evidence. The primary studies comprised three cross-sectional studies, five cohort studies, two observational study, and two prospective study. Sample sizes exhibited significant variability among the included studies, with the biggest being 2,000 women undergoing ART, followed by a cohort of 1,500 women of reproductive age (WHO 2023). The majority of investigations were performed in clinical or ART environments in countries such as China, the Netherlands, Iran, the United Kingdom, and Italy (Li *et al.* 2021, 2014; Parazzini *et al.* 2017). Moreover, other population-based cohorts and national surveys from the United States, South Korea, and Japan were incorporated (Wise *et al.* 2018; Kim *et al.* 2018; Ota *et al.* 2023).

The integration of results reveals a continuous correlation between lifestyle factors associated with circadian biology and reproductive health outcomes. Chrononutrition factors, specifically meal timing and the duration of the eating window, have been demonstrated to affect reproductive indices in both males and females. Moreover, disordered eating practices, including night eating syndrome and irregular dietary patterns, correlated with suboptimal ART outcomes, underscoring the necessity of synchronising food intake with circadian rhythms.

Circadian disturbance in men, especially from shift work and poor sleep hygiene, has been associated with altered testosterone levels and

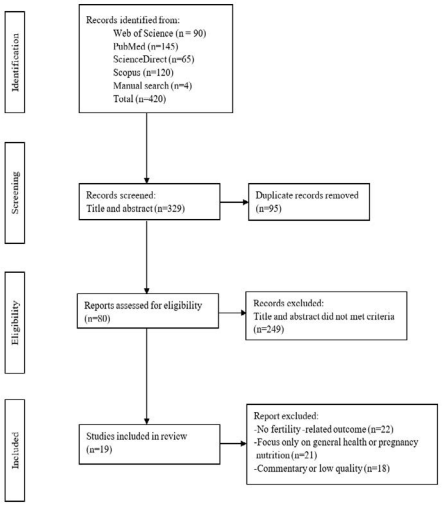

Figure 1. Shows the PRISMA diagram of the process used in paper selection

Table 1. Summary of articles

Authors (Year)	Study design & Population	Factors studied	Fertility outcomes	Key findings
Maluin *et al.* (2025)	Cross-sectional, subfertile patients, Malaysia	Chrononutrition (eating window, last meal), sleep, Vitamin D	Vitamin D status	Evening eating & high fat intake linked with Vitamin D deficiency; poor sleep common but not significant predictor.
Teoh *et al.* (2023a)	Cohort, pregnant women (MY-CARE)	Chrononutrition, melatonin, cortisol	Circadian hormones	Longer eating window → lower melatonin; breakfast skipping → lower cortisol.
Teoh *et al.* (2021)	Cross-sectional, pregnant women	Meal timing, sleep, melatonin	Sleep quality, circadian rhythm	Late eating & high dinner fat linked with poor sleep & melatonin misalignment.
Teoh *et al.* (2023b)	Cohort, pregnant women	Temporal dietary intake, melatonin	Melatonin secretion	Evening-heavy energy intake altered maternal melatonin.
Chen *et al.* (2022)	Prospective cohort, IVF patients	Sleep duration	IVF outcomes	Both short (<6h) & long (>9h) sleep linked with lower pregnancy rates.
Pastore *et al.* (2021)	Observational, women with PCOS	Sleep disturbances	Reproductive hormones	Poor sleep linked with disrupted LH, FSH, AMH, testosterone.
Zhang *et al.* (2020)	Cohort, healthy men	Sleep duration	Semen quality	Very short & very long sleep associated with reduced semen quality.
Lerchbaum *et al.* (2021)	Cohort, infertile women	Vitamin D levels	Ovarian reserve markers	Higher Vitamin D associated with better AMH & ovarian reserve.
Salameh & Sharara (2023)	Narrative review	Vitamin D	PCOS, endometriosis, male infertility, ovarian reserve	Vitamin D deficiency linked to multiple reproductive disorders.
Zhou *et al.* (2022)	Systematic review & meta-analysis	Vitamin D supplementation	Female infertility, ART outcomes	Daily supplementation (1,000–10,000 IU) improved reproductive outcomes.
Wang *et al.* (2024)	Systematic review	Sleep disturbances	Infertility, IVF success	Poor sleep duration/quality associated with infertility risk & poorer ART outcomes.
Blomberg Jensen *et al.* (2018)	Review	Vitamin D	Male reproduction	Vitamin D improves sperm motility & testosterone regulation.
Asher & Sassone-Corsi (2015)	Mechanistic review	Chrononutrition & circadian clocks	Fertility physiology	Meal timing strongly interacts with circadian clocks that govern reproduction.
Qian & Scheer (2016)	Review	Circadian rhythm & metabolism	Fertility link via insulin resistance	Circadian misalignment via eating timing may worsen PCOS & infertility.
Alzoubi *et al.* (2023)	Systematic review/ meta-analysis	Chrononutrition in pregnancy	Maternal & offspring outcomes	Meal skipping & night eating adverse outcomes; mechanistic insight for fertility
McHill *et al* . (2017)	Experimental, healthy adults	Late night eating, circadian timing	Hormonal & Metabolic markers	Eating during biological night disrupt circadian regulation and may effect reproductive hormones
Loy *et al.* (2017)	Cohort, pregnant women	Night fasting interval	Metabolic regulation	Longer night fasting associated with improved metabolic profile relevant to reproductive health
Baron *et al*. (2011)	Observational	Night eating behaviour	Circadian rhythm & hormones	Night eating linked to circadian disruption affecting hormonal balance
Xiao *et al.* (2019)	Cross sectional/cohort	Meal timing irregularity	Reproductive marker	Irregular eating patterns associated with adverse reproductive indicators

IVF: In Vitro Fertilisatio; LH: Luteinising Hormone; FSH: Follicle-Stimulating Hormone; AMH: Anti-Müllerian Hormone; PCOS: Polycystic Ovary Syndrome; IU: International Units; ART: Assisted Reproductive Technology

decreased spermatogenesis, indicating a biological mechanism for these effects (Wang *et al.* 2024).

Extensive studies indicated that sufficient serum 25-hydroxyvitamin D levels correlated with enhanced clinical pregnancy and live birth rates in women undergoing In Vitro Fertilisation (IVF) and Intracytoplasmic Sperm Injection (ICSI), while deficiency was associated with diminished ovarian reserve indicators (Zhou *et al.* 2022). In men, adequate vitamin D levels were associated with improved semen parameters, particularly sperm motility. Nonetheless, certain research revealed no significant correlations, indicating persistent disagreement in the evidence about the extent and dependability of vitamin D benefits (Zhou *et al.* 2020).

The majority of studies focused on women of reproductive age, specifically university

students and young adults, whereas only a limited number evaluated male reproductive factors. The research mostly examines meal timing exposures such as breakfast consumption, late-night eating, irregular meal patterns, and time-restricted eating habits.

Numerous observational studies investigated the connection between reproductive outcomes and skipping breakfast. For instance, Fujiwara *et al.* (2020) found that among female college students, missing breakfast was linked to reproductive abnormalities, including irregular menstruation. Similar findings from other studies have shown that irregular eating habits may lead to endocrine and metabolic problems, which may then have an impact on reproductive function. Mechanistic and review publications highlighted the significance of circadian rhythms in controlling metabolic processes and hormonal pathways related to fertility in addition to observational findings. For example, Qian and Scheer (2016) emphasised the significance of coordinating food intake with endogenous physiological cycles, while Asher and Sassone-Corsi (2015) discussed the relationship between meal timing, circadian clocks, and metabolic regulation.

Emerging research on chrononutrition and reproductive health has been further synthesised in more recent review studies. According to Teoh *et al.* (2023), irregular meal timing and late-night eating can interfere with circadian alignment and metabolic homeostasis, which could have an impact on fertility outcomes and reproductive hormone regulation. All of the research points to the possibility that irregular or delayed eating habits, like eating late at night or skipping breakfast, could disrupt circadian rhythms and lead to hormonal imbalance, insulin resistance, and systemic inflammation, which are known risk factors for decreased fertility. In support of this, a survey of Japanese female college students (ages 18 to 20) revealed that, although having equal Body Mass Index (BMI), those who routinely skipped breakfast had greater incidences of dysmenorrhea and irregular menstrual periods. According to these results, skipping breakfast is linked to irregular menstruation and may have detrimental effects on young adults' reproductive health, which could have long-term effects on fertility (Fujiwara *et al.* 2020).

Additionally, a 10% increase in calorie consumption after 5 p.m. was linked to a 3% increase in C-Reactive Protein (CRP), a measure of systemic inflammation, according to data from the National Health and Nutrition Examination Survey (NHANES). Furthermore, taking more calories at breakfast and less at dinner has been linked to better reproductive results when energy intake is shifted earlier in the day.

In addition, Li *et al.* (2021) carried out a six-week intervention study examining an 8-hour TRE regimen among anovulatory women with Polycystic Ovary Syndrome (PCOS). The findings showed significant improvements across metabolic and reproductive indicators. Participants exhibited reductions in body weight, BMI, total body fat, and visceral fat accumulation.

From a metabolic standpoint, insulin sensitivity improved, as reflected by decreased fasting insulin concentrations and lower Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) scores. Systemic inflammation also declined significantly, demonstrated by reduced high-sensitivity C-Reactive Protein (hsCRP) levels.

The TRE intervention resulted in advantageous hormonal modifications. Total Testosterone (TT), / Luteinising Hormone (LH), Follicle-Stimulating Hormone (FSH), and Free Androgen Index (FAI) levels were markedly decreased, although Sex Hormone-Binding Globulin (SHBG) concentrations elevated. These results indicate that TRE may serve as an effective non-pharmacological method for enhancing metabolic regulation and endocrine equilibrium in women with PCOS, thereby benefiting reproductive health outcomes.

In the reviewed literature, vitamin D status was generally assessed using serum 25-hydroxyvitamin D levels, whereas reproductive outcomes encompassed clinical pregnancy rate, live birth rate, ovarian reserve indicators, and semen characteristics. Numerous studies indicated that sufficient vitamin D levels correlated with improved reproductive results in women undergoing fertility treatment. Zhou *et al.* (2022) indicated that adequate vitamin D levels may correlate with increased clinical pregnancy and live birth rates in assisted reproductive technology cycles.

Certain research has investigated the correlation between vitamin D and male fertility. The existence of vitamin D receptors in male reproductive organs and spermatozoa indicates a physiological function in spermatogenesis and sperm efficacy. Blomberg Jensen (2018) indicated

that sufficient vitamin D levels may correlate with enhanced semen parameters, especially sperm motility. Moreover, several reviews have underscored the potential role of vitamin D insufficiency in reproductive illnesses such as polycystic ovarian syndrome and endometriosis, which may indirectly influence fertility (Salameh & Sharara 2023).

The studies exhibited significant variability in design, demographics, and outcome measures. Although the majority of research has been on women utilising assisted reproductive technologies, there is a paucity of studies addressing natural fertility or male reproductive health, indicating an evolving and heterogeneous knowledge base. Moreover, the synthesis of vitamin D relies on exposure to sunshine and exhibits a diurnal rhythm driven by the light-dark cycle. Research indicates that circulation concentrations of 25(OH)D and $1,25(OH)_2D$ vary diurnally, exhibiting diminished levels at night and elevated levels throughout the day (Jones *et al.* 2017).

Numerous epidemiological and clinical research have identified a substantial association between low levels of circulating 25-hydroxyvitamin D and monthly abnormalities as well as ovulatory disorders. Singh *et al.* (2021) found that women with vitamin D insufficiency had more than 13 times the likelihood of experiencing an irregular menstrual cycle compared to those with adequate vitamin D levels. Moreover, research on idiopathic male infertility has established a correlation between diminished vitamin D levels and heightened sperm DNA fragmentation, so reinforcing its possible involvement in male reproductive impairment. These data indicate that vitamin D status may be a possible connecting factor between circadian-related lifestyle patterns and infertility outcomes.

The research consistently indicates a correlation between sleep patterns and reproductive health outcomes in both genders. Sleep was evaluated based on length, quality, and circadian alignment, with indications that deviations from ideal sleep may negatively impact fertility. In females, sleep duration and quality were significantly associated with reproductive outcomes. A prospective cohort study of women undergoing IVF indicated a U-shaped correlation, wherein both insufficient sleep (<6 hours) and excessive sleep (>9 hours) were linked to diminished pregnancy rates (Chen *et al.* 2020). In women with PCOS, inadequate sleep quality correlated with alterations in essential reproductive hormones, such as LH, FSH, AMH, and testosterone (Pastore *et al.* 2021). These hormonal changes are recognised to hinder ovulation and overall reproductive efficacy.

Cohort research in males shown that both inadequate and excessive sleep duration correlated with diminished semen quality, highlighting the significance of proper sleep for spermatogenesis and male fertility (Zhang *et al.* 2020). These data indicate that circadian disruption associated with sleep may affect hormonal control and gamete quality. A comprehensive review by Wang *et al.* (2024) established that inadequate sleep duration and quality correlate with a heightened risk of infertility and diminished success rates in. Cross-sectional studies indicated that late-night consumption and high-fat evening meals correlated with poorer sleep quality and melatonin misalignment, suggesting a bidirectional link between sleep and eating schedule (Teoh *et al.* 2021).

The research suggests that adequate sleep length, high sleep quality, and synchronisation with circadian rhythms are crucial for preserving reproductive hormonal equilibrium and fertility. Sleep disruption may lead to infertility via endocrine dysregulation, diminished gamete quality, and decreased success in ART. Inadequate sleep duration and suboptimal sleep quality have been linked to monthly irregularities, heightened infertility risk, and diminished ovarian reserve in women (Park *et al.* 2018). Circadian disruption in men, caused by shift work or insufficient sleep, has been associated with diminished testosterone levels and compromised spermatogenesis (Chen *et al.* 2020). Sleep modulates reproductive hormones, including gonadotropins and sex steroids, offering a scientific rationale for these correlations (Andersen *et al.* 2017). Nevertheless, a significant portion of the current evidence is based on self-reported sleep metrics, underscoring the necessity for more objective evaluations in forthcoming studies.

Sleep disruption can mechanistically dysregulate the Hypothalamic–Pituitary–Adrenal (HPA) axis, leading to elevated cortisol release and systemic inflammation, both of which adversely impact reproductive processes. Moreover, disrupted sleep may diminish melatonin synthesis, a hormone crucial for follicular growth, implantation, and ovarian function. In addition to

female reproduction, sleep disruptions have been associated with modified levels of oestrogen, progesterone, and testosterone in both genders, hence further undermining fertility potential (Jahan *et al.* 2022). These findings underscore the significance of circadian-aligned behaviours, wherein sufficient sleep and optimal meal timing together enhance reproductive health. Circadian disruption due to inadequate sleep may encourage late-night eating and a preference for energy-dense foods (St-Onge *et al.* 2016), leading to metabolic disturbances such as insulin resistance and obesity.

Irregular eating practices, including late-night eating, prolonged eating windows, and breakfast omission, were consistently linked to circadian misalignment and hormone regulatory changes across the evidence base. Research from cohort and experimental research suggests that food consumption during the biological night may inhibit melatonin secretion and disturb endocrine function, both of which are essential for reproductive activities. Conversely, extended nighttime fasting periods correlated with enhanced metabolic results, indicating that aligning dietary habits with circadian rhythms may benefit reproductive health.

Sleep patterns further solidify these connections. Insufficient and excessive sleep durations were correlated with negative fertility outcomes, while poor sleep quality was associated with disturbances in critical reproductive hormones, such as LH, FSH, and AMH, especially in women with PCOS. In males, excessive sleep lengths correlated with diminished semen quality, underscoring the significance of sleep in reproductive function for both genders. These data indicate that sleep difficulties may exacerbate circadian disruption caused by irregular eating habits.

Vitamin D status has been identified as a pertinent yet less reliable determinant in reproductive outcomes. Numerous research indicated that sufficient vitamin D levels correlated with enhanced ovarian reserve, semen quality, and outcomes of ART. Nevertheless, alternative investigations indicated no significant correlations, suggesting variability in the intensity and consistency of the evidence. Not with standing this fluctuation, vitamin D may still play a role in reproductive health by participating in hormonal control and metabolic pathways, which are affected by circadian mechanisms.

Inconsistent meal timing can disrupt peripheral clocks in metabolic tissues, negatively affecting glucose homeostasis and insulin sensitivity, which subsequently impacts ovarian steroidogenesis and spermatogenesis (Boivin *et al.* 2022). Vitamin D may facilitate circadian control via its light-dependent production and its possible influence on clock gene expression in reproductive organs (Anderson *et al.* 2017). Sleep disorders aggravate these processes by affecting Hypothalamic–Pituitary–Gonadal (HPG) axis signalling, elevating stress hormone levels, and reducing melatonin release, which is intricately associated with oocyte quality and implantation (Chakrabarti *et al.* 2020).

The influence of chrononutrition-related parameters may vary between genders. In females, erratic dietary habits and insufficient vitamin D levels have been correlated with ovulatory dysfunction, PCOS, and diminished implantation success (Li *et al.* 2021; Irani & Merhi 2014). In males, insufficient sleep duration correlates with diminished testosterone levels and inferior semen quality (Chen *et al.* 2020), whereas vitamin D deficiency is associated with compromised sperm motility and morphology (Deng *et al.* 2023). These data indicate that lifestyle treatments aimed at circadian synchronisation may be advantageous for both genders, but gender-specific strategies may be necessary.

From a clinical standpoint, chrononutrition constitutes a viable non-pharmacological strategy for enhancing fertility. Interventions including time-restricted eating, vitamin D optimisation, and enhancement of sleep hygiene may complement traditional reproductive therapy. These measures may be especially pertinent in communities exhibiting a high prevalence of PCOS, obesity, and vitamin D insufficiency, as well as in men experiencing subfertility. At the public health level, advocating for sufficient solar exposure, sleep education, and optimal meal scheduling habits may significantly impact reproductive health.

Not with standing these encouraging results, the area is still in its nascent phase of development. A significant portion of the existing evidence is from observational studies and small-scale trials, with a scarcity of randomised controlled trials specifically assessing chrononutrition therapies in infertility. Research on male populations is notably few in comparison to studies centred on females, and

there is a paucity of investigations exploring the synergistic impacts of meal time, sleep, and vitamin D status. Cultural, occupational, and regional influences on these lifestyle determinants are yet little examined.

Future study should employ multidisciplinary methodologies that incorporate chronobiology, reproductive endocrinology, and nutritional science. Extensive, sex-specific randomised controlled studies are required to elucidate the efficacy of time-restricted meals and vitamin D supplementation in enhancing reproductive results. Moreover, the examination of genetic and epigenetic determinants, such as differences in circadian clock genes and vitamin D receptor polymorphisms, may assist in identifying those most vulnerable to circadian disruption. Incorporating chrononutrition principles into fertility management may provide a more comprehensive and individualised strategy for enhancing reproductive outcomes.

CONCLUSION

This scoping study illustrates that chrononutrition, dietary habits, sleep quality, and vitamin D levels are intricately linked to reproductive health and infertility. Evidence suggests that circadian misalignment, marked by inconsistent meal timing, late-night eating, and altered sleep patterns, may adversely affect reproductive hormones, ovulatory processes, and spermatogenesis. Concurrently, vitamin D seems to significantly influence reproductive physiology, impacting ovarian follicular growth and sperm functionality via both genomic and non-genomic pathways.

ACKNOWLEDGMENT

This study was funded by Universiti Teknologi MARA Malaysia, internal grant, 600-RMC/KEPU 5/3 (006/2023).

DECLARATION OF CONFLICT OF INTEREST

The authors have no conflict of interest.

DECLARATION OF GENERATIVE AI IN SCIENTIFIC WRITING

During the preparation of this manuscript, the author used generative Artificial Intelligence (AI) tools to assist with language editing, grammar refinement, and improving the clarity of academic writing. The AI tool was used only to support the organization and presentation of ideas and did not contribute to the generation of original scientific content, data analysis, or interpretation of results. No AI tools were used to generate data, conduct analyses, or produce results reported in this study.

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