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# Understanding the Human Chronotype Research

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***Author's contribution***

*The sole author designed, analysed, interpreted and prepared the manuscript.*

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## ABSTRACT

A chronotype is essentially your body's innate tendency towards a specific sleep-wake pattern. It is controlled by heredity and works in unison with your circadian rhythm, or internal 24-hour clock. Knowing your chronotype can help you improve your daily energy levels, work more efficiently, and sleep schedule. Countries like the United States have a typical distribution of chronotypes; 25% morning types, 50% intermediate types, and 25% evening types. The distribution is skewed in tropical nations, where morning types are more prevalent. Seasonal variations, occupation, social and cultural characteristics, ageing, and lifestyle factors all have an impact on similar changes in chronotype. Studies show that while people are younger, they want to do things in the morning, but as they become older, they move to the afternoon and evening. Geographical differences are the main factor influencing the spread of chronotypes. It is well recognized that evening types are more suited to a nighttime lifestyle and shift work than morning types, as our society grows more dependent on nightlife and shift work in a 24/7 environment. Therefore, research on shifts in sleep-wake preferences would be beneficial for modifying social and professional practices to achieve optimal productivity, minimal errors, improved sleep quality, and a higher quality of sleep.

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## 1. INTRODUCTION

Natural fluctuations in sleep-wake cycles would have been experienced by our hunter-gatherer ancestors. While some individuals would have been more suited for staying up late to watch for predators, others might have been more adept at getting up early to find food [1]. It is thought that chronotypes have an evolutionary origin [2]. The variety of sleep-wake cycles may have given early human populations advantages in resource gathering, predator avoidance, and other areas of survival. Morning chronotypes are preferred due to the necessity of rising early and synchronizing with daylight hours, which became important with the advent of agriculture approximately 10,000 years ago. Since farming is typically best done in the daytime, early waking has naturally become preferred by society [3].

With the introduction of factory employment in the late 18th and 19th centuries, there was a shift to fixed work hours. This period reaffirmed the necessity of a set work schedule, frequently catering to morning people who were more easily adjusted to early shifts. Because evening people frequently found the strict early hours difficult, society became predisposed towards morning people. Artificial illumination and more flexible work schedules have made it possible for evening chronotypes to better match their natural timetables in today's culture [4]. However, the desychronization between a person's biological clock and societal duties, such as job or school schedules, can still cause problems. This desynchronization frequently affects evening types, resulting in lack of sleep and related health problems [5]. Furthermore, the abundance of screens and artificial illumination can intensify the innate inclinations of night owls, making it more difficult for them to maintain regular sleep schedules.

The 20th century saw the formal study of the concept of chronotypes. Nonetheless, throughout history, there have been references to "morning people" and "night people." The scientific study of chronotype was initiated in the 1900s by scholars such as Nathaniel Kleitman, who, with the publication of his book "Sleep and Wakefulness" in 1939, offered a summary of sleep research up to that point and suggested the existence of a fundamental cycle of rest and activity [6].

The chronotype can be seen as a physiological process that intertwines with the circadian cycle, with early chronotypes exhibiting an earlier phase of entrainment and evening types exhibiting a delayed one [7]. This dichotomy in morning and evening preference was first observed in the 1900s in humans and has recently been observed among Drosophila and mice. In 1939, Kleitman discovered the basic rest-activity rhythm. Birds rise early in the morning, while owls rise late at night [6]. Even though both have a 24-hour rest-activity cycle, they prefer skewed periods for rest and activity. This preferential rest-activity is endogenous and has evolved in response to the availability of food, shelter, and mates—the three essential needs of any population [8]. Almost all animals, plants, and humans have adapted to a specific rest and activity window. Variations in the preference for rest-activity time have been discovered over the past few decades, allowing people to be classified as morning-type, evening-type, or intermediate-type [9]. Chronotype is the aggregate name for this phenomenon (Fig. 1).

Chronotype quantifies the timing of actual or preferential rest-activity behaviors under idealized conditions (without any influence of external or internal factors) [10]. Based on preferential timing, humans can be broadly divided into three types: morning-type, intermediate-type, and evening-type. Recently, a fourth type has been identified as a unihemispheric sleeper type called the dolphin type [11].

Morning types (lark type, bird type, bear type) are people who are more productive during the morning hours compared to intermediate and evening types [12]. Morning types follow the solar cycle and can wake up early in the morning, usually without an alarm. They have trouble staying awake at night. Psychologically, they are extroverted and happy people [13]. About 55% of people fall under this category. According to studies, morning people are the ones who cannot tolerate nightlife or shift work. Working outside of an "endogenous temporal window" for a long period can cause mental and physiological illness [14].

Intermediate types (lion type) take time to get energized after waking up in the morning and exhibit peak activity around lunchtime that lasts

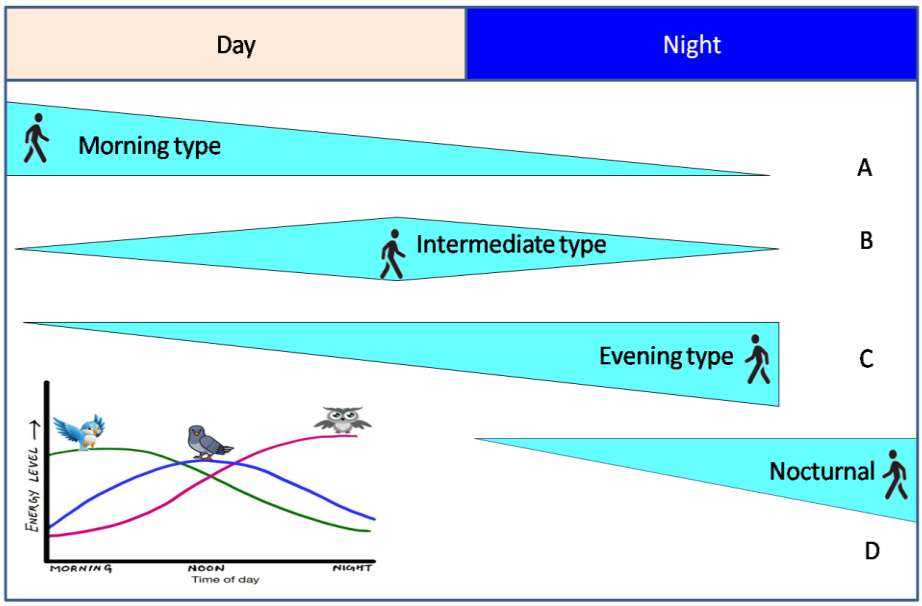


**Fig. 1. Chronotypes: Showing variation in morningness-eveningness preference among human. The symbol indicates activity and the triangle indicates the amount of activity where broader side represent high and narrower side represent low activity**

until early evening. Working either late at night or in the early morning hours is difficult for these lions. Psychologically, intermediates are considered natural leaders, charismatic, and early risers. About 15% of people fall into this category [15,16].

Evening types (wolf types) are people who have positively adapted to modern human lifestyles and are nocturnal. They find it difficult to rise early in the morning, but they can wake and work comfortably during the night hours. They show maximum productivity during the late night hours, with the least physical or mental illness. However, evening types are also subjected to insufficient sleep with reduced self-perceived health during student life as they have to wake-up early that opposes their natural time preferences [17].

## 2. CHRONOTYPE AS FUNCTION OF CIRCADIAN REST-ACTIVITY IN TODDLERS

When sleep and wake hormones pass through the mother, they cross the placenta and affect the baby. This means when the mother is awake and active, her baby typically is too, and when the mother is starting to doze off into dreamland, her baby will likely follow close behind. The baby's sleep patterns aren't affected by light or darkness while in the womb. The baby is reacting to the mother's hormones, so its growing brain doesn't associate active time with daytime or sleep time with nighttime. When the baby is born and no longer receives hormones from the mother, it starts to develop its circadian rhythm. Some unresolved topics include how the circadian rhythm is formed. Simpkin et al. (2014) conducted an intriguing study on toddler chronotype and rest-activity rhythm using an actimeter and the Children's Chronotype Questionnaire (CCTQ). They discovered that the majority of toddlers aged 2 to 3 years are morning types, followed by moderately morning types. In addition, they discovered a substantial link between chronotype, rest-activity rhythm, and melatonin rhythm. Surprisingly, no evening type was discovered among toddlers. Maternal circadian rhythm and its influence on pregnancy and birth outcomes in human studies are scarce. The majority of previous studies on chronotypes have focused on shift work issues. There are few studies based on chronotype in pregnant women and newborn babies.

## 3. METHODS OF CHRONOTYPE DETECTION

The identification of a chronotype is through subjective assessment. It also coincides with a sleep-wake pattern that can be objectively assessed. The most widely used questionnaire is the MEQ of Horne & Östberg [18]. Another widely used questionnaire is the Munich Chrono Type Questionnaire (MCTQ) developed by Till

Roenneberg et al. [19], which evaluates chronotype concerning sleep-wake patterns during workdays and free days. The self-reported MCTQ has been used in adults, adolescents, and children as young as 10 years of age. Both measures recognize and assess chronotype as a psychological process, with participants in control of their sleep-wake behavior, and as a physiological process governed by internal circadian clocks. However, it is difficult to determine whether these questionnaires reflect the phase preference of the endogenous biological clock or simply reflect the daily routine and lifestyle of the subject [20].

## 4. FLEXIBLE AND FIXED CHRONOTYPE

The biological clock exhibits some degree of character flexibility. Research on the intriguing idea of flexible vs. fixed chronotypes is still in its early stages. The concept of fixed and flexible chronotypes implies that certain individuals are more adaptable than others when it comes to their sleep habits. People with flexible chronotypes may find it easier to modify their sleep cycle in response to external events or work schedules [21]. Their rest-activity rhythm may slightly differ from their natural preference, but it won't have a significant impact. Conversely, those with fixed chronotypes may find it more difficult to adjust their sleep routine. Deviating from their innate inclination may result in exhaustion, decreased attentiveness, and challenges with functioning. Due to a lack of scientific data, people cannot yet be definitively classified as "flexible" or "fixed" chronotypes. It is more likely a spectrum, with the majority of people falling in the middle. Chronotype flexibility is independent of age but it is significantly higher among males as compared to females [22]. Hormonal changes cause teenagers to frequently have more variable sleep habits, while adult chronotypes usually become more defined [23]. Individual with higher flexibility better adapt the night time work and feel less sleepiness [22]. Additionally, those who maintain regular sleep schedules and patterns of light exposure may have a more stable chronotype.

## 5. CHRONOTYPE AS FUNCTION OF GENES

The chronotype mechanism can be an outcome of genetics and environment. It reflects a strong stable state of individual and could not be consider as a trait exactly [24]. When the internal chronotype and external environment desynchronizes many physical and psychological health problems rises. This usually happens with evening type people as human beings at large are evolved as diurnal animals [25].

Both the non-clock genes and the clock gene polymorphism may be linked to the individual differences in chronotypes [26]. Adenylate kinase (AK), NR1D1, 2, D-site of albumin promoter Binding Protein (DBP), Basic Helix–Loop–Helix family gene member E40 (BHLHE40, 41), Timeless Gene (TIM), Nuclear Factor, Interleukin 3 regulated (NFIL3), and RORC, SCN clock genes (PER1, PER2, PER3, CRY, FBXL3, ARNTL, PER2, RGS16, FBXL13, and AK5) are among the clock genes [27,28]. Evening chronotype was adversely correlated with NFIL3 rs2482705 and RORC rs3828057 [29]. Furthermore, in a healthy population, non-clock genes like GWAS and candidates for the serotonin 2A receptor gene (5HT2A) receptor (HTR2A) were linked to chronotype [30].

The inheritance of chronotype can be seen in some family studies; however, molecular evidence is unclear (Kalmbach et al., 2017). Rs35333999, a missense variant of PER2 common in European populations, has been shown to associate with a later chronotype [31]. Circadian genotype, determining the phase of entrainment and timing of melatonin secretion (biology) influenced by light (environmental) are factors in regulating sleep-wake behaviors, as are family and occupational demands (social). Genetics of people having a 'fixed' chronotype may provide a better picture.

## 6. FACTORS INFLUENCING CHRONOTYPE

1. **Age and Gender:** Children up to the age of 14 are reportedly more likely to be morning types. Up until the age of 20 to 25, they tend to be of the evening and intermediate type, and this pattern continues until old age [32,33,34]. Men often have later chronotypes than women do, especially throughout adolescence [35]. In addition, comparable gender-based chronotype discrepancies also exist in the population. Social differences between males and females, such as differences in culture and family responsibilities, may be reflected in different chronotypes. Thus, these variations in chronotype could occur from aging and gender differences or might be a cohort-specific phenomenon.

2. **Geographical Distribution:** The amount of solar irradiation varies dynamically with the season, especially with increasing distance from the equator. With no underlying impact of cardiorespiratory and hematological quantities, the human chronotype varies with altitude [36]. In 2012, Tonetti et al. reported that Indians tend to be morning-types, whereas Italians have a higher prevalence of eveningness [37].
3. **Social Obligations and Responsibilities:** Recently, during COVID-19, many studies on human circadian sleep-wake patterns reported chronotype shifting towards morningness, in the absence of social obligations [38]. This also signifies that many people are just facultative and not endogenously intermediate or evening types. Further, recent studies on Stone Age sleep patterns and pre-industrialization sleep patterns revealed plasticity in morningness-eveningness preference. In 2014 Piosczyk et al. experimented in a stone-age environment (with no modern facilities) and found early and prolonged sleep in their subjects [39]. The finding suggests that chronotype could be an exogenous phenomenon. In 2016 Ekirch also found an interesting fact on sleep-wake patterns during pre-industrialization conditions called 'segmented sleep' [40]. His data revealed that in European human culture, segmented sleep was reported during pre-industrialization. They called it 'first sleep' and 'second sleep,' where both sleeps occur during the nighttime. Monophasic, biphasic, and polyphasic sleep are also common in some individuals. Its impact on chronotype would be interesting to know.
4. **Seasonal Changes and Chronotype:** Light is the most potent time cue for phase-shifting circadian rhythms, but the timing and amount of solar irradiation vary dynamically with the season. According to some texts, chronotype depends on season-related mood. For example, winters are lazier than summers. Modern lifestyles that include access to artificial light at night, temperature-controlled environments, and spending much less time outdoors offer a buffer to the environmental changes of the seasons and may contribute to humans becoming less responsive to seasons [41].

## 7. IMPACT OF CHRONOTYPE ON PHYSICAL AND MENTAL HEALTH

Chronotype is associated with psychic and personality traits as well as cognitive ability Morning types tend to be diligent, while evening types are more extroverted, narcissistic, and intelligent [42,43]. In addition, evening types exhibit a higher propensity for psychopathic disorders than morning types, including cyclothymic (a milder form of the disorder, which involves episodes of moodiness and depression) and euphoric temperaments (abnormally exaggerated happiness in normal situations), as well as more apathetic (lack of goal-directed activity), volatile, and disinhibited temperaments (involving irresponsibility, impulsivity, distractibility, risk-taking, and rigidity) [44]. Evening personalities also tend to substance use disorder and eating disorder [26], take more risks, be more impulsive, sensation seekers, and prefer present over future time views [45,46]. Evening types are also tend According to research by Fabian et al. in 2016, poor psychological health has also been linked to the physical health of evening-type personalities [47]. Circadian rhythm disruption is common among mental patients [48]. Evening Chronotype is more likely to have circadian disruption so with psychological disorders [26]. Research indicates that evening type personality are subjected to large daily sleep debt and morning sleepiness, however there is no difference in the daytime alertness and performance [49,50].

## 8. SOCIAL MEDIA AND CHRONOTYPE

There is a link between social media use and the circadian rhythm of sleep and wakefulness. Evening types, according to research, utilize social media more at night. Their sleep schedule may be disturbed by this late-night activities, leaving them exhausted the following day [51]. Additionally, because of their impulsive and attention deficits, they can be more vulnerable to social media addiction. But others that rise early don't experience the same problems with social media and sleep. When people are most productive in the mornings, social media can be distracting [52].

## 9. SIGNIFICANCE OF CHRONOTYPE RESEARCH AND FUTURE RESEARCH

Studying chronotypes may help us better understand sleep, optimize our daily schedules for improved health, and adapt work and

educational settings to better suit individual preferences. By identifying chronotypes, we can enhance academic performance, improve sleep patterns, and tailor teaching strategies to students' innate preferences, thereby improving their mental health by addressing anxiety and depression [53]. Research on chronotypes can also aid in planning shift work, enabling schedules that align with employees' circadian rhythms, leading to reduced fatigue and increased productivity. Additionally, treatment schedules for medications could be optimized based on a person's chronotype, potentially making therapies more effective and beneficial. This could lead to the development of chronotype-specific treatments or interventions [54]. Future research might explore the mechanisms behind physiological disorders like diabetes associated with chronotype and develop preventive strategies tailored to different chronotypes [55].

Furthermore, research on chronotypes could inform strategies to help night owls adapt to shift work and educational schedules, potentially reducing fatigue and improving overall well-being. Though chronotype is considered mostly fixed, some research suggests there might be limited flexibility. Future studies could explore ways to slightly adjust chronotypes, if possible, to enhance health or well-being. While research on the link between chronotype and cognitive function has yielded mixed results, future studies might delve deeper into understanding how chronotype affects different aspects of cognition throughout the day. Overall, future research in chronotypes holds promise for a more nuanced understanding of sleep, health, and our daily functioning. By unraveling the complexities of chronotypes, we can potentially personalize our sleep habits, optimize our daily routines, and create work and educational environments that better suit our natural inclinations.

## 10. CONCLUSION

The present review highlighted the need and possibilities of humans occupying different time zones in the future. Human chronotype may bring several social advantages, such as better shift work ability among evening-types, nighttime alertness, improved quality of life in our 24x7 societies, and better utilization of resources. Unlike other species that are highly sensitive to artificial lights, the human biological clock is still primarily entrained by sunlight (phase shifts after jet lag tend to adjust with sunlight rather than artificial light). The highly flexible phase-shifting capacity of the biological clock allows a person to adjust to new time zones, shift work, temperature changes, seasonal changes, job schedules, social obligations, and other urgent activities. Moreover, it seems that chronotype is only a consequence of the aforementioned factors. In the absence of genetic research, based on present facts, there is a significant possibility that chronotype in a given population may collapse without social obligations. Furthermore, 'what we are doing today is mostly what we prefer,' thus only subjective assessment of chronotype may not be sufficient. One should also correlate it with their workday and free day sleep-wake schedules. The present review suggests that studying chronotype and its underlying mechanisms in 'fixed chronotype people' as well as primitive tribal populations living under zero-modernized conditions could provide new insights into the concepts of early, prolonged, and segmented sleep.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE):

I hereby declare that Google-gemini AI tool, basic version, was used during writing of the manuscript. Gemini tool helps to detect potentially inaccurate statements, hence aid writing.

**Details of the AI usage are given below:**

1. Prompted Social app and circadian rhythm; date June 29 at 12:21 PM
2. Gemini Apps, Prompted chronotype research papers, date May 17 at 9:14 PM
3. Gemini Apps, Prompted flexible and fixed chronotype, date May 17 at 4:44 PM
5. Gemini Apps, Prompted changes in chronotype, date May 17 at 4:41 PM
6. Gemini Apps, Prompted rest-activity rhythm and chronotype, date May 17 at 4:15 PM.
7. Gemini Apps, Prompted SIGNIFICANCE OF CHRONOTYPE STUDY, date May 14 at 12:19 AM
8. Gemini Apps, Prompted chronotype and sleep wake pattern, date May 4 at 2:21 PM

## COMPETING INTERESTS

Author has declared that no competing interests exist.

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