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# LIVING AGAINST THE CLOCK: A NARRATIVE REVIEW OF SOCIAL JETLAG, HEALTH CONSEQUENCES, AND MODIFIABLE RISK FACTORS

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**ABSTRACT**

**Objective:** This review examines the prevalence, causes, and health impacts of social jetlag (SJL), a chronic circadian misalignment arising from mismatches between biological sleep-wake timing and socially imposed schedules. It synthesizes contemporary knowledge on SJL's epidemiology, measurement, biological mechanisms, and public health relevance.
**Background:** SJL has become increasingly common among adolescents and shift workers, driven by factors such as early school start times, rotating work shifts, and increased nighttime digital screen use. These influences disrupt regular sleep patterns, resulting in persistent conflicts with endogenous circadian rhythms.
**Methods:** A narrative review was conducted including peer-reviewed studies from 2015 to 2025, with one foundational exception (Wittmann et al., 2006). Databases searched were PubMed, Scopus, Web of Science, and Google Scholar. Studies were included based on relevance to SJL, circadian misalignment, and health outcomes in humans.
**Results:** Literature indicates SJL is linked to elevated cardiometabolic risks, including type 2 diabetes, obesity, and systemic inflammation. In adolescents and young adults, SJL is also associated with poor sleep quality, increased daytime sleepiness, and higher depressive symptom rates. Objective measures, like actigraphy and biomarkers, support these findings. Social and institutional timing structures are modifiable contributors to SJL.
**Discussion:** SJL is a measurable and harmful circadian disruption with short-term effects such as fatigue and cognitive impairments and long-term impacts including metabolic and mental health disorders. Despite evidence growth, longitudinal and intervention research remains limited, hindering population-level mitigation strategies.
**Conclusion:** SJL is a common, modifiable circadian health issue linked to broad physiological and psychological risks. Interventions like delaying school starts and chronotype-personalized shift schedules could alleviate SJL's burden and improve long-term public health.

**KEYWORDS**

Circadian Rhythm, Sleep-Wake Disorders, Obesity, Mental Health, Chronotype

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## Introduction

Social jetlag (SJL) is a form of chronic circadian misalignment defined as the discrepancy between an individual's endogenous biological clock and socially imposed sleep-wake schedules. Unlike travel-related jet lag, which involves rapid exposure to new time zones, social jetlag occurs repeatedly in everyday life when people are required to wake, sleep, and eat at times misaligned with their natural circadian rhythm, often dictated by work, school, or caregiving responsibilities. A common example is the shift in sleep timing between workdays and free days, where a person may rise early for school or work on weekdays and compensate by sleeping in on weekends, essentially cycling between biological time zones each week without leaving their location (Wittmann et al., 2006).

Social jetlag has become increasingly prevalent due to profound shifts in modern lifestyles. The widespread use of digital devices late into the evening delays the endogenous circadian phase, especially in adolescents and young adults (Caliandro et al., 2021). In parallel, rigid early school start times conflict with the natural delay in sleep-wake preference that emerges during puberty, placing teenagers at heightened risk for SJL (Sasawaki et al., 2023). Rapid urbanization, light exposure at night, and the growing demand for 24-hour services have also led to irregular work schedules, particularly among shift workers in healthcare, manufacturing, and transport sectors (Zhu et al., 2024). As a result, social jetlag is now observed across large swathes of the population, not only among shift workers, but also among students, evening chronotypes, and urban dwellers alike (Windred et al., 2024).

There is now robust evidence that prolonged exposure to social jetlag is associated with a wide range of adverse health outcomes. Cohort and cross-sectional studies link persistent SJL to increased risk for obesity, insulin resistance, and cardiometabolic disease effects that persist even when total sleep duration is controlled for (Hayes et al., 2022). In adolescents, high SJL (typically more than two hours) is associated with significantly poorer sleep quality, greater daytime sleepiness, and increased metabolic vulnerability (Sasawaki et al., 2023). Recent meta-analytic evidence confirms strong associations between SJL and depressive symptoms in youth, particularly at higher misalignment thresholds (Sun et al., 2025). In occupational groups such as shift-working nurses, SJL has been shown to follow a U-shaped relationship with body mass index, associated with both underweight and obesity, suggesting underlying dysfunctions in energy regulation and circadian physiology (Zhu et al., 2024).

Given the growing interest in circadian health, understanding how social jetlag emerges and affects different populations - and how it contributes to pathophysiology - is critical for informing evidence-based interventions, workplace policy, and public health guidance.

This review synthesizes current scientific knowledge on social jetlag with four main objectives:

1. Define the phenomenon and clarify how it differs from other sleep disturbances.
2. Explain why SJL prevalence is increasing, particularly in adolescents and shift workers.
3. Examine the most affected demographic and occupational groups.
4. Summarize the known health and behavioral consequences linked to persistent circadian misalignment.

The review is organized thematically into sections discussing conceptual foundations and measurement approaches, population vulnerabilities, biological mechanisms, and observed health risks, drawing from recent epidemiological findings, systematic reviews, and mechanistic studies.

**Background**

The concept of social jetlag (SJL) originates from research into human circadian rhythms and the influence of societal demands on sleep habits. Wittmann et al. (2006) first systematized the term, describing SJL as the misalignment between an individual's endogenous biological clock and externally imposed social schedules, such as work or school routines (Wittmann et al., 2006). Prior research on sleep and chronobiology had predominantly emphasized pathological states, including shift work and timezone-related jet lag. However, Wittmann and colleagues highlighted the everyday, recurring nature of these disturbances among healthy individuals. Their findings indicated that even in the absence of transmeridian travel, people commonly experience discrepancies exceeding one hour between their preferred sleep-wake patterns and actual schedules, with the effects especially pronounced between workdays and free days (Wittmann et al., 2006).

Subsequent studies have expanded upon this foundational work. Reviews and empirical investigations consistently show that social jetlag is alarmingly prevalent among adolescents, shift workers, and the general population, and is linked to a variety of adverse health outcomes, such as increased risk of obesity, cardiometabolic diseases, depressive symptoms, and impaired sleep quality (Caliandro et al., 2021; Sasawaki et al., 2023; Zhu et al., 2024; Hayes et al., 2022; Chen et al., 2024; Sun et al., 2025). The mechanisms identified include chronic desynchrony between circadian and social timing, screen exposure, meal timing, shift work, and behavioral regularity. Furthermore, studies emphasize that sleep regularity may represent a stronger predictor of health outcomes, such as mortality risk, than sleep duration alone (Windred et al., 2024).

**Key Definitions**

*Social jetlag (SJL)* refers to the discrepancy between an individual's endogenous circadian timing and the demands of their social environment. It is most commonly operationalized as the difference in the midpoint of sleep between workdays and free days. For example, a person who sleeps from midnight to 7 a.m. on weekdays but from 2 a.m. to 10 a.m. on weekends experiences a 2-hour social jetlag (Wittmann et al., 2006; Caliandro et al., 2021; Sasawaki et al., 2023).

*Chronotype* denotes an individual's innate propensity for earlier or later sleep and wake times, often categorized as morningness or eveningness. This trait is influenced by genetic, developmental, and environmental factors, which modulate adaptability to social or occupational schedules (Wittmann et al., 2006; Caliandro et al., 2021).

*Circadian misalignment* is a broader term encompassing any mismatch between the internal biological clock and external or behavioral schedules. Social jetlag represents one of the most common and mild but persistent forms of circadian misalignment in the general population, contrasting with more severe disruptions seen in shift workers or travelers experiencing jet lag (Caliandro et al., 2021; Chen et al., 2024).

**Measurement of Social Jetlag**

The Munich Chronotype Questionnaire (MCTQ) is the most widely used instrument for assessing social jetlag (Roenneberg et al., 2003; Wittmann et al., 2006). Developed by Roenneberg and colleagues, the MCTQ collects detailed self-reported sleep timing separately for workdays and free days, enabling calculation of the midpoint of sleep for each condition. Social jetlag is then quantified as the absolute difference between these midpoints, serving as an estimate of weekly circadian disruption (Wittmann et al., 2006; Chen et al., 2024; Zhu et al., 2024). For instance, if an individual's midpoint of sleep is 3:30 a.m. on workdays and 5:30 a.m. on free days, social jetlag would be calculated as 2 hours (Wittmann et al., 2006).

Beyond self-report questionnaires, objective measures such as actigraphy wrist-worn devices that track movement and light exposure, along with sleep diaries, are commonly employed in research to validate self-reported sleep timing and to quantify social jetlag more accurately over time. These methods provide detailed insights into sleep timing and regularity while reducing recall bias (Hayes et al., 2022; Chen et al., 2024). Although subjective surveys remain the most feasible option for large-scale epidemiological studies, the use of actigraphy has increased in precision-focused research and intervention trials.

Utilizing these assessment tools, research robustly documents that social jetlag is a prevalent feature of modern lifestyles, particularly among adolescents, young adults, shift workers, and individuals with an evening chronotype (Caliandro et al., 2021; Sasawaki et al., 2023; Zhu et al., 2024). Accurately measuring social jetlag and distinguishing it from mere sleep deprivation or travel-related jet lag is fundamental for advancing understanding of its health consequences and underlying mechanisms (Wittmann et al., 2006; Hayes et al., 2022).

**Methodology**

This review synthesizes recent research on social jetlag (SJL) by systematically searching and evaluating the scientific literature to present a current, evidence-based overview of the field. To ensure relevance and rigor, we included only peer-reviewed articles published between 2015 and 2025 with a single, well-justified exception noted below. This time frame captures the most up-to-date advancements while allowing for the inclusion of foundational studies where essential.

**Literature Search and Selection Process**

We conducted searches in established public scientific databases, including PubMed, Scopus, Web of Science, and Google Scholar. Search terms combined concepts central to this review, such as "social jetlag," "circadian misalignment," "chronotype," "sleep regularity," "shift work," "adolescents," and "health outcomes." Boolean logic (e.g., "social jetlag" AND "health") and strategic use of synonyms allowed for comprehensive retrieval. Reference lists of key reviews were also screened to capture influential or frequently cited works.

We applied the following inclusion criteria to all retrieved articles:

- Full-text, peer-reviewed research or systematic/narrative reviews, published in English from 2015 to 2025.
- Studies directly investigating social jetlag as a primary or central variable, or addressing closely related outcomes (e.g., chronotype–work/school misalignment).
- Research focusing on human populations, reporting prevalence data, risk factors, or group vulnerabilities (e.g., adolescents, shift workers), health consequences (e.g., metabolic, mental, behavioral), or mechanistic pathways.

We excluded:

- Animal studies, conference abstracts, non-peer-reviewed literature, and articles focused solely on unrelated sleep disturbances or on classic travel jet lag.
- Studies without clear reporting of population, methods, or relevant SJL outcomes.

**Exception to the Date Range and Its Significance**

One highly influential article was included despite being published prior to 2015: Wittmann et al., 2006. This seminal study is the original work that introduced the term "social jetlag", provided its core definition, and established the measurement standard (midpoint of sleep difference between workdays and free days). Wittmann et al. (2006) is still universally cited and underpins both conceptual and methodological advances in all later research. Its inclusion is critical, as it offers the theoretical and operational foundation for the entire field and for interpreting results in newer studies.

**Review Process and Grouping of Articles**

After searching and screening, we carried out a structured, critical analysis of the articles meeting our criteria. Each was evaluated for scientific quality, direct relevance to social jetlag as defined above, and potential to contribute to distinct review themes. From the eligible set, we selected a representative group of core articles that collectively address conceptual foundations, prevalence and epidemiology, age and occupational vulnerability, health consequences (metabolic, psychiatric, behavioral), methodology, and mechanisms.

For clarity and effective synthesis, these articles were grouped into thematic categories:

- Conceptual development and measurement of SJL (including our foundational exception).
- Population prevalence and epidemiology.
- Biological and metabolic health effects.
- Mental and behavioral health outcomes.
- Circadian misalignment in real-world risk groups (adolescents, shift workers).

This approach enabled not only comprehensive coverage of the current literature but also ensured that each section of the review was grounded in the strongest available evidence. Throughout, references are consistently numbered as per our unified citation list.

**Results**

**Core Reviews, Epidemiological Data & Measurement**

**Foundations: Conceptual Models and Definitions**

The foundational framework for understanding social jetlag (SJL) was established by Wittmann et al. (2006), who defined SJL as the chronic misalignment between an individual's endogenous circadian clock and the external demands of society, notably work and school schedules. Social jetlag is distinguished by the recurring difference between one's preferred sleep-wake timing (chronotype) and the socially determined schedule, operationalized as the absolute difference in the midpoint of sleep between workdays and free days. This model has become the gold standard for conceptualizing social jetlag and underpins much of the current research (Wittmann et al., 2006).

Building on this foundation, Caliandro et al. (2021) synthesized evidence on the public health relevance of social jetlag, documenting its consistent association with metabolic, behavioral, and mental health risks. Their review highlights that social jetlag reflects a persistent form of circadian misalignment experienced broadly in the general population, especially among adolescents and individuals with evening chronotypes, not only shift workers (Caliandro et al., 2021).

**Quantitative Epidemiology and Global Prevalence**

Epidemiological research consistently demonstrates that social jetlag (SJL) is widespread throughout developed nations. Large-scale population and cohort studies indicate that substantial proportions of both adults and adolescents experience sleep timing differences of at least one hour between weekdays and weekends, with many reporting even larger discrepancies (Caliandro et al., 2021; Sasawaki et al., 2023; Windred et al., 2024). For example, Windred et al. (2024) identified that irregular sleep timing where social jetlag is a principal contributor is highly prevalent and, even after controlling for total sleep duration, independently predicts all-cause and cardiometabolic mortality.

Furthermore, the prevalence and severity of social jetlag are not uniform across populations. Adolescents, due in part to the natural delay in circadian phase during puberty, urban residents, and individuals engaged in shift work or rotating schedules exhibit notably higher levels of social jetlag (Caliandro et al., 2021; Sasawaki et al., 2023; Casjens et al., 2022). Casjens et al. (2022) provide direct quantitative evidence from industrial shift workers, assessing social jetlag using objective wrist actigraphy over a 28-day period. Their findings revealed that the mean absolute social jetlag exceeded three hours among shift workers, with permanent night-shift workers experiencing the greatest circadian misalignment often surpassing five hours. These data underscore the amplifying effects of specific work schedules on circadian disruption beyond levels observed in the general population.

**Measurement Practices and Challenges**

Reliable measurement of social jetlag (SJL) is critical for both epidemiological research and intervention studies. The Munich Chronotype Questionnaire (MCTQ), developed by Roenneberg and colleagues, remains the most widely employed instrument for assessing SJL in large samples (Wittmann et al., 2006; Caliandro et al., 2021). The MCTQ quantifies sleep timing separately on workdays and free days, calculates mid-sleep points, and defines SJL as the absolute difference between these midpoints. For shift workers, specific adaptations of the MCTQ have been implemented to accommodate irregular and rotating schedules by calculating SJL separately for distinct shift types, allowing for more accurate circadian profiling (Casjens et al., 2022).

Complementing self-report methods, actigraphy wrist-worn devices that objectively record movement and light exposure has become increasingly prevalent. Actigraphy offers granular day-to-day sleep timing and regularity data, reducing recall bias and enhancing the accuracy of SJL quantification in research settings (Caliandro et al., 2021; Casjens et al., 2022). For example, Casjens and colleagues conducted a 28-day actigraphy assessment in industrial shift workers, enabling detailed evaluation of SJL, sleep debt, and sleep quality across various roster patterns.

Despite advances, measurement challenges persist, particularly in capturing the complexity of rotating shift schedules, naps, and intraindividual variability across days. Nonetheless, ongoing improvements in analytic approaches and thoughtful study designs are enhancing the precision of SJL assessment in real-world and diverse populations (Caliandro et al., 2021; Casjens et al., 2022).

**Adolescents and Young Adults (High-Risk Populations)**

Adolescents and young adults consistently demonstrate the highest prevalence of social jetlag (SJL). This predominance is primarily driven by the biological shift toward later sleep-wake timing (“eveningness”) emerging during puberty, while educational and social schedules typically remain fixed to early start times. Consequently, teenagers frequently experience discrepancies of one to two hours or more between weekday and weekend sleep timing, especially in bedtimes and wake times. Large-scale epidemiological studies indicate that over half of adolescents report at least a one-hour difference, with a substantial minority exhibiting differences greater than two hours, the threshold linked to elevated clinical and behavioral risks (Sasawaki et al., 2023).

Key factors contributing to SJL in this population include the biological circadian delay as well as social and environmental influences, such as extensive evening use of electronic devices, academic workload, and social engagements that delay sleep onset on free nights. For example, a study in Japanese high school students reported both a high prevalence of significant SJL and a direct association between increased SJL and poorer sleep quality, alongside excessive daytime sleepiness (Sasawaki et al., 2023). Notably, these negative outcomes were independent of total sleep duration, emphasizing that variability in sleep timing itself adversely impacts alertness and daily functioning.

Beyond sleepiness, accumulating evidence links elevated SJL in adolescents to adverse metabolic consequences. Large cross-sectional research in Spanish adolescents showed that those with higher SJL had significantly greater body mass index (BMI) and an increased likelihood of overweight or obesity, even after controlling for physical activity and dietary quality (Zhu et al., 2024). Similarly, studies in young adults corroborate that persistent SJL predicts unfavorable weight trajectories during critical periods such as the transition to adulthood (Hayes et al., 2022).

Moreover, the broader literature associates sleep variability and irregularity, core characteristics of SJL, with compromised mental health among adolescents and young adults. Recent systematic reviews highlight that irregular sleep patterns, including frequent fluctuations in sleep timing across the week, relate to higher rates of depressive symptoms, increased psychosocial difficulties, and unhealthy behaviors such as poor diet and sedentary lifestyle (Caliandro et al., 2021; Sasawaki et al., 2023; Hayes et al., 2022; Sun et al., 2025). Collectively, these findings support the potential efficacy of interventions targeting reduced SJL and improved sleep regularity, such as delaying school start times, promoting consistent sleep schedules, and addressing modifiable lifestyle factors to enhance health outcomes in adolescent populations.

**Occupational Risk: Shift Workers and Nurses**

Shift work, particularly within healthcare and industrial sectors, is associated with some of the highest levels of social jetlag (SJL) and circadian disruption. Nurses and industrial workers engaged in rotating or night shifts frequently experience SJL exceeding three hours; permanent night-shift workers often record misalignments exceeding five hours. Such pronounced circadian disturbances contribute to considerable sleep debt and disrupted biological rhythms, correlating with increased risk of both underweight and overweight statuses (Zhu et al., 2024; Casjens et al., 2022).

Emerging evidence links chronic circadian misalignment among shift workers to elevated cardiovascular risks. Zhu et al. (2024) found a U-shaped association between SJL and body mass index (BMI) in nurses, wherein both underweight and obesity were more common with higher SJL levels. Furthermore, Casjens et al. (2022) documented substantial variation in sleep timing and quality across roster types, highlighting permanent night-shift workers as experiencing the most severe misalignment. Complementary research by Gusmão et al. (2022) revealed that night and rotating shift work are related to early arterial stiffness—a known precursor to cardiovascular disease—along with increased inflammatory and metabolic strain.

Independent of sleep duration, it appears that irregularity and circadian misalignment elevate risks for cardiovascular morbidity as well as all-cause mortality, as demonstrated by the large prospective cohort study of Windred et al. (2024). Long-term exposure to shift work has also been implicated in cognitive decline; Leso et al. (2021) performed a systematic review linking night and rotating shift work to increased risks of dementia and mild cognitive impairment, with risk escalating alongside shift work duration and potentially continuing post-retirement. Mechanistically, sleep fragmentation, metabolic dysregulation, systemic inflammation, and vascular dysfunction—all exacerbated by ongoing social jetlag and circadian disturbance—contribute to these neurocognitive outcomes (Caliandro et al., 2021; Leso et al., 2021).

In summary, shift workers and nurses face elevated and persistent social jetlag exposure, which markedly increases their vulnerability to cardiometabolic and neurocognitive health decline. These findings underscore the urgent need for occupational health policies focused on shift schedule redesign, promotion of regular sleep practices, and circadian health prioritization.

**Health Consequences and Biological Mechanisms**

Chronic social jetlag (SJL) is strongly linked to increased risk of cardiometabolic diseases, systemic inflammation, and obesity. Prospective cohort studies demonstrate that persistent misalignment between an individual's endogenous circadian clock and their actual sleep-wake patterns, hallmarks of social jetlag, is associated with elevated risk for type 2 diabetes, coronary heart disease, and stroke. In a large population-based study employing objective sleep measurements, individuals with greater circadian misalignment experienced significantly higher incidences of these diseases, independent of age, body mass index (BMI), and physical activity. Importantly, the risk increased in a dose–response manner with the degree of misalignment, underscoring the critical role of biological timing beyond the quantity of sleep (Chen et al., 2024).

Weight gain and adverse metabolic outcomes are also closely related to SJL. A longitudinal study of young adults found that participants with consistently high SJL exhibited greater weight gain and increased waist circumference over two years compared to peers with more regular sleep schedules. These differences remained significant after controlling for total sleep duration, physical activity, and diet, highlighting sleep timing variability as an independent risk factor for metabolic dysfunction (Hayes et al., 2022).

Research also connects SJL to increased markers of systemic inflammation and metabolic dysregulation, including elevated C-reactive protein levels, impaired insulin sensitivity, and disrupted glucose metabolism. These biological alterations likely mediate the increased risk of noncommunicable diseases associated with sleep timing misalignment (Caliandro et al., 2021; Chen et al., 2024).

Further support for the relationship between SJL and obesity arises from observational and mechanistic studies. Circadian disruption influences hormones regulating appetite, such as leptin and ghrelin, promotes late-night eating behaviors, and reduces metabolic efficiency. Both adolescent and adult populations with higher SJL are more likely to be overweight or obese, regardless of total sleep duration or dietary quality (Zhu et al., 2024; Hayes et al., 2022). These findings suggest that sleep timing and its synchrony with internal biological rhythms should be prioritized in public health strategies targeting metabolic disease prevention (Caliandro et al., 2021).

Taken together, the evidence confirms that social jetlag adversely impacts cardiovascular and metabolic health via a combination of behavioral and physiological pathways. Promoting consistently regular sleep routines, enhancing alignment between social and biological time, and raising awareness are key measures to mitigate this growing public health burden, particularly in at-risk groups (Caliandro et al., 2021; Zhu et al., 2024; Hayes et al., 2022; Chen et al., 2024).

**Mental Health and Behavioral Risk**

Social jetlag (SJL) has gained recognition as a significant factor affecting mental health, particularly among adolescents and young adults. Meta-analytic evidence indicates that individuals experiencing high levels of SJL, operationalized as a difference of two or more hours between weekday and weekend sleep timing, have significantly higher odds of depressive symptoms compared to those with more consistent sleep schedules. Sun et al. (2025) reported a 44% increase in odds of depressive symptoms among youth with pronounced SJL, with the relationship demonstrating a graded dose effect; only substantial misalignment reaches clinical significance. This association was robust across multiple analytical methods, affirming SJL as a modifiable public health risk factor for depression in young populations (Sun et al., 2025).

The pathway linking SJL to mental health symptoms is multifaceted. Circadian misalignment can exacerbate mood and psychiatric disorders partly through the mechanism of sleep inertia, the difficulty in transitioning from sleep to wakefulness, which is particularly pronounced in evening chronotypes compelled to adhere to early schedules. Burns et al. (2024) found that sleep inertia, amplified by SJL, serves as a stronger predictor of psychiatric disorder risk than chronotype alone, supported by findings in both epidemiological and genetic datasets. These results point to shared biological pathways connecting circadian regulation, sleep transitions, and vulnerability to psychiatric conditions (Burns et al., 2024).

Behavioral risks linked to SJL encompass detrimental eating and lifestyle patterns. Mutti et al. (2023) reviewed the bidirectional relationship between sleep pathologies, including social jetlag and disordered eating behaviors. Their review highlights that misaligned or irregular sleep timing negatively influences appetite regulation, meal timing, and emotional control, while disordered eating further disrupts sleep quality and timing. This reciprocal interaction likely heightens susceptibility to both psychological distress and metabolic imbalances, especially in youth populations (Mutti et al., 2023).

Digital media use significantly contributes to the development and persistence of social jetlag, particularly in adolescents. A large cross-sectional study of Swedish adolescents aged 13 to 15 found that over half had SJL exceeding two hours. Nighttime screen time and texting were independently associated with greater SJL, irrespective of socioeconomic background (Hena & Garmy, 2020). These activities delay sleep onset and degrade sleep quality, amplifying risks of depressive symptoms and daytime impairment.

Collectively, these findings underscore that social jetlag contributes substantially to psychological and behavioral risk profiles. They emphasize the need for integrated interventions addressing sleep timing, digital media habits, mental health, and lifestyle factors to mitigate its detrimental effects.

**Contextual Risks and Emerging Mechanisms**

Social jetlag (SJL) exists within a broader context of circadian misalignment that impacts not only sleep patterns but also physiological, metabolic, and environmental systems. Emerging evidence highlights biological mechanisms and modifiable social factors that contribute to or exacerbate the health risks associated with SJL.

Recent research emphasizes the gut–brain axis and microbiome regulation as critical pathways linking circadian disruption to both physical and mental health outcomes. Codoñer-Franch et al. (2023) reviewed studies demonstrating that irregular sleep and meal timing, common among individuals with SJL, disrupt gut microbial rhythms and provoke neuroinflammatory responses. Such misaligned feeding impairs natural oscillations of gut bacteria, undermining intestinal and metabolic homeostasis. Over time, these disruptions increase vulnerability to mood disorders, cognitive decline, and metabolic dysregulation. Chrononutrition interventions, particularly time-restricted eating aligned with the biological day, show early promise in promoting microbial resilience and mitigating negative consequences of circadian misalignment (Codoñer-Franch et al., 2023).

Sleep inertia, defined as cognitive and emotional sluggishness upon awakening, is another pivotal mechanism. This phenomenon disproportionately affects late chronotypes forced to wake earlier due to societal constraints like school or work. Burns et al. (2024) reported that sleep inertia, exacerbated by SJL in evening types, better predicts psychiatric disorder risk than chronotype alone. This finding, supported by epidemiological and genetic data, suggests convergent biological pathways linking circadian regulation, sleep transitions, and vulnerability to psychiatric illnesses (Burns et al., 2024).

Hormonal instability further contributes to SJL's downstream effects. Disruption of circadian rhythms alters secretion patterns of hormones, including melatonin, cortisol, leptin, and ghrelin, which regulate metabolism, appetite, stress, and sleep. Such irregularities may promote emotional dysregulation, immune dysfunction, and heightened cardiometabolic risk (Caliandro et al., 2021).

Social and environmental factors critically shape SJL prevalence and severity. Fixed, early school or work schedules compel adolescents and shift workers to rise at times misaligned with their internal clocks, making SJL nearly unavoidable for many. Caliandro et al. (2021) emphasize that this tension between societal timing and biological rhythms poses a modifiable public health problem. They advocate for community and institutional interventions, such as delaying school start times or aligning shift work to chronotype, as effective strategies to reduce SJL, improve sleep consistency, and ameliorate associated health impacts (Caliandro et al., 2021).

Together, these biological and contextual mechanisms underscore the multifaceted nature of SJL's health consequences. Effective mitigation will require comprehensive approaches addressing behavioral patterns as well as systemic influences within education, work, diet, and healthcare systems.

**Discussion**

The accumulated evidence from recent studies demonstrates that social jetlag (SJL) is highly prevalent across modern societies, transcending age groups, occupational categories, and cultural differences. SJL arises from a multifaceted interaction of biological, behavioral, and environmental determinants, including innate circadian timing variation (chronotype), fixed social demands like school and work schedules, as well as lifestyle factors such as digital media use and meal timing (Wittmann et al., 2006; Caliandro et al., 2021; Codoñer-Franch et al., 2023). Consistently, SJL has been linked to an array of adverse health outcomes encompassing obesity, cardiometabolic diseases, systemic inflammation, and poor mental health (Caliandro et al., 2021; Hayes et al., 2022; Chen et al., 2024; Sun et al., 2025; Burns et al., 2024). Adolescents and young adults are especially susceptible, where even moderate circadian misalignment can produce negative metabolic and psychological sequelae (Sasawaki et al., 2023; Hayes et al., 2022; Sun et al., 2025; Hena & Garmy, 2020).

Despite this growing consensus, certain limitations and inconsistencies warrant consideration. Variability in defining and measuring SJL, ranging from thresholds of one to two hours for clinical significance, affects prevalence estimates and risk associations (Caliandro et al., 2021; Windred et al., 2024; Hayes et al., 2022). Methodological heterogeneity, including demographic differences, sampling strategies, and measurement tools, complicates direct comparisons across studies (Caliandro et al., 2021; Sasawaki et al., 2023; Casjens et al., 2022). Furthermore, research remains predominantly cross-sectional; well-powered longitudinal and intervention studies are scarce, limiting causal inference about the directionality of SJL-health relationships (Hayes et al., 2022).

Critical gaps persist concerning the long-term effects of SJL and the evaluation of sustained intervention strategies. There is an urgent need for large-scale, population-based trials assessing interventions such as delayed school start times, chronotype-aligned shift schedules, and targeted behavioral sleep interventions to determine efficacy in mitigating SJL-related risks (Caliandro et al., 2021; Hayes et al., 2022; Codoñer-Franch et al., 2023). Early evidence suggests delaying school start times reduces SJL and improves adolescent sleep and mood, but broader implementation and prospective evaluation remain limited (Caliandro et al., 2021; Hena & Garmy, 2020). Similarly, optimization of shift work scheduling and personalized timing approaches holds promise for occupational groups exposed to high circadian disruption (Casjens et al., 2022; Codoñer-Franch et al., 2023).

Practically, these findings support multi-level prevention strategies. Institutional schedule adjustments aligning with population chronotype distributions, alongside education promoting stable sleep and meal times, reduced evening screen exposure, and circadian-friendly lifestyle habits, may greatly reduce social jetlag's burden (Caliandro et al., 2021; Hayes et al., 2022; Hena & Garmy, 2020; Codoñer-Franch et al., 2023). Adoption of such policies and practices has the potential to enhance sleep regularity, mitigate disease risks linked to circadian misalignment, and foster healthier, more productive communities.

**Conclusions**

Current literature provides consistent and robust evidence that social jetlag (SJL) is a prevalent and impactful form of circadian misalignment affecting diverse populations worldwide. Adolescents and shift workers exhibit particularly high susceptibility due to structural mismatches between intrinsic biological sleep timing and socially imposed schedules, such as early school start times and rotating work shifts (Wittmann et al., 2006; Caliandro et al., 2021; Sasawaki et al., 2023; Casjens et al., 2022). Epidemiological and clinical studies associate persistent SJL with elevated risks of obesity, insulin resistance, cardiometabolic diseases (Hayes et al., 2022; Chen et al., 2024), depressive symptoms, disordered eating behaviors, and impaired daytime functioning (Sun et al., 2025; Burns et al., 2024; Mutti et al., 2023).

Importantly, SJL represents a modifiable risk factor with clear intervention potential. Strategies such as delaying school start times, tailoring shift work schedules to individual chronotypes, promoting sleep hygiene, and encouraging consistent daily routines have demonstrated promising effects in reducing circadian misalignment and mitigating associated health risks across the lifespan (Caliandro et al., 2021; Hayes et al., 2022; Hena & Garmy, 2020; Codoñer-Franch et al., 2023).

Scientifically, understanding SJL illuminates the critical role of circadian timing in mediating the interplay between everyday behaviors and health outcomes. Practically, it provides actionable targets for public health initiatives, policy reform, and individual behavior change. Growing advocacy to adapt school, workplace, and urban environments in support of circadian health holds promise for reducing the burden of preventable chronic diseases and enhancing overall well-being.

In summary, social jetlag is a measurable, widespread, and clinically meaningful phenomenon, and its reduction is both scientifically justified and societally beneficial. Continued research, focused prevention, and informed policy action are essential to align societal structures with biological clocks and promote healthier, more resilient populations.

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