A Review on Screen Time and Endocrine Rhythms: Unraveling Hormonal Imbalance in Digital Lifestyles

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Abstract
Modern lifestyles have been transformed by the quick spread of digital technology based on screens, but this has also brought about hitherto unheard-of difficulties for maintaining physiological homeostasis, especially with regard to circadian and endocrine cycles. This review examines the growing body of research showing that excessive screen time and artificial light exposure, particularly in the evening, alter endogenous hormone cycles that control metabolism, sleep, stress response, and reproductive health. Digital gadgets' artificial light inhibits melatonin secretion, which delays the onset of sleep and changes the architecture of sleep. Additionally, by changing the dynamics of leptin, ghrelin, and insulin, screen-induced circadian misalignment raises the risk of obesity, insulin resistance, and type 2 diabetes by contributing to metabolic disorders. Chronic screen time and sedentary behaviour have been linked to changes in reproductive hormones, such as luteinizing hormone (LH), follicle-stimulating hormone (FSH), oestrogen, and testosterone, which have a negative impact on menstrual cycles and fertility. In the context of our increasingly digitalised environment, it is essential to comprehend these connections in order to create measures to prevent endocrine disruption.

Keywords: Screen time; Hormonal imbalance; Melatonin suppression; Digital lifestyle; Endocrine disruption; Leptin and ghrelin.

Introduction

Human activity patterns and biological cycles have been drastically altered in the current digital era due to the widespread use of electronic gadgets and the resultant exposure to artificial light at night (ALAN). The widespread use of screen-based devices, such as smartphones, tablets, computers, televisions, and wearable screens, has accelerated this change and given rise to what is now known as the "digital lifestyle." This phrase refers to prolonged screen time and regular use of digital platforms throughout daily life, frequently at the price of exposure to the outdoors, physical activity, and in-person contacts (Lissak, 2018; Nagata et al., 2020). An inbuilt timekeeping system that coordinates physiological functions across a 24-hour period, the circadian system is extremely sensitive to external stimuli, especially light (Bedrosian & Nelson, 2017).

Maintaining synchronised circadian and endocrine cycles is severely hampered by digital lifestyles, which are defined by extended screen time, irregular sleep patterns, and midnight activity. The COVID-

19 pandemic functioned as a digital accelerant. Social distancing mandates, lockdowns, and school closures necessitated a sudden and global shift to remote learning, telecommuting, and digital socialization. Consequently, screen time surged dramatically across populations. A multinational study reported that daily screen time among adolescents increased by 2.7 hours during the early pandemic period compared to pre-pandemic levels (Drexler et al., 2021). Adults reported similarly dramatic increases, especially among those in knowledge-based occupations reliant on virtual meetings, online collaboration tools, and social media.

Blue-enriched light in the 460–480 nm wavelength range, which is highly emitted by smartphones, tablets, and computers, has been shown to be particularly potent in suppressing melatonin production through activation of the intrinsically photosensitive retinal ganglion cells (ipRGCs) that project to the suprachiasmatic nucleus (SCN), the central circadian pacemaker (Cajochen et al., 2011; Prayag et al., 2019; Korman et al., 2020). Melatonin, a crucial hormone involved in circadian rhythm and sleep-wake balance, is disrupted by artificial light, particularly from LED-emitting gadgets (Touitou & Reinberg, 2017). In addition to affecting the timing and quality of sleep, melatonin suppression disrupts the hypothalamic-pituitary-adrenal (HPA) axis and other endocrine pathways, which may result in immune system impairment, metabolic dysregulation, and reproductive issues (Fonken & Nelson, 2014). The suppression of melatonin adversely affects sleep architecture, with long-term consequences for circadian alignment, mood, and metabolic regulation (Benedetti et al., 2020).

Furthermore, there is strong circadian rhythmicity in the endocrine system itself. The closely regulated daily cycles of hormones such cortisol, insulin, growth hormone, and thyroid-stimulating hormone are vulnerable to phase shifts brought on by light and sleep disturbances (Cajochen et al., 2011). Digital behaviours such as streaming, social media use, and late-night internet use lead to circadian misalignment, or "social jetlag," and also associated with shorter sleep duration, increased daytime fatigue, and poorer cognitive performance which has been connected to higher risks of cardiovascular disease, obesity, and insulin resistance (Wright et al., 2013; Leone & Sigman, 2020).

According to experimental and observational research, using light-emitting screens in the evening, particularly one to two hours before bed, significantly delays the circadian phase, lowers endogenous melatonin, and impairs cognitive function and alertness the following morning (Chang et al., 2015; Heo et al., 2017). According to a randomised crossover study, even five nights of tablet screen time resulted in longer sleep latency, less REM sleep, and lower subjective alertness the next day (Harvard Medical School, 2015). Furthermore, chronic circadian desynchrony might affect thyroid function, immunological surveillance, and glucose metabolism, making adolescents and shift workers groups with significant nocturnal screen exposure particularly susceptible (Wright et al., 2013; Papantoniou et al., 2018).

Light at night has cumulative physiological consequences that might lead to long-term health problems, such as diabetes, obesity, infertility, and even hormone-sensitive malignancies because of endocrine dysregulation and protracted circadian disruption (Blask et al., 2009; Leproult & Van Cauter, 2011; Ekelund et al., 2019; Saunders et al., 2020; Patterson et al., 2020). According to Elhai et al. (2020), problematic smartphone use is associated with anxiety, depression, and subpar academic performance. Excessive screen time may alter reward circuits and contribute to behaviours similar to substance addiction, according to brain imaging research (Montag & Diefenbach, 2018).

This article reviews the ways in which artificial light from screens, particularly blue light, changes circadian entrainment and postpones the onset of melatonin, upsetting sleep-wake cycles and subsequent hormonal cascades. The paper explores how important hormone systems that are essential for preserving physiological balance are disrupted by screen-induced circadian misalignment. Digital screen artificial light exposure, especially in the evening, suppresses melatonin secretion and modifies the natural cortisol rhythm, two hormones that are essential for controlling sleep-wake cycles. Insulin, leptin, and ghrelin are among the metabolic hormones that are affected, which raises the risk of metabolic disorders and impairs glucose regulation and appetite management. Additionally, luteinizing hormone (LH), follicle-stimulating hormone (FSH), testosterone, oestrogen, and other reproductive hormones can all be adversely affected by circadian misalignment, which may lead to irregular menstrual cycles, decreased fertility, and other reproductive dysfunctions. Furthermore, dysregulated cortisol and adrenocorticotropic hormone (ACTH) release affects the stress-response system, aggravating psychological stress and related complications. The dysregulated cortisol and adrenocorticotropic hormone (ACTH) release inturn affects the stress-response system, aggravating psychological stress and raising vulnerability to mood and anxiety disorders.

The Importance of Hormonal Balance in Maintaining Homeostasis

The endocrine system plays a crucial role in homeostasis, the dynamic process by which the body preserves internal stability in the face of external disturbances. Numerous physiological processes, such as metabolism, growth, stress response, fluid and electrolyte balance, immunological function, circadian rhythms, and reproduction, are regulated by hormones, which work as biochemical messengers. Maintaining homeostatic balance depends on the precise secretion, feedback regulation, and receptor sensitivity of hormones. The integration and control of many biological systems depend on hormonal homeostasis. Hormonal balance disturbances, whether brought on by endogenous dysfunctions, lifestyle choices, or environmental exposures, have systemic effects that jeopardise homeostasis and play a role in the aetiology of many chronic illnesses. Widespread pathological effects can be triggered by even small disturbances in hormonal balance (Fliers & Kalsbeek, 2021; Taylor et al., 2020).

The intricate hormonal regulation required for energy balance is best illustrated by the insulin-glucagon axis, which is essential to glucose homeostasis. Insulin helps the body absorb and store glucose, and glucagon encourages the production of gluconeogenesis and the breakdown of glycogen while fasting. Insulin resistance and type 2 diabetes mellitus are examples of dysregulation of this axis, which throws off energy homeostasis and raises the risk of cardiovascular disease, nonalcoholic fatty liver disease (NAFLD), and neurodegeneration (Kahn et al., 2019; Roden & Shulman, 2019). A neuroendocrine feedback loop that is essential to the regulation of energy intake is also formed by hormones like ghrelin and leptin, which work together to coordinate hunger and satiety signals through the hypothalamus (Müller et al., 2022).

The body's reaction to both physical and psychological stress is controlled by the hypothalamic-pituitary-adrenal (HPA) axis. The hypothalamus releases corticotropin-releasing hormone (CRH) in response to stress, which causes the anterior pituitary to release adrenocorticotropic hormone (ACTH), which in turn causes the adrenal cortex to release more cortisol. In addition to regulating blood pressure and immunological function, cortisol mobilises energy stores. But long-term stress, shift work, or circadian misalignment can raise cortisol levels, which can cause mood disorders, immunosuppression, visceral obesity, and impaired glucose metabolism (Marin et al., 2020; Herman et al., 2021; Nicolaides et al., 2022).

The regulation of basal metabolic rate, thermogenesis, and the metabolism of fats and carbohydrates all depend on thyroid hormones (T3 and T4). Dyslipidaemia, exhaustion, cognitive impairment, and irregular menstruation can all result from even asymptomatic hypothyroidism (Taylor et al., 2020). On the other hand, hyperthyroidism can result in cardiovascular arrhythmias, muscle atrophy, and catabolism. Neurodevelopment also depends on healthy thyroid function, especially in the foetal and neonatal phases (Grozinsky-Glasberg et al., 2020).

Beyond reproduction, sex steroid hormones including oestrogens, progesterone, and androgens are crucial for maintaining bone density, protecting the heart, and regulating neurobehavior. Increased risks of osteoporosis, atherosclerosis, and mood problems are linked to oestrogen insufficiency, especially after menopause (Finkelstein et al., 2022; Mauvais-Jarvis et al., 2021). Similarly, depression, insulin resistance, and sarcopenia are associated with decreased testosterone levels in men. Feedback mechanisms tightly regulate the hypothalamic-pituitary-gonadal (HPG) axis, and disturbances can lead to hypogonadism, PCOS, or infertility (Bhasin et al., 2020).

Through the renin-angiotensin-aldosterone system (RAAS), hormones like aldosterone, renin, natriuretic peptides, and antidiuretic hormone (ADH) control blood pressure and water-electrolyte balance. In order to maintain blood volume and osmolarity, aldosterone promotes potassium excretion and salt retention. Hormonal imbalance can seriously impair fluid homeostasis and neuronal function, as shown by conditions like diabetes insipidus and syndrome of inappropriate antidiuretic hormone secretion (SIADH) (Verbalis, 2021; Nunes et al., 2023).

New research shows that the endocrine and immunological systems interact, with sex hormones, vitamin D, and glucocorticoids influencing immune responses. Although glucocorticoids are necessary for reducing inflammation and decrease pro-inflammatory cytokines, long-term overuse impairs immune surveillance and increases vulnerability to infections and cancers (Cain & Cidlowski, 2020). Additionally, androgens and oestrogens have immunomodulatory effects that affect the occurrence and severity of autoimmune diseases in both sexes (Klein & Flanagan, 2016; Márquez et al., 2020).

The temporal coordination of physiological activities is guaranteed by the circadian regulation of hormone secretion. Growth hormone, insulin, cortisol, melatonin, and other hormones have diurnal cycles that are controlled by the hypothalamic suprachiasmatic nucleus (SCN). Jet lag, shift work, or excessive nighttime light exposure can all disrupt these rhythms, which can worsen metabolic diseases, raise the risk of cancer, and affect glucose tolerance (Kervezee et al., 2020; Duffy & Czeisler, 2021).

Major Hormonal Disruptions Due to Screen Time

Melatonin, a neurohormone synthesized by the pineal gland, is tightly regulated by the light-dark cycle and plays a crucial role in signaling circadian night and initiating sleep. Numerous studies have shown that evening screen exposure, particularly to blue-enriched LED light, leads to melatonin suppression and delayed secretion onset (Cajochen et al., 2019; Touitou & Reinberg, 2017). Chang et al. (2015) found that participants using e-readers before bedtime exhibited significantly lower evening melatonin levels, increased sleep onset latency, and reduced rapid eye movement (REM) sleep compared to those reading printed material. The suppression of melatonin adversely affects sleep architecture, with long-term consequences for circadian alignment, mood, and metabolic regulation (Benedetti et al., 2020). According to recent studies, nighttime screen-based light exposure dramatically reduces melatonin release, postpones its peak timing, and shortens its duration (Münch et al., 2022). By decreasing both REM and deep NREM sleep stages, this disturbance lengthens the time it takes for sleep to begin and lowers the quality of sleep (Gringras et al., 2021). Teenagers and young adults are more susceptible to melatonin suppression from smartphones, tablets, and LED monitors used at night because of their increased circadian sensitivity (van der Lely et al., 2019).

Cortisol, the primary stress hormone regulated by the hypothalamic-pituitary-adrenal (HPA) axis, normally follows a diurnal rhythm with peak levels in the early morning and a decline toward night. With high levels in the morning and a slow drop during the day, cortisol exhibits a diurnal pattern. However, it has been demonstrated that excessive digital stimulation whether from social media, video games, or emotionally charged content activates the sympathetic nerve system and raises evening cortisol levels, which can lead to hyperarousal and disrupt sleep (Heath et al., 2021). Additionally, long-term use of digital media has been connected to flattened diurnal patterns and a blunted cortisol awakening response, which are indicators of dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis, which is linked to mood disorders and chronic stress (Romm et al., 2023). Excessive and prolonged screen time, especially involving stimulating or emotionally engaging content, has been associated with elevated evening cortisol levels (Markovic et al., 2020). This hyperarousal state delays sleep initiation and affects restorative sleep. Chronic exposure to digital media may flatten cortisol's diurnal slope, a biomarker of HPA axis dysregulation linked to increased risk for depression, anxiety, and burnout (Zhou et al., 2023).

Leptin and ghrelin, the primary hormones regulating appetite and satiety, are strongly influenced by sleep quality and circadian timing. Late-night screen use disrupts sleep, leading to altered secretion of these hormones. Specifically, insufficient sleep increases ghrelin, the hormone that stimulates hunger while decreasing leptin, which normally rises at night to suppress appetite (Morselli et al., 2021). A large-scale cross-sectional study by Haapala et al. (2022) found that higher screen time in teenagers is positively correlated with emotional eating and a preference for energy-dense foods. This association is mediated by hormonal imbalances caused by sleep deprivation and circadian misalignment. Sleep deprivation induced by prolonged screen exposure results in decreased leptin and increased ghrelin levels, which together heighten appetite and caloric intake, particularly for foods high in sugar and fat (Knutson & Van Cauter, 2021). In adolescents and young adults, excessive screen use is also linked to late-night snacking, emotional eating, and increased body mass index (BMI), suggesting a complex behavioral and hormonal feedback loop driven by disrupted sleep patterns and altered reward processing (Chung et al., 2022).

For the best insulin secretion and glucose metabolism, circadian synchronisation is necessary. Circadian disruption from screen exposure negatively impacts glucose metabolism and insulin sensitivity. Controlled laboratory investigations have shown that nighttime light exposure, especially from screens, decreases insulin sensitivity and worsens glucose tolerance (Rifkin et al., 2022). Sedentary behaviour linked to screen time exacerbates these consequences and raises the risk of type 2 diabetes and insulin resistance. Even after controlling for BMI and physical activity, a recent cohort study found that increased nighttime screen time was independently linked to higher fasting glucose and insulin levels (Turel et al., 2021). Experimental studies indicate that light exposure during typical sleep hours leads to decreased insulin secretion and increased glucose intolerance (Cheung et al., 2019). Moreover, sedentary behavior accompanying prolonged screen time exacerbates insulin resistance, further increasing the risk of type 2 diabetes (Wang et al., 2021). A large-scale cohort study by Kocevska et al. (2023) reported that individuals with high screen time and poor sleep patterns had significantly higher fasting glucose and insulin levels, independent of physical activity.

Emerging research suggests that digital lifestyle factors may influence reproductive hormonal rhythms.

In males, excessive screen time and sedentary behavior have been associated with lower testosterone levels and reduced semen quality (Ismail et al., 2020; Chiu et al., 2021). In females, disrupted circadian cycles due to nighttime screen use may alter estrogen and progesterone dynamics, contributing to menstrual irregularities and reduced fertility potential (Minges et al., 2022). The underlying mechanisms are believed to involve melatonin suppression, metabolic dysregulation, and altered hypothalamic signaling to the gonadal axis. Extended periods of screen usage have been linked to disruptions in the regulation of reproductive hormones. Sedentary lifestyles and more digital screen time were linked to decreased serum testosterone levels and lower-quality sperm in men (Ishikawa et al., 2020). According to research, women's circadian disturbance from screen use, particularly at night, might change the rhythms of oestrogen and progesterone, which may lead to irregular menstruation and decreased fertility (Taheri et al., 2021). Particularly, melatonin suppression has been linked to a decrease in the hypothalamic-pituitary-gonadal (HPG) axis's function, which impacts ovulatory cycles and reproductive health (Khan et al., 2023).

The Effects of Circadian Disturbances caused by prolonged exposure to digital screens

Endogenous, nearly 24-hour cycles known as circadian rhythms control a variety of physiological functions, such as hormone secretion, metabolism, sleep-wake cycles, and reproductive activity. Widespread health effects impacting several body systems result from the disruption of these cycles, which is typically brought on by erratic light exposure, screen usage, and lifestyle variables.

Disrupted circadian signalling is closely associated with insomnia, which is characterised by trouble falling or staying asleep. Poor sleep efficiency, fragmented sleep, and reduced daytime functioning are the outcomes of this desynchronisation (Ritter et al., 2020). Furthermore, those with Delayed Sleep Phase Syndrome (DSPS), a particular circadian sleep problem, have a persistently delayed sleep schedule in comparison to society's norms. This condition is frequently made worse by late-night exposure to light from computers and other gadgets (Baron & Reid, 2020). Due to extensive screen time, the prevalence of DSPS has significantly grown among teenagers and young adults, resulting in chronic sleep deprivation and detrimental effects on scholastic and professional performance (Crowley et al., 2019). Changes in core body temperature rhythms and a delayed initiation of melatonin secretion are part of the pathogenesis (Wright et al., 2022).

Disrupted rhythms affect mood regulation and emotional resilience by changing the profiles of stress hormones and neurotransmitter dynamics (McCarthy & Welsh, 2021). Walker et al.'s meta-analysis from 2022 verified that people who have circadian misalignment have greater rates of anxiety and depression symptoms. Notably, overnight screen use and irregular light-dark cycles make these symptoms worse by interfering with sleep and raising evening cortisol levels (Logan et al., 2020). Bright light therapy and melatonin supplements are two examples of circadian rhythm-based therapies that have demonstrated potential in reducing mood symptoms by re-establishing rhythm integrity (Bedrosian & Nelson, 2019). Furthermore, poor prefrontal brain functioning associated with sleep loss and rhythm disturbance may be the cause of the irritability and emotional dysregulation observed in circadian disruption (Felix et al., 2023).

Blood pressure regulation, glucose metabolism, and energy balance are all affected when endogenous clocks and behavioural cycles are not in sync (Taheri, 2020). Insulin resistance, decreased glucose tolerance, and increased hunger are all caused by disrupted secretion of important metabolic hormones such insulin, leptin, and adiponectin (Björck et al., 2021). According to epidemiological statistics, those who work shifts or have irregular sleep patterns both of which cause circadian disruption are far more likely to acquire type 2 diabetes, hypertension, and obesity (Vetter et al., 2018). According to experimental research, nighttime light exposure exacerbates metabolic inefficiency by delaying peripheral clock gene expression in organs such as the liver and adipose (Kettner et al., 2019). Additionally, altered timing of food intake driven by circadian misalignment is an independent risk factor for metabolic syndrome (Gu et al., 2021).

Menstrual abnormalities and decreased fertility result from circadian disruption, which alters the timing and amplitude of reproductive hormone release (Gamble et al., 2021). Amenorrhoea, oligomenorrhea, and delayed ovulation are more common in shift workers and people who spend a lot of time in front of screens at night, according to studies (De Blasio et al., 2020). Conception rates are decreased when follicular development and ovulation are disrupted by irregular LH and FSH surge timing (James et al., 2019). Moreover, egg quality and embryo implantation are adversely affected by melatonin suppression brought on by exposure to evening light, which exacerbates reproductive issues (Tamura et al., 2019). Lower testosterone levels and decreased sperm motility and concentration are associated with circadian disturbance in males, most likely due to changed Leydig cell activity (Jana et al., 2022).

The necessity of awareness-raising initiatives

The swift and extensive rise in screen time, especially in the evening, has become a serious public health concern. By inhibiting the production of melatonin, the primary hormone that signals nighttime and promotes the onset of sleep, exposure to artificial light from electronic devices like computers, smartphones, and tablets during the night disrupts the body's natural circadian rhythms (Cajochen et al., 2019; Münch et al., 2022). This disturbance can lead to metabolic dysregulation, an elevated risk of obesity, and mood disorders in addition to impairing the quality of sleep and changing the secretion patterns of other hormones that regulate hunger, such as ghrelin and leptin (Knutson & Van Cauter, 2021; Morselli et al., 2021).

The global public health burden is made worse by the higher incidence of chronic conditions such as diabetes, cardiovascular disease, and mental health disorders that result from these hormonal and sleep disturbances, according to population health perspectives (Walker et al., 2023; World Health Organisation, 2024). Vulnerable populations like adolescents and young adults are particularly affected because of their developing circadian systems and behavioural patterns, which make them more susceptible to nighttime light exposure and irregular sleep schedules (van der Lely et al., 2019; Hale & Guan, 2015).

Comprehensive public health interventions that include awareness campaigns, workplace and school policy changes, and evidence-based recommendations on screen time and hormone health are desperately needed in light of these complex health dangers. On a population level, these interventions can help realign sleep-wake cycles, lower risks for mental and metabolic health, and encourage healthier lifestyle choices (National Sleep Foundation, 2024; Zhong et al., 2025).

School and Workplace Policy Adaptations

The rapid digitalization and increasing accessibility of smartphones, tablets, and computers have led to a sharp rise in screen use across all age groups, particularly among students and working professionals. This trend, coupled with late-night screen exposure, has emerged as a pressing public health concern due to its adverse effects on sleep quality and hormonal health (Rao et al., 2022; Kumar & Singh, 2023).

Adolescents face unique challenges related to late-night screen use. The competitive academic environment often encourages extended study hours and digital learning through online classes and assignments, increasing screen exposure during evening hours (Sharma et al., 2021). Addressing this requires targeted school policies like Schools should integrate sleep education into health and wellness programs, highlighting how excessive evening screen time can disrupt melatonin secretion and impair academic performance. Educating students about balancing digital learning with healthy sleep habits is critical (Patel & Mehta, 2020). Given the rise in digital learning, schools can recommend or enforce "digital curfews" during evenings, especially in residential schools or hostels, to encourage screen-free hours before bedtime (Srinivas & Rao, 2022). Many households are highly involved in children's education; thus, schools can organize workshops and distribute guidelines to parents on managing children's screen time and promoting consistent sleep routines at home (Reddy et al., 2019). Encouraging participation in physical activities, yoga, and cultural programs can offer screen-free alternatives that support better sleep and mental health (Narayan et al., 2020).

The growing IT and service sectors have increased the prevalence of extended working hours and screen exposure among adults, often extending into late evenings and night due to global work timings and remote work practices (Gupta & Kumar, 2023). Companies can establish policies to limit after-hours emails, meetings, and screen use, especially for employees working across different time zones. This can help reduce circadian disruption caused by prolonged exposure to blue light and mental stimulation (Sharma et al., 2022). With diverse chronotypes in the workforce, offering flexible start and end times can enable employees to align work schedules with their natural sleep-wake cycles, thereby improving sleep quality and productivity (Joshi et al., 2021).Organizations can conduct regular awareness sessions on the importance of sleep hygiene and practical steps to reduce nighttime screen exposure, such as using blue light filters and setting device curfews (Mishra & Singh, 2020). Promoting screen breaks, ergonomic device usage, and adaptive lighting systems that mimic natural light can help employees maintain better circadian health even during long work hours (Chatterjee & Bhatia, 2021).

Guidelines for Hormone Health and Screen Exposure in the Indian Setting

The need for evidence-based, culturally sensitive screen exposure standards to safeguard hormone and sleep health has become critical due to India's exponential expansion in digital device use, which is affecting both urban and increasingly rural people. Excessive nighttime screen usage is associated with altered hunger hormone profiles and disrupted melatonin release, which have serious consequences for mental, cognitive, and metabolic health. Therefore, in order to reduce these dangers, public health authorities, educational institutions, employers, and families must all implement explicit, doable rules. First and foremost, it's critical to restrict screen usage in the evening and at night. Limiting non-essential screen time at least one to two hours before bed is advised in order to give melatonin levels time to naturally increase. Since their circadian rhythms are more susceptible to phase delays brought on by light, teenagers and young adults should pay special attention to this. Frequent brief breaks (5–10 minutes per hour) can help reduce cumulative light exposure and mental tiredness for people who are constantly using screens, such as those who work remotely or participate in online education.

Reducing blue light exposure is another important tactic. Circadian disruption can be considerably decreased by promoting the use of laptops, tablets, and cellphones with built-in blue light filters or night modes. This intervention is very useful as most well-known smartphone companies offer these functions. Additionally, encouraging the use of blue-blocking eyewear, particularly among professionals and students, can assist reduce melatonin suppression in situations where evening screen time is unavoidable. Maintaining the quality of sleep is mostly dependent on content management. Action-packed videos, competitive gaming, and stressful social media conversations are examples of content that might increase cognitive arousal and postpone the start of sleep. In order to promote relaxation, public health messaging should stress the value of consuming soothing or instructive content in the evening. Teaching adults and children media literacy can help them make better consumption choices by educating them about how digital information affects their emotional and hormonal well-being.

It's also critical to support offline pre-sleep activities that encourage relaxation. Activities that promote melatonin production and sleep readiness include reading printed books, engaging in mindfulness or meditation, doing moderate yoga, and listening to calming music. These activities are culturally relevant in India. For increased acceptability and adherence, these guidelines can incorporate traditional Indian wellness practices. Limiting screen multitasking, such as utilising several devices at once or quickly moving between tasks, can also lessen cumulative screen time and mental stimulation, which in turn reduces hormone disruption.

It is crucial to make specific suggestions for vulnerable populations, including children, adolescents, and working adults. Stricter restrictions on recreational screen time and parental monitoring should be prioritised for younger children. Establishing device "shutdown" habits and promoting tech-free wind-down intervals before to bed might assist working professionals handle the demands of digital work while maintaining hormonal balance and enhancing the quality of their sleep. It is imperative that these standards be included into national policy and public health programs. Given India's sociocultural variety, the Ministry of Education and the Ministry of Health and Family Welfare might work together to release official guidelines that would apply to both urban and rural communities. To guarantee widespread awareness and efficient implementation, these principles can be disseminated via mass media campaigns, workplaces, primary healthcare facilities, and educational institutions.

To protect hormone balance and sleep quality in technologically savvy populace, culturally specific, scientifically supported screen exposure standards that prioritise scheduling, light quality, content kind, and alternative pre-sleep behaviours must be put into place. The increasing prevalence of mental health issues, metabolic diseases, and cognitive deficits associated with screen-induced circadian disruption can be reduced with the support of such guidelines.

Conclusion

The immeasurable costs of evening screen time on our hormone and sleep health are becoming increasingly noticeable as screens become an indispensable aspect of contemporary Indian life, whether in urban families or rural communities, or in classrooms and businesses. A seemingly innocuous practice, such as browsing social media late at night, using a laptop to do work, or allowing kids to watch videos before bed, can subtly throw off the body's normal rhythm, impacting not just our sleep patterns but also our eating, thinking, and emotional states. This is a global health issue, not simply a personal one. Child obesity rates are on the rise, teen mental health problems are on the rise, and working adult burnout is on the rise as a result of sleep deprivation and hormone imbalances in melatonin, leptin, and ghrelin. In countries, where internet access is growing more quickly than knowledge of its negative health effects, these issues are particularly urgent.

Making small adjustments like turning off devices after sunset, selecting peaceful offline activities before bed, and being aware of how screen material impacts our brains can have a big impact.

Establishing settings where digital use is thoughtful rather than mindless is a responsibility shared by companies, families, schools, and healthcare providers. Above all, as a society, we need to learn to recognise the night as a time for rest rather than stimulation and to follow the body's natural cycles. We can maintain the advantages of technology without compromising our health provided we have clear regulations, caring education, and encouraging policies. By doing this, we create space for a future in which advancements in technology coexist with wellbeing and where sleep and hormonal balance are safeguarded as vital components of a healthy human beings.

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